Welsh Region: River Arrow, Dreneuydd/Broadway Reen, Dysynni Low Level Drain

Annex of R&D Note 456

Silsoe College, Cranfield University

R&D Project Record 317/22/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 Arrow, Dreneuydd/Broadway Reen and the Dysynni Low Level Drain in the Welsh 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 ARROW

R&D 317/22/ST

CONTENTS

RIVER ARROW

1. BACKGROUND 1

1.1 PHYSICAL BACKGROUND 1

1.2 STUDY REACH 1

1.3 RIVER CHARACTERISTICS 1

1.4 LAND DRAINAGE 3

1.5 GEOLOGY, SOILS AND LAND CAPABILITY 3

1.6 CAPITAL WORKS 5

1.7 RIVER MAINTENANCE 5

1.7.1 Farmers views on maintenance 6

1.7.2 Alternative maintenance strategies 6

1.8 CLIMATE 6

1.9 AQUATIC VEGETATION 8

1.9.1 Submerged vegetation 8

1.9.2 Emergent vegetation 8

1.9.3 Algae 8

2. FARM SURVEY 9

2.1 INTRODUCTION 9

2.2 FARM TYPE, SIZE AND TENURE 9

2.3 LIVESTOCK ENTERPRISES 9

2.4 ARABLE ENTERPRISES 10

2.5 LAND USE IN THE BENEFIT AREA 10

2.6 TURNOUT AND YARDING DATES 12

2.7 GRASS CONSERVATION 14

2.8 NITROGEN APPLICATION 16

2.9 FLOODING 16

2.10 WATERLOGGING 16

2.11 STATISTICAL ANALYSIS 17

3 HYDRAULIC AND HYDROLOGICAL INFORMATION 19

3.1 INTRODUCTION 19

3.2 CROSS-SECTION SURVEYS 19

3.3 FLOOD RETURN PERIOD 25

4. LAND DRAINAGE 27

4.1 FIELD DRAINAGE STATUS 27

4.2 DEBRIS DAMS 29

4.2.1 Nature of debris dams 29

4.2.2 Impact of debris dams 30

4.3 SIMULATION OF DEBRIS DAMS IN THE CHANNEL DEBRIS DAMS 30

4.3.1 Physical effect of in-channel blockage 31

5 SCHEME APPRAISAL 33

5.1 BENEFITS OF TREE AND BUSH MAINTENANCE 33

5.2 MAINTENANCE BENEFITS 33

5.3 DEBRIS DAMS 40

5.3.1 Financial and economic impact of debris dams 41

5.4 MAINTENANCE COSTS 42

5.5 SCHEME APPRAISAL 42

6 ENVIRONMENT 44

6.1 INTRODUCTION 44

6.2 RIVER CORRIDOR SURVEY 44

6.3 PUBLIC CONSULTATION 44

6.4 FARMER ASSESSMENT 45

6.5 CHANNEL AND BANK QUALITY 45

7 CONCLUSIONS 46

7.1 SCHEME APPRAISAL 46

7.2 MAINTENANCE BEST PRACTICE 46

Channel 46

Bank 47

7.3 RECOMMENDATIONS 47

7.4 EPILOGUE 47

8. REFERENCES 48

APPENDIX I Example of input and output data for the watertable model

APPENDIX II River corridor survey

LIST OF FIGURES

Figure 1 Site location and land use blocks 2
Figure 2 Soil profiles 4
Figure 3 Land use in the benefit area 11
Figure 4 Land drainage and location of cross-sections 13
Figure 5 Areas prone to flooding and location of debris dams 15
Figure 6 Channel information 20
Figure 7 Flood return period curve 26

LIST OF TABLES

Table 1.1 Rainfall totals 7
Table 1.2 Probability of climatic condition 7
Table 2.1 Land use within the benefit area 12
Table 2.2 Turnout dates 14
Table 2.3 Yarding dates 14
Table 2.4 Grass conservation 14
Table 2.5 Nitrogen application rates 16
Table 2.6 Farmer assessment of wetness condition 17
Table 3.1 Bankfull capacity and return periods 25
Table 3.2 Flood return periods and flooded areas 25
Table 4.1 Drainage status for wet, average and dry seasons, with/without maintenance 28
Table 4.2 Impact of 50 % of cross-sectional area blocked by debris dam on drainage status 32
Table 4.3 Impact of 75 % of cross-sectional area blocked by debris dam on drainage status 32
Table 5.1 Financial net returns 35
Table 5.2 Economic net returns 36
Table 5.3 Flood costs 37
Table 5.4 Change in financial net returns 38
Table 5.5 Change in economic net returns 39
Table 5.6 Farmer assessment of maintenance benefits 40
Table 5.7 Net return with 50 % and 75 % blockage 41
Table 5.8 Maintenance scheme appraisal: River Arrow 42

WELSH RIVER ARROW

1. BACKGROUND

1.1 Physical Background

The River Arrow rises in the area of Gwaunceste Hill, to the north of Glascwm in the Radnor Region of Wales. From its source to the confluence with the River Lugg, the River Arrow is 56.16 km in length. The river drains a catchment area of 284.9 km^2, which is mainly rural in character.

1.2 Study Reach

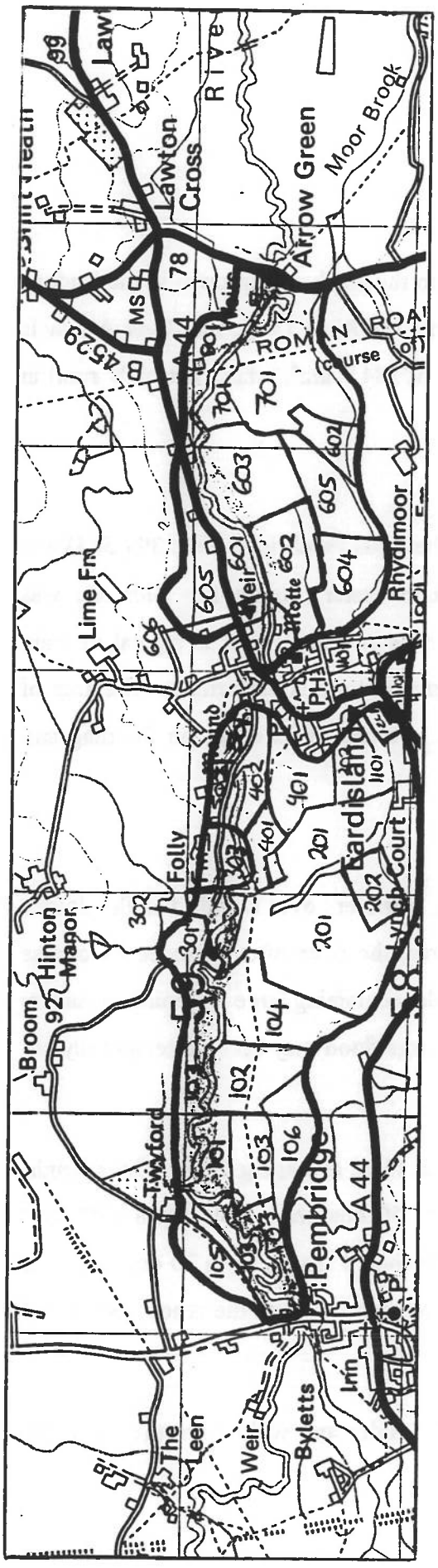
The section of river selected for study runs for 8.5 km between Pembridge (GR. 391 585) and Arrow Green (GR. 438 588), 4 km to the west of Leominster (Figure 1). This site was selected for inclusion within the River Maintenance Evaluation Study as it is typical of main rivers within the region on which tree and bush maintenance work is performed. The area of land deriving benefit from the river maintenance work in terms of its effect on flooding and land drainage has been estimated to be 297 ha.

1.3 River Characteristics

The River Arrow lives up to its name of "Arrow" as it meanders over a wide flat floodplain. According to the farmers interviewed in the benefit area, the river often changes its course after a large flood event. The meander belt is 300 m wide, containing large sweeping meanders and those with tight necks which under conditions of a large flood may become temporally cut off.

The river width within the selected reach ranges from 3 to 15 m, averaging 6.5 m. Bank height varies from 0.5 to 2 m, with an average bank angle of 50 degrees. Solid earth cliffs and slumped banks are regular features along this length. Freeboard ranges from 30 cm to 1.5 m. Gravel and cobbles are the dominant bed substrates throughout most of the reach. Sand and silt prevail through the village of Eardisland.

There is a high density of trees along the study reach. Alder and willow are the dominant species. Many have reached the mature stage of growth.



Legend : Scale 1 : 12 500

Benefit area

101 Land use blocks

Land Classification Class 4

Figure 1 Location of the River Arrow site, benefit area, land blocks and land classification

1.4 Land Drainage

The water levels upstream and downstream of Eardisland are controlled by weirs. At Arrow Bridge, a flood relief channel provides a second channel to the river. A weir controls water levels in this flood relief channel and in the Mill Race which provided water for the now disused mill at Arrow Green.

Eight ditches discharge water into the river within the study reach. In total 20 % of the benefit area is underdrained. The majority of the land drained by pipes is under arable land use. Further details on drainage installation and land use are presented in Section 2.5.

1.5 Geology, Soils and Land Capability

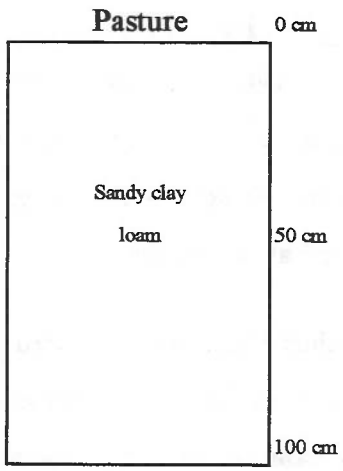
The geology of the area is characterised by siltstones and mudstones of Devonian Age which are overlain by reddish till. This is an unsorted deposit of glacial origin consisting of rounded stones in a loamy or clayey matrix.

Soils of the Fladbury Association and Conway and Clywd series dominate the valley. They are typical of alluvial gley soils which are mottled in the subsoil due to a high watertable. Infiltration through the Conway series is slow and soils are seasonally waterlogged, hence they are awarded a Wetness Class of IV or V by the SSEW (Rudeforth et al, 1984). The soil profile is commonly waterlogged within 40 cm of the surface for over 180 days in one year. The soils in the Clwyd series commonly have a Wetness Class of III as soil is waterlogged within 70 cm of the surface for 90 - 180 days in the year. Both soils respond well to underdrainage.

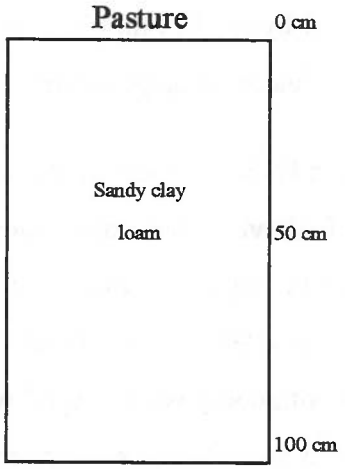
Rainfall records from the nearest meteorological station to the study reach (Lyonshall, GR. 339 576), indicate an average annual rainfall of 865 mm. Soil profiles taken at three points along the selected reach are shown in Figure 2. The soils are dark yellowish brown in colour. Mottling was not in evidence at the time of the survey.

The Agricultural Land Classification system of the Ministry of Agriculture, Fisheries and Food (MAFF) classifies the land within the meander belt as Grade 4. This is poor quality agricultural land on which the range of crops is severely restricted. Outside this area, the land is classed as Grade 3 - good to moderate agricultural land (Figure 1). Some limitations are posed on the type of crop which can be grown. Arable root crops are not suited to this land.

Grid Reference	393 585
Soil Core Number	1
Soil Colour	Dark yellowish brown
Comments	Uniform profile



Grid Reference	414 587
Soil Core Number	2
Soil Colour	Dark yellowish brown
Comments	Uniform profile



Grid Reference	437 586
Soil Core Number	3
Soil Colour	Dark yellowish brown
Comments	Friable texture

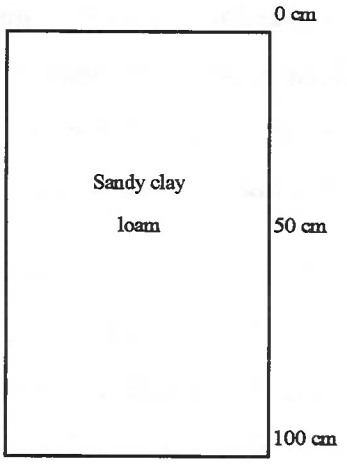


Figure 2 Soil profiles in the River Arrow benefit area

1.6 Capital Works

During the 1960s a River Bank Improvement Scheme was completed on the River Arrow between Pembridge and Arrow Green. This was the first time trees and bushes were cleared from the banks of the River Arrow. The purpose of the scheme was to provide a clear channel and to remove some overhanging and unstable limbs.

The Eardisland Flood Alleviation Scheme was also completed in the 1960s. Revetments were erected in the village and the channel was subject to a dredging programme.

1.7 River Maintenance

The River Arrow is subjected to a regular maintenance programme for the purpose of reducing flooding and for the benefit of land drainage. Tree and bush maintenance is performed by hand on a rolling programme every 8 years. The last work was carried out in 1992. Prior to this, tree and bush maintenance was performed in 1984. Fallen and insecure trees are removed and bank vegetation which would cause a significant obstruction to normal summer flows is cut. Trees are pollarded and timbers tied into the banks to provide protection from erosion in areas where the risk of bank erosion is significant. Debris is removed as required.

Desilting of the river through Eardisland village is usually performed every 6 to 7 years, in September. This reach of the river was last desilted in 1994. Gravel shoals are removed as necessary, especially if they accumulate around bridges and cause flow to be diverted which may cause erosion which undermines bridge supports.

The main reason for the current level of maintenance on the River Arrow is that it is scheduled into a regular maintenance programme and the river is subject to regular inspections by NRA staff. Customer demand and availability of equipment and labour also exert some influence on the timing of maintenance and the regime followed. Standards of service for the level of maintenance are based on custom and practice and an engineers survey. Methods of maintenance adopted are based on proven suitability of the technique.

All people with frontages on the river are notified prior to maintenance. Landowners and tenants are notified by a telephone call and personal visit. Fisheries receive written notification and conservation bodies are invited to attend a meeting to discuss the proposed maintenance

scheme. The meeting is followed up by a site visit during which individual aspects of the maintenance may be discussed in detail.

1.7.1 Farmers views on maintenance

During the interviews with farmers, the general opinion of the maintenance expressed was that it is necessary in order to prevent the river becoming blocked by fallen trees and debris. However, the view that the maintenance regime was too severe was also expressed. One farmer stated that through the removal of trees, river banks are exposed and thus suffer significant erosion during periods of higher flow. Trees were also said to be pollarded too severely - a practice that concerned one farmer in case the trees were not able to fully recover.

A poor understanding of impact of the tree and bush maintenance seemed apparent amongst a few of the people interviewed. Some were not sure if the trees pollarded were alder or willow and did not realise that willows do benefit form occasional pollarding which may look severe and potentially damaging.

1.7.2 Alternative maintenance strategies

One alternative maintenance strategy was suggested by those interviewed during the course of the study. This related to the timing of maintenance. The suggestion was made that if the trees and bushes were trimmed and maintained during the spring, the exposed bare river banks would not suffer so much from the effects of erosion as grass and vegetation would colonise the exposed areas more quickly than if maintenance were performed in the autumn.

1.8 Climate

The impact of river maintenance on the watertable 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 are presented in Table 1.1. The probability of wet, dry and average seasons and years occurring has been determined through analysis of monthly rainfall figures which span a 25 year period. The classification system of the Food and Agricultural Organisation (FAO) was used to determine the wet, dry and average 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.

The summer of 1992 was particularly wet when compared to the long term rainfall average. This fact is confirmed by farmers who reported wet conditions underfoot during the summer months.

Table 1.1 Rainfall totals

Period	Season	Actual Rainfall (mm)	Average * Rainfall (mm)	% Average Rainfall
1992	Spring	160.8	173.5	92.7
	Summer	346.0	173.2	199.7
	Autumn	260.9	222.4	117.3
1993	Spring	173.9	173.5	100.2
	Summer	198.6	173.2	114.6
	Autumn	279.9	222.4	125.8
1994	Spring	224.5	173.5	129.4
	Summer	193.6	173.2	111.7
	Autumn	207.2	222.4	93.2
1995	Spring	153.0	173.5	88.2
Year	1992	951.6	822.0	115.8
	1993	841.2	822.0	102.3
	1994	1007.3	822.0	122.5

* Based on 25 Year record from Lyonshall (GR. 339 576), 1970 to 1994

The probability of each type of a wet, dry and average season and year occurring is shown in Table 1.2. The rainfall probabilities are based on a 25 year record of data from the Lyonshall meteorological station (Station reference 473 822, GR. 339 576).

Table 1.2 Probability of climatic condition

Season	Dry *	Average *	Wet *
Spring	0.08	0.75	0.17
Summer	0.21	0.71	0.08
Autumn	0.29	0.63	0.08
Year	0.21	0.71	0.08

* Based on records since 1970

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 and year occurring.

1.9 Aquatic Vegetation

Although the River Arrow is subject to a tree and bush maintenance scheme and not aquatic vegetation clearance, some aquatic weeds are present within the channel. Due to the predominantly gravel and cobble substrate, many aquatic weeds are unable to find firm anchorage for their roots. High flows and flashy floods also serve to clean the channel of these weakly rooted plants. Trees and bushes lining the channel provide shade which further restricts plant growth.

Further information on the aquatic plants present within the channel during the study period is provided in Sections 1.9.1 to 1.9.3.

1.9.1 Submerged vegetation

Juncus (Rush), is a narrow-leaved submerged plant which is fairly common within this river. This many branched plant may reach 2 m in length with individual hair-like leaves growing to 60 cm in length. It remains streamlined in the direction of flow and acts as a silt trap in areas of slow flow as suspended fines settle out from the flow and become trapped in the hair like network of leaves.

1.9.2 Emergent vegetation

Glyceria (Reed Sweet-Grass) is found at the river margins within the watercourse. This tall narrow-leaved emergent grass with bluish leaves, may reach 1.2 m in height and grows in stands along the shallow waters edge. This plant provides a greater resistance to flow than some submerged plants as it can provide a fairly impermeable barrier to the flow of water, depending on the density of the vegetation stand.

1.9.3 Algae

Filamentous algae is present within the areas of slower flow. The long chains of this algae grow up from the hydrosoil. It is difficult to control as it can be found anywhere and grows rapidly through simple fission by which each cell divides. Algae is common in nutrient rich waters and frequently invades areas where other aquatic plants have been controlled or eradicated.

2. FARM SURVEY

2.1 Introduction

Through structured interviews and informal discussions with farmers and a topographical survey, the area deriving benefit from the river maintenance work in terms of its impact on land drainage and flooding is estimated to be 297 ha. This area is classed as the benefit area (BA). The benefit area has been divided into separate blocks (Figure 1) according to drainage, land use and management practices.

2.2 Farm Type, Size and Tenure

There are two farms out of 12 within the benefit area, classed as general cropping enterprises under the European Union (EU) classification system. Two farms are classed as dairy and five are lowland and livestock enterprises. Two farms are horticultural enterprises and one is classed as 'other'. The latter is a caravan park.

Farm size ranges from 7 to 130 ha, averaging 43 ha. The Standard Man Day (SMD) or Man-Work-Unit requirement for the agricultural enterprises ranges from 7 to 719 with an average of 287. This requirement may be used to assess the labour requirement of agricultural enterprises. Generally, the higher the SMD value, the greater the amount of labour required.

Ten farms are under sole proprietorship and one is run in a partnership. The other is run by a farm manager. All farmers have one holding except the managed farm which is composed of five units which are run as one farm under the same holding number. The majority of the land within the benefit area is owner occupied, only 10.9 ha is rented under a 364 day tenancy agreement.

2.3 Livestock Enterprises

Five farms have beef herds of various sizes. Of these, two have Charolais and Friesian herds which finish fat beefstock for sale at 12 months old. The herd sizes range from 35 to 60 cattle. Two other farms follow the 18 month grass / cereal system, with autumn calving. One has a herd of cattle 6 to 12 months old and the other, 35 cattle 1 to 2 years old. Beasts are typically sold on reaching 500-600 kg live weight. On the remaining farms, four Hereford cross cattle

are following a 24 month system and 100 are being fattened off silage. Stocking rates for beef cattle average 15 beasts/ha.

Four farms have sheep enterprises. Three have Welsh and Scotch Mules under the fat lamb system and the other has store lambs which are finished off grass and stubble turnips. Flock sizes range from 60 to 200 for the fat lambs and 470 for the store lambs. Lambing rates range from 1.6 to 1.75. The average rate is 1.7 lambs / ewe tupped. Some of the fat lambs (120) are grazed under a tack system whereby they are brought from the Welsh hills to graze the lowland pastures throughout the winter months.

Two farms have a dairy enterprise. These consist of Fresian herds ranging in size form 35 to 80 beasts. Milk yields are average, typically 5500 litres/cow/year.

2.4 Arable Enterprises

Six farmers follow some arable enterprises, five of which typically follow a four year rotation. Winter wheat, winter barley and potatoes are the most common crops grown. Spring barley, combining peas and oil seed rape are also included within some rotations.

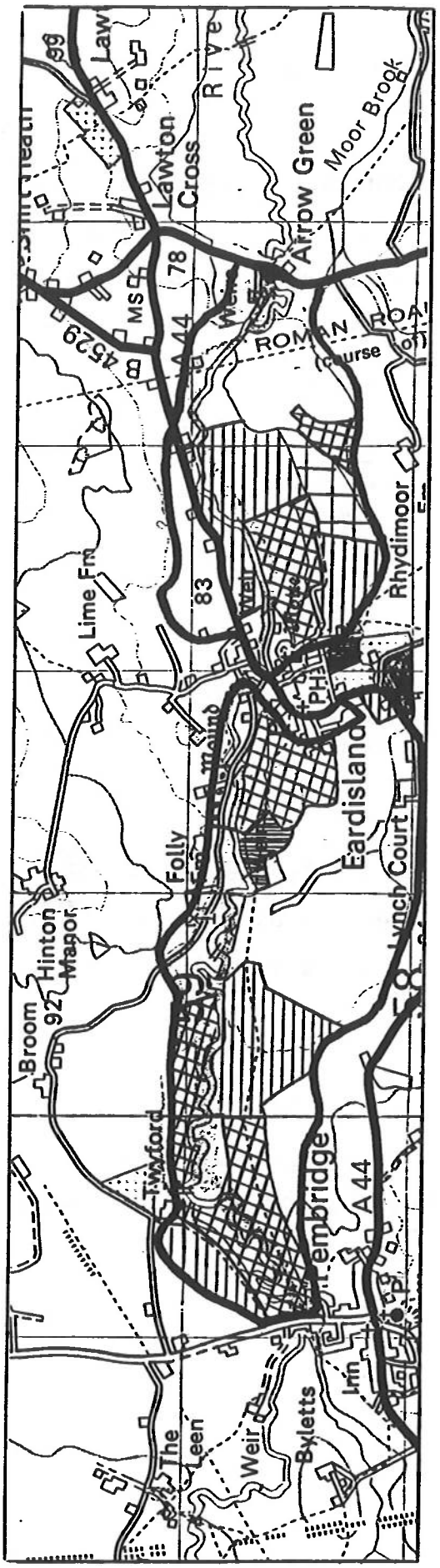
The two general cropping farms follow a different rotation pattern ranging from 4 to 7 years. Both grow winter wheat and use maincrop potatoes or beans as a break crop. The average yield for winter wheat is 7.5 tonnes/ha. Potatoes typically yield 45 to 50 tonnes/ha.

The largest arable enterprise is a grass / arable rotation under which crops are grown for five years followed by a two year ley of rye grass. Winter wheat, potatoes and sugar beet are followed by two years of rye grass ley which is grazed once the grass has been harvested for seed.

Two other farms have apple orchards which supply the local cider makers and one has one 5 ha field under continuous cropping of horticulture and potatoes.

2.5 Land Use In The Benefit Area

Figure 3 and Table 2.1 provide a breakdown of land use within the benefit area. The majority of land within the benefit area is under extensive grassland (50 %).



Legend :

Scale 1 : 12 500

- Intensive grass
- Extensive grass
- Grass / arable
- Cereal / root crop rotation
- All cereal rotation
- Horticulture
- Other

Figure 3 Land use in the benefit area

Land under a cereal / root crop rotation covers 26 % of the area and intensive grassland covers 15 %. Land use classed as other comprises a caravan site.

Extensive grassland is classified as that which receives little or no nitrogen input and is subjected to little or no grass conservation. If conserved, hay is usually cut. Grazing seasons for beef and sheep are short. In comparison, intensive grassland is usually grazed over long seasons by dairy cattle. Multiple cuts of silage are commonly taken and levels of nitrogen input are high (> 100 kg N/ha).

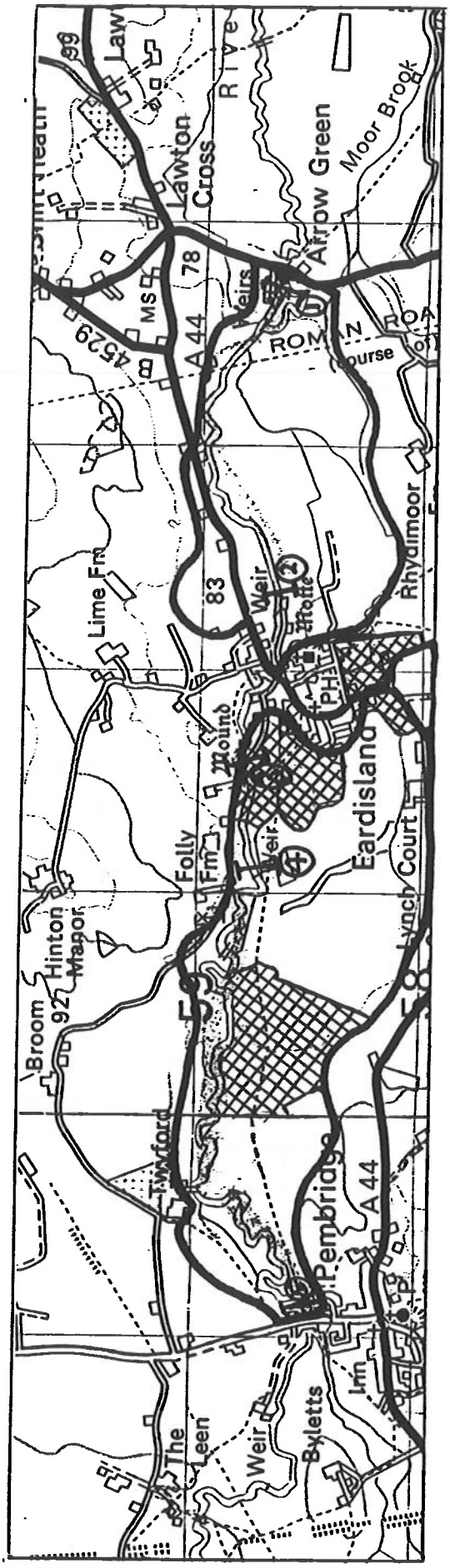
Table 2.1 Land use in the benefit area

Land Use	Area (ha)	% of Benefit Area	% Land With Field Drains
Extensive grass	148.0	49.8	0.0
Intensive grass	44.7	15.1	57.5
Grass / arable	4.3	1.4	0.0
Cereal / root	77.1	26.0	33.5
All cereal	15.0	5.1	0.0
Horticulture / orchard	5.1	1.7	100.0
Other	2.8	0.9	100.0

All the land under horticultural enterprises and orchards is drained by pipes. Fifty six percent of intensive grassland land 34 % under a cereal / root crop rotation also has field underdrainage installed. Further details are presented in Table 2.1 and Figure 4.

2.6 Turnout and Yarding Dates

Turnout dates for livestock vary over the benefit area. Over 13 % of the benefit area, livestock is turned out to grass in mid to late April. Silage is cut before stock is turned out to pasture over 28 % of the benefit area and 6 % is not grazed. Tables 2.2 and 2.3 provide a breakdown of turnout and yarding dates for livestock over the benefit area.



Legend : Scale 1 : 12 500

Natural drainage

Piped drainage

Cross-section location

Figure 4 Land drainage and location of cross-sections

Table 2.2 Turnout dates

Turnout Date	% Grassland Area	% of Benefit Area
Mid/late April	20.7	13.4
After silage cut	43.9	28.5
Overwintered	26.4	17.1
Not grazed	9.0	5.8

Table 2.3 Yarding dates

Yarding Date	% Grassland Area	% of Benefit Area
Mid/late October	34.9	22.6
Early/mid November	16.7	10.8
Early/mid December	11.2	7.3
Mid/late December	1.8	1.2
Overwintered	26.4	17.1
Not grazed	9.0	5.8

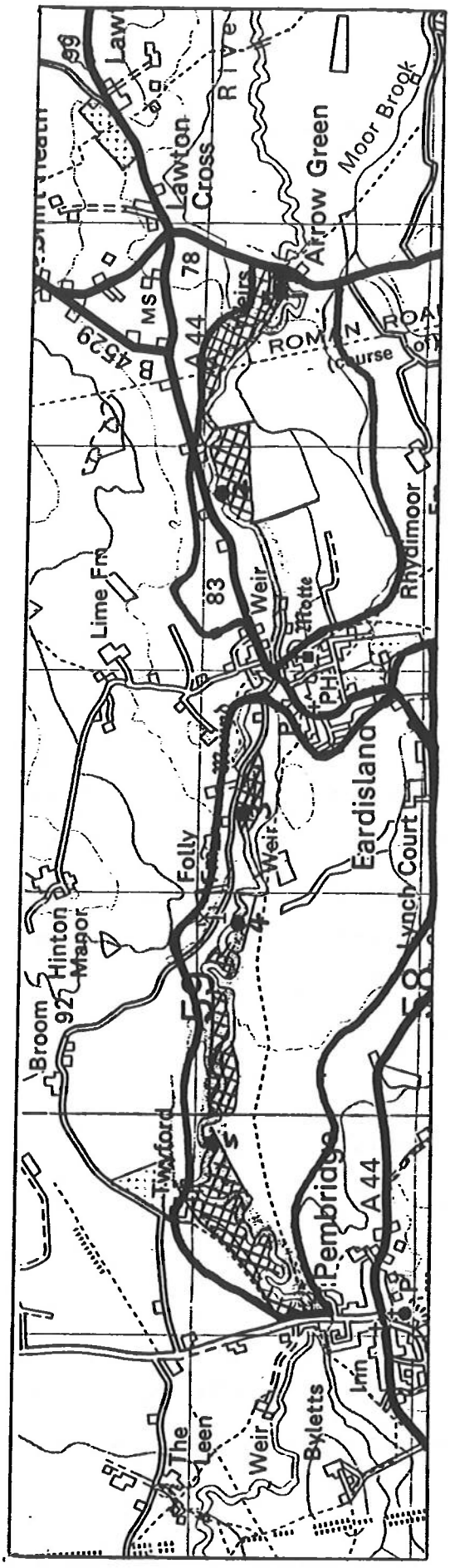
Yarding dates for livestock range from mid to late October over 35 % of the grassland area to December on 13 % of grassland within the benefit area. Livestock are overwintered out at grass over 26 % of the grassland area.

2.7 Grass Conservation

The majority of grassland is grazed only and not conserved. On the land which is cut, one and three cuts of hay and silage respectively are common. The first cut of silage is taken in mid to late May whilst the hay is cut in early June. The second and third cuts of silage are taken at intervals of six weeks after the first cut. Grassland under the grass/arable rotation is not included in Table 2.4. The grassland under this system is cut once for silage.

Table 2.4 Grass Conservation

Conservation System	% Grassland Area
1 Cut hay	9.0
1 Cut silage	7.1
3 Cut silage	9.0
Grazed only	74.9



Legend :

Scale 1 : 12 500

Flooded areas

Location of debris dams

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

2.8 Nitrogen Application

Nitrogen is applied to 51 % of the grassland area. One farmer applies straight nitrogen whilst the remainder used a compound NPK fertiliser, commonly ICI No. 8 in the proportions of 20:8:14 or a compound in the proportion 20:10:10. Farm yard manure and chicken manure are also applied to some areas. Table 2.5 provides information on application rates. Land within the grass/arable rotation is not included within Table 2.5 but receives 50 kg N/year

Table 2.5 Nitrogen application rates

Rate (kg N/ha)	Grassland Area (ha)	% Grassland Area
0	93.6	48.6
20	31.5	16.3
50	67.6	35.1

2.9 Flooding

Seven farmers within the benefit area report flooding to be common on their land. Areas commonly flooded are shown in Figure 5. In each case high river water levels due to excessive rainfall are thought to be the predominant factor responsible for the flood conditions. However, weeds in the channel and blockages caused by fallen trees are also thought by two farmers to be a significant contributory factor. In each case the consequences of flooding are reported to be litter and debris on the land which has to be cleared by hand. One farmer reports crop damage in the form of reduced yields as a major impact of flooding.

The majority of flooding occurs during the winter months. Summer flooding is reported to affect only 3 % of the benefit area. All the farmers reported the flood duration to be only one or two days. Land under cereal/root crop rotation, horticultural and orchard enterprises is not prone to flooding

2.10 Waterlogging

Throughout the benefit area, the wetness condition of the land follows a similar pattern (Table 2.6). During the spring, 57 % of the benefit area is classed as being rarely wet. Only 6 % is prone to wet conditions. Throughout the summer months the majority of land, 72 %, is rarely

wet. In the autumn, more land is prone to waterlogging and 37 % of the land is classed as occasionally wet and 10 % as often wet.

Table 2.6 Farmer assessment of wetness condition

Season	Wetness Condition	Area (ha)	% Benefit Area
Spring	Rarely wet	170.7	57.5
	Occasionally wet	108.6	36.6
	Often wet	17.7	5.9
	Permanently wet	0.0	0.0
Summer	Rarely wet	212.7	71.6
	Occasionally wet	84.3	28.4
	Often wet	0.0	0.0
	Permanently wet	0.0	0.0
Autumn	Rarely wet	159.1	53.6
	Occasionally wet	108.4	36.5
	Often wet	29.5	9.9
	Permanently wet	0.0	0.0

The wet conditions have been attributed to a variety of factors by the farmers. The wetter conditions in the spring and autumn have been attributed to the low lying nature of much of the land and due to the clayey soil type. According to one farmer the rising watertable level corresponding to a rise in river water level was the main factor responsible for wet conditions underfoot.

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 Arrow maintenance programme:

- Land use is strongly associated with the presence of field drainage. Extensive grassland is predominantly naturally drained whilst intensive land use such as horticulture and cereal /

root crop rotations have a high installation of field drainage. (Statistically there is a 93 % chance of correctly predicting the installation of field drainage on the basis of land use).

- Turnout dates for livestock in the spring are strongly associated with the field wetness condition. Turnout dates are earlier on land (April) which is well drained in the spring (rarely wet) compared to on land which is often wet (after silage cut). (Statistically there is a 98 % chance of correctly predicting turnout dates on the basis of field wetness condition in the spring).

- Yarding dates for livestock are strongly associated with field wetness conditions. Land which is often wet in the autumn is closed up in October compared to land which is rarely wet in the autumn on which livestock are overwintered. (Statistically there is a 91 % chance of correctly predicting livestock yarding dates according to field wetness conditions in the autumn).

- A significant relationship exists between the grass conservation system and levels of nitrogenous fertiliser application. Grass which is cut for silage receives higher rates of nitrogen than that which is cut for hay. The majority of grassland which is grazed only and not conserved receives no application of nitrogen. (Statistically there is 98 % chance of correctly predicting the conservation system followed on the basis of levels of nitrogen application).

- There is a relationship between land use and flooding frequency. Intensive land use such as horticulture and cereal / root crop rotations does not flood. Grassland areas are prone to flooding. (Statistically there is a 40 % chance of correctly predicting the incidence of flooding according to land use).

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 study reach at an average interval of 2 km (Figure 4). Channel capacity has been determined from these cross-sections. Because the channel dimensions were not altered during the tree and bush clearance process, a post-maintenance cross-sectional survey of the channel was not necessary.

Before maintenance was carried out, the roughness of the channel 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, channel sinuosity and relative effect of channel obstructions. 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' (after/post) and 'without' (before/pre) maintenance situation.

Stage/discharge curves were 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 6.

Throughout the period of the study (1993 - 1995), river water level information was collected from a gauge station at Titley Mill (GR. 328 585), upstream of the study reach. A conversion factor, supplied by the NRA was used to transpose this data into that which was representative of flows in the study reach.

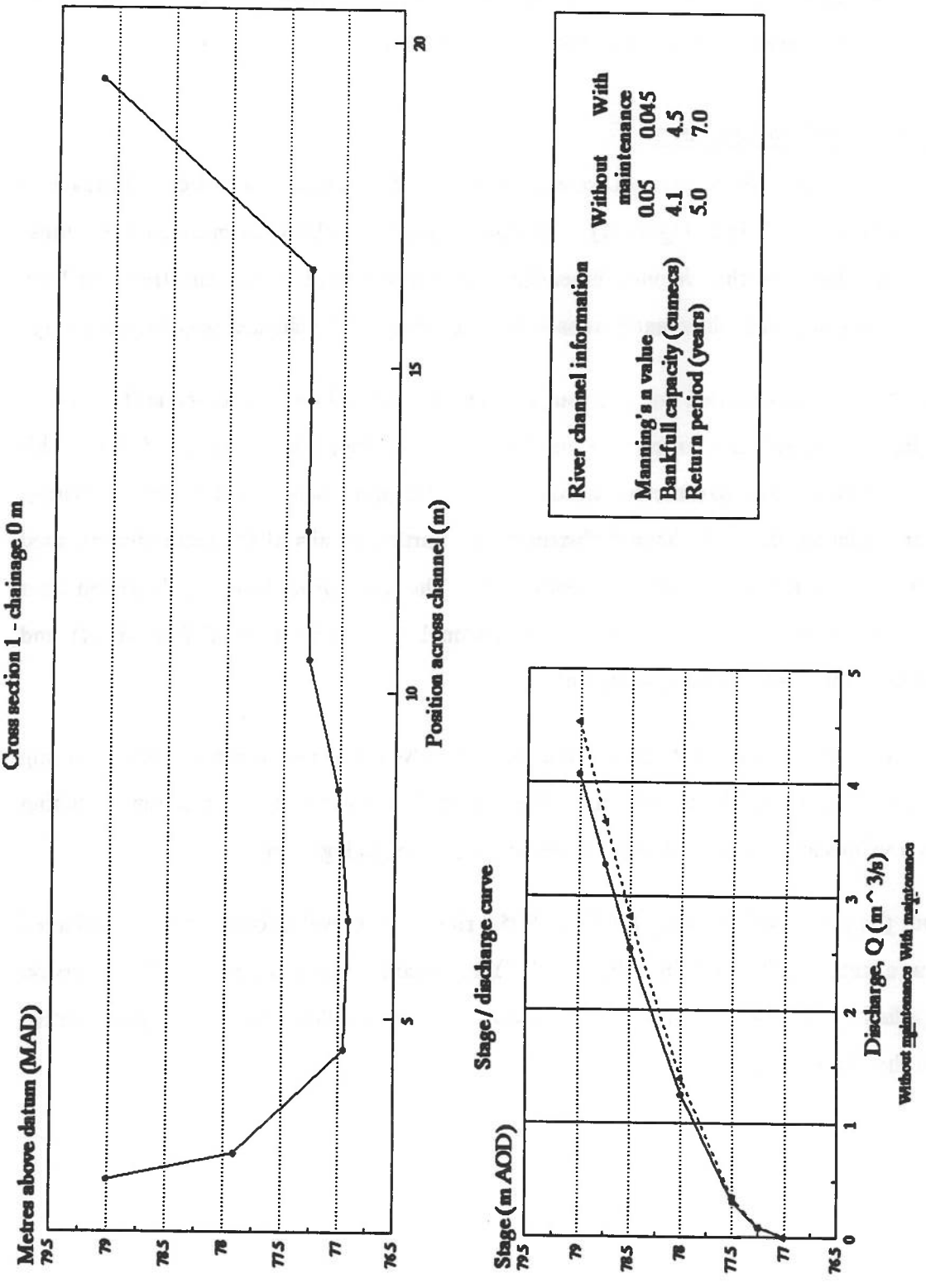
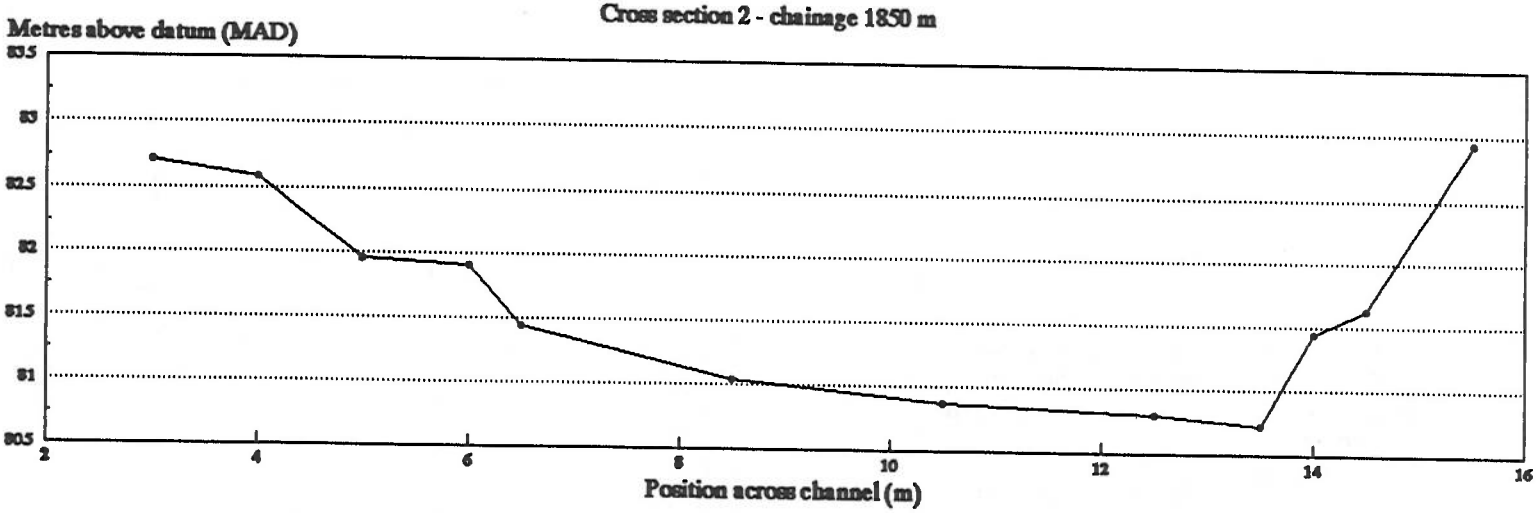
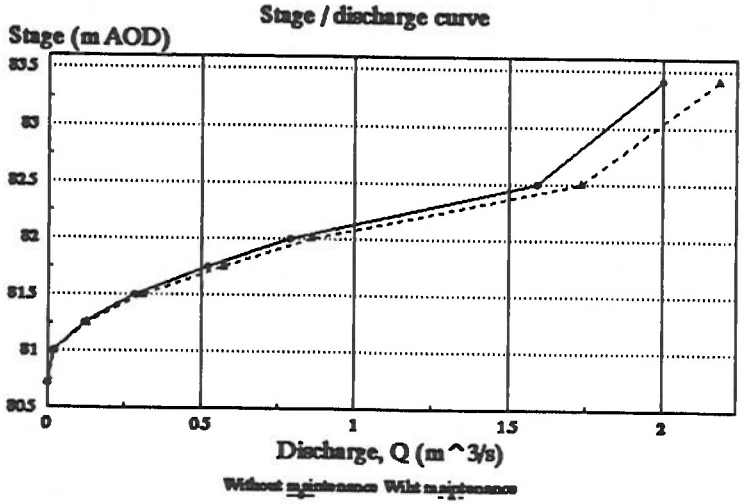


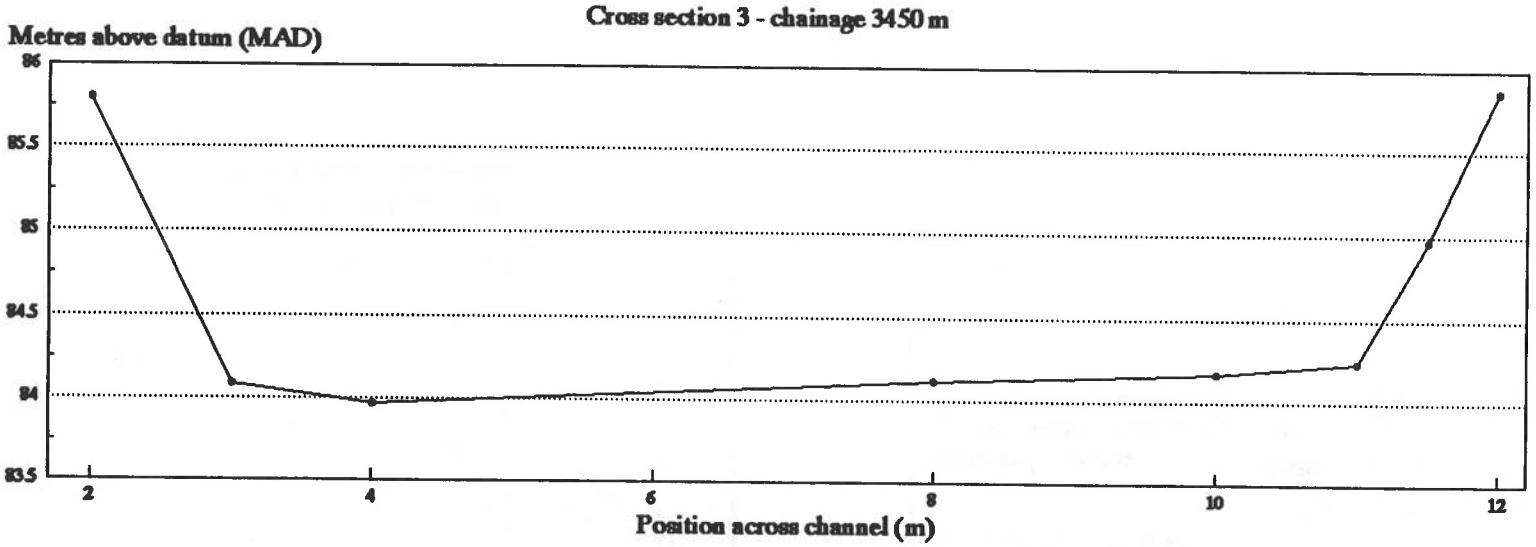
Figure 6 **River Arrow channel information**

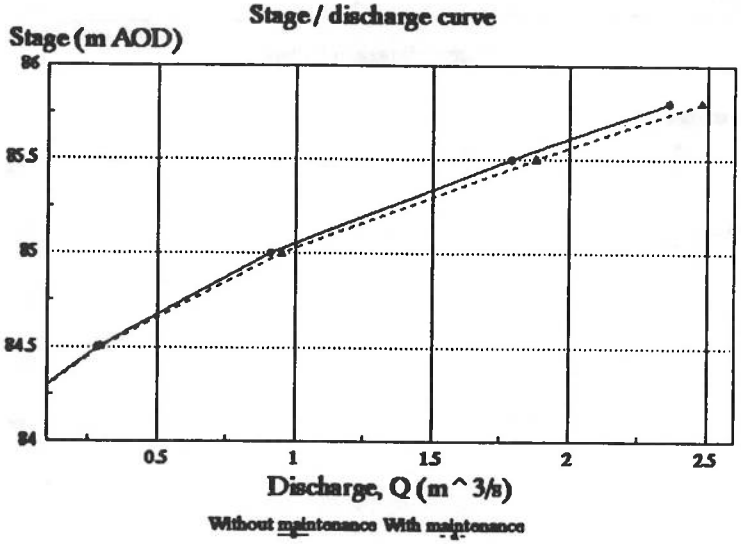




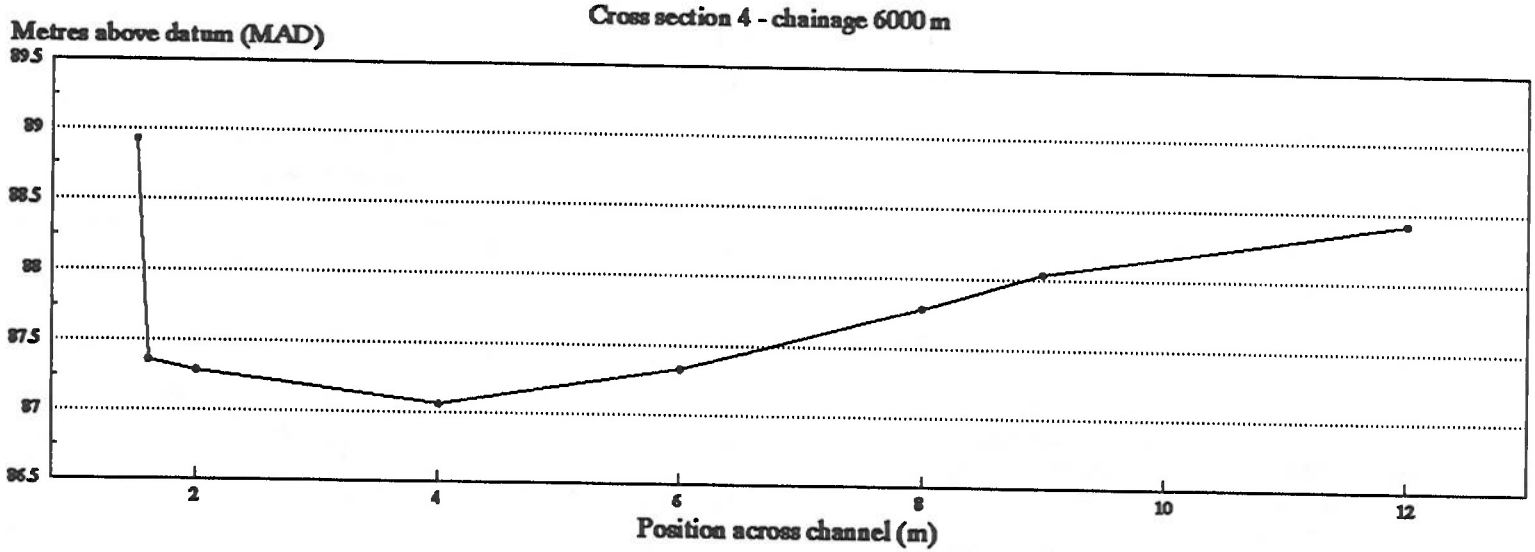
River channel information

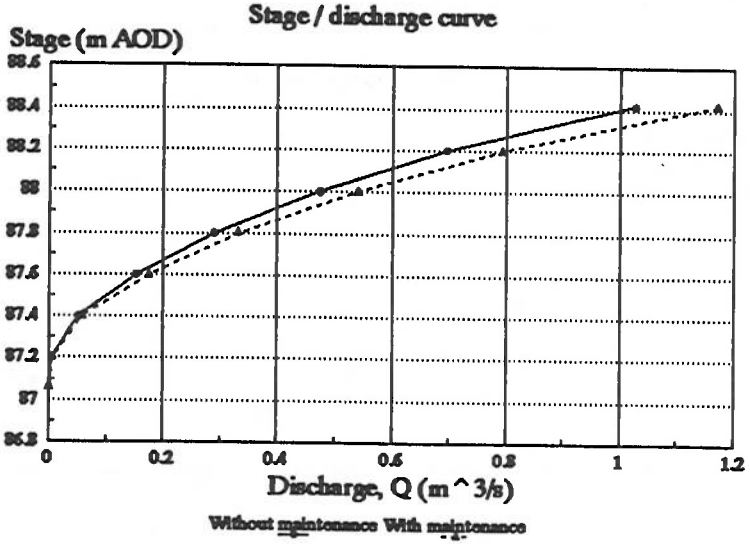
	Without maintenance	With maintenance
Manning's n value	0.049	0.045
Bankfull capacity (cumecs)	2.01	2.2
Return period (years)	0.8	0.9





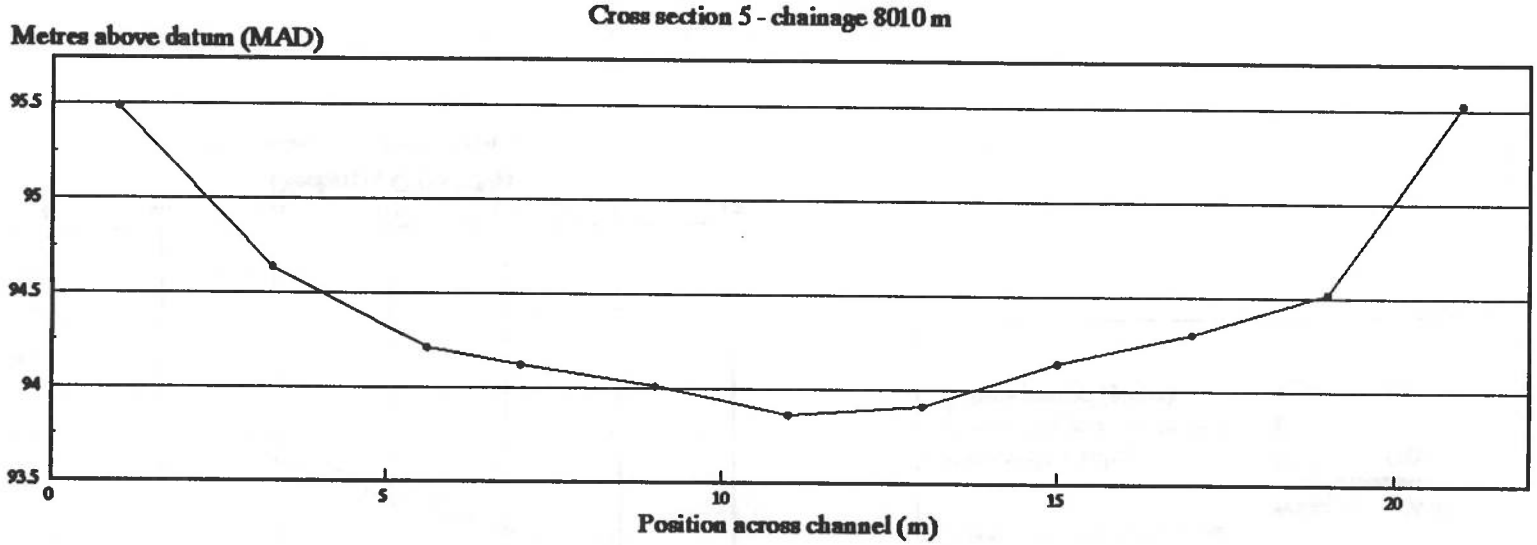
River channel information	Without maintenance	With
Manning's n value	0.043	0.041
Bankfull capacity (cumecs)	2.4	2.5
Return period (years)	1.0	1.3

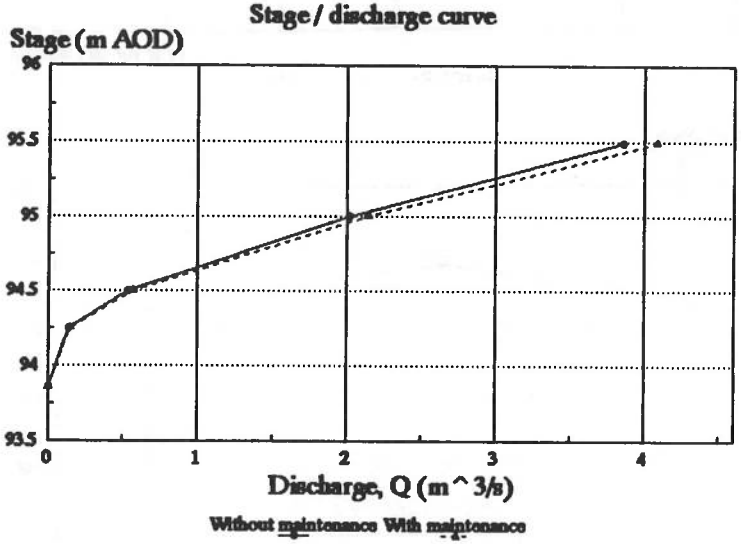




River channel information

	Without maintenance	With
Manning's n value	0.057	0.05
Bankfull capacity (cumecs)	1.03	1.2
Return period (years)	0.34	0.4





River channel information	Without maintenance	With
Manning's n value	0.036	0.034
Bankfull capacity (cumecs)	3.9	4.1
Return period (years)	4.0	5.0

Table 3.1 Bankfull capacity and flood return periods

Cross-Section	Without maintenance		With maintenance	
	Bankfull Capacity (cumecs)	Return Period (years)	Bankfull Capacity (cumecs)	Return Period (years)
1	4.1	5.00	4.5	7.0
2	2.0	0.80	2.2	0.9
3	2.4	1.00	2.5	1.3
4	1.0	0.35	1.2	0.4
5	3.9	4.00	4.1	5.0

(Source: modelled estimates)

3.3 Flood Return Period

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 the River Arrow. The frequency of floods of different magnitudes can be estimated by using this flood return period curve (Figure 7).

The bankfull capacity figures obtained from the cross-sections indicate an average increase in capacity attributable to maintenance of 9 % and an average increase in the interval between floods of 19 %.

The flood return period for each block which floods and 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.	Block Size (ha)	Flooded Area (ha)	Flood Return Period (Years)	
			Without Maintenance	With Maintenance
101	14.6	5.11	0.35	0.5
102	8.0	1.20	0.35	1.0
103	11.0	5.52	0.35	1.0
105	9.7	1.94	1.00	4.0
302	3.7	0.99	0.35	1.0
303	2.0	0.06	0.50	1.0
401	4.3	0.30	1.00	1.0
402	5.9	1.89	1.00	4.0
603	16.0	9.12	1.00	5.0
1001	6.9	0.69	0.80	3.0
1201	6.8	0.34	0.80	3.0

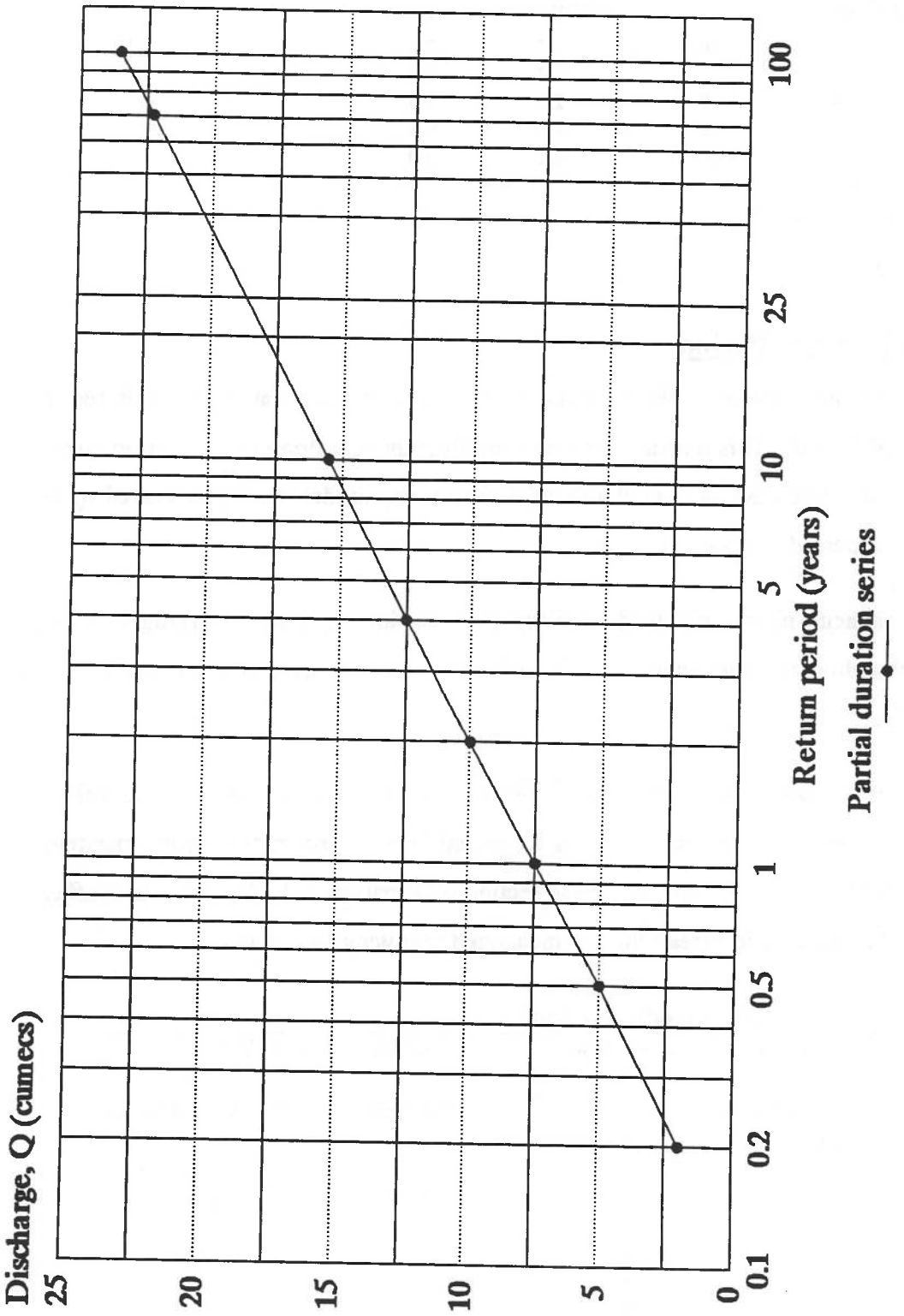


Figure 7 **River Arrow flood return period curve**

4. LAND DRAINAGE

4.1 Field Drainage Status

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

The drainage status of land within the benefit area of the River Arrow 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 scenario using the same climatic data in each case, in order to isolate the impact of maintenance on drainage status. Appendix 1 contains an example of the input and output data produced by the watertable model.

The results of the watertable modelling and the assessment of drainage status made by farmers for land within the benefit area are shown in Table 4.1. In some cases, there is a difference in the number of weeks that the watertable is under good, bad or very bad levels following maintenance. However, these changes may not be of sufficient magnitude to change the drainage status classification. Where a change in drainage status classification between maintained and non-maintained conditions has occurred due to maintenance, the changes appear in bold print in Table 4.1.

The output from the watertable model is consistent with the farmers assessment of drainage status under dry and average climatic conditions. Under wet conditions, there is 77 % agreement between farmer and modelled assessments. For the 'without' maintenance situation there is 85 % agreement between the modelled and farmer assessment of field drainage status under average conditions.

These assessments confirm that the 'with' maintenance drainage status in the benefit area is generally bad in wet climatic conditions and good in average and dry conditions. If maintenance is not performed, drainage conditions would deteriorate to very bad over 7 ha in a wet season and to generally bad drainage under average weather conditions. This may be due to localised rises in river levels and hence watertable levels due to log jams and debris dams blocking the channel and restricting flow.

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

Block No		Wet Season *		Average Season *		Dry Season *		Farmer Assessment With Maintenance			Without
		Without	With	Without	With	Without	With	Wet	Average	Dry	
101	N	B	B	B	B	B	B	B	B	G	VB
102	Y	B	B	B	B	G	G	B	*G*	G	B
103	N	B	B	B	B	**B**	**G**	B	*G*	G	B
104	Y	B	B	B	B	**B**	**G**	B	B	G	B
105	N	B	B	**B**	**G**	G	G	B	G	G	B
106	N	**B**	**G**	**B**	**G**	G	G	G	G	G	B
201	N	**B**	**G**	**B**	**G**	**B**	**G**	*B*	G	G	G
202	N	G	G	G	G	G	G	G	G	G	G
301	N	B	B	G	G	G	G	B	G	G	G
302	N	B	B	G	G	G	G	*G*	G	G	B
303	N	B	B	**B**	**G**	G	G	B	G	G	G
401	N	B	B	**B**	**G**	G	G	B	G	G	B
402	Y	B	B	**B**	**G**	G	G	B	G	G	B
501	N	B	B	**B**	**G**	G	G	B	G	G	B
502	Y	B	B	**B**	**G**	G	G	B	G	G	B
601	N	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
602	N	B	B	G	G	G	G	B	G	G	G
603	N	G	G	G	G	G	G	*B*	G	G	G
604	N	B	B	G	G	G	G	B	G	G	G
605	N	B	B	G	G	G	G	B	G	G	G
701	N	G	G	G	G	G	G	G	G	G	G
801	N	G	G	G	G	G	G	G	G	G	G
901	Y	B	B	**B**	**G**	G	G	B	G	G	B
1001	N	B	B	G	G	G	G	*G*	G	G	G
1101	Y	B	B	G	G	G	G	*G*	G	G	G
1201	Y	B	B	**B**	**G**	G	G	*G*	G	G	B

NB : * Modelled results
Bold type indicates a change in drainage classification as a result of maintenance.
Italics highlight differences between farmer assessment and modelled drainage conditions with maintenance

River maintenance results in the prevention of a deterioration of drainage status on 3 blocks of land in a wet season, on 11 blocks in an average season and 3 blocks in a dry season. The percentage change of area by drainage status as a result of maintenance activities are estimated and the results presented below.

- maintenance prevents a deterioration in land drainage condition in a wet season from :

  B to VB over 6.9 ha (2 % of the BA)
  G to B over 82.5 ha (28 % of the BA)

- maintenance prevents a deterioration in land drainage condition in an average season from :

  G to B over 137.4 ha (46.3 % of the BA)

- maintenance prevents a deterioration in land drainage condition in a dry season from :

  G to B over 92.8 ha (31.2 % of the BA).

Farmer perception of drainage deterioration due to lack of maintenance (under average conditions) was good to bad on 32 % of the benefit area and bad to very bad on 5 %.

4.2 Debris Dams

Maintenance is carried out as a preventative measure to minimise the probability of fallen timber accumulating against structures such as bridges and as debris dams thus causing localised flooding, increased water level upstream of the debris dam, waterlogging and structural damage.

4.2.1 Nature of debris dams

Debris dams are accumulations of organic matter within the river channel. 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) such as a tree root. 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 unless removed. 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 as it crosses the dam reduces the flow of 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 within the River Arrow benefit area 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 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 Arrow affected river levels for a distance of approximately 700 m upstream of the dam. A 50 % blockage at five locations within the study reach is estimated to result in the change in drainage status over 154 ha (52 % of BA) whilst a 75 % blockage results in a change over 215 ha (72 % of the BA). The impact of debris dams on drainage status is shown in Tables 4.2 and 4.3. The impact of debris dams on retained river levels and drainage status is greatest in the spring.

Table 4.2 **Impact of 50 % of cross-sectional area blocked by debris dam on drainage status**

Dam Location	Season	Current Drainage Status	Drainage Status with debris dam	Area affected (ha)	Land Use
1	Spring	G	B	17.1	Intensive & extensive grass
1	Summer	G	B	6.3	
1	Autumn	G	B	13.5	
2	Spring	G	B	19.2	Intensive grass & cereal/root
2	Summer	G	B	9.9	
2	Autumn	G	B	17.1	
3	Spring	G	B	27.9	Extensive grass
3	Summer	G	B	18.2	
3	Autumn	G	B	24.9	
4	Spring	No Change			
4	Summer	No Change			
4	Autumn	No Change			
5	Spring	No Change			
5	Summer	No Change			
5	Autumn	No Change			

Table 4.3 **Impact of 75 % of cross-sectional area blocked by debris dam on drainage status**

Dam Location	Season	Current Drainage Status	Drainage Status with debris dam	Area affected (ha)	Land Use
1	Spring	G	B	22.4	Intensive & extensive grass
1	Summer	G	B	11.9	
1	Autumn	G	B	19.6	
2	Spring	G	B	22.8	Intensive grass & cereal/root
2	Summer	G	B	13.2	
2	Autumn	G	B	19.0	
3	Spring	G	B	31.1	Extensive grass
3	Summer	G	B	25.9	
3	Autumn	G	B	29.8	
4	Spring	No Change			
4	Summer	No Change			
4	Autumn	No Change			
5	Spring	B	VB	10.4	Extensive grass
5	Summer	No Change			
5	Autumn	B	VB	8.6	Extensive grass

5 SCHEME APPRAISAL

5.1 Benefits of Tree and Bush Maintenance

The river maintenance on the Arrow comprise a number of elements. The removal of silt directly influences the hydraulic performance of the channel. The control of tree and bush growth also has a direct, albeit small, influence on hydraulic performance. Tree and bush work reduces the probability of debris falling into the channel and creating a debris dam. When dams do arise, they are removed to limit the potential damage to the channel, adjacent land and structures downstream. The following benefit assessment examines these 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 £ 7771 in 1995 financial prices, equivalent to about £ 27/ha per year. Two thirds are associated with protecting field drainage status and one third with flood alleviation benefits. 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 £ 5120 in economic prices for the benefit area, equivalent to £ 18/ha. On this basis, the benefit to the national economy is about 66 % 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.

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.

Table 5.1 Financial net returns

Block	Block size	Net Return (£/ha)			Change in Net Return (£/ha)		
	(ha)	G	B	VB	G-B	G-VB	B-VB
101	14.60	277	231	157	46	120	74
102	8.00	468	414	173	54	295	241
103	11.00	437	333	246	103	191	88
104	17.80	539	471	182	68	357	288
105	9.70	539	471	182	68	357	288
106	18.50	197	171	137	26	61	35
201	64.00	317	282	246	35	71	36
202	9.30	104	92	81	12	23	11
301	1.00	180	148	117	33	63	31
302	3.70	264	230	194	34	70	37
303	2.00	118	103	70	15	48	33
401	4.30	164	132	65	32	98	67
402	5.90	74	68	56	6	19	12
501	3.50	136	120	105	16	31	15
502	2.80	Caravan park					
601	6.90	432	384	178	48	255	207
602	10.60	52	48	56	4	-5	-8
603	16.00	432	384	178	48	255	207
604	11.90	433	382	167	50	265	215
605	15.00	387	359	227	29	160	132
701	15.90	410	345	246	65	164	99
801	12.60	278	241	201	37	77	40
901	13.00	376	371	307	5	69	64
1001	6.90	240	226	192	15	49	34
1101	5.10	Orchard					
1201	6.80	1187	647	226	540	961	421

Table 5.2 Economic net returns

Block	Block size	Net Return (£/ha)			Change in Net Return (£/ha)		
	(ha)	G	B	VB	G-B	G-VB	B-VB
101	14.60	120	93	27	26	93	67
102	8.00	344	313	154	31	190	158
103	11.00	437	333	26	103	411	307
104	17.80	420	381	207	39	213	174
105	9.70	420	381	207	39	213	174
106	18.50	76	63	48	13	28	15
201	64.00	102	87	72	15	30	15
202	9.30	12	7	6	5	6	1
301	1.00	84	60	39	24	45	21
302	3.70	63	45	29	18	34	16
303	2.00	9	3	-5	5	14	8
401	4.30	16	-1	-24	17	40	23
402	5.90	-74	-70	-46	-5	-28	-24
501	3.50	41	34	27	7	14	7
502	2.80	Caravan park					
601	6.90	366	333	195	33	170	138
602	10.60	-72	-68	-47	-5	-25	-21
603	16.00	365	333	195	32	170	138
604	11.90	365	330	185	35	180	145
605	15.00	335	301	185	34	150	116
701	15.90	78	52	26	26	52	26
801	12.60	110	88	65	22	45	23
901	13.00	47	100	80	-53	-33	20
1001	6.90	54	54	39	0	15	15
1101	5.10	Orchard					
1201	6.80	1140	627	207	513	933	420

Table 5.3 Flood costs associated with flood risk

			GOOD DRAINAGE		BAD DRAINAGE		VERY BAD DRAINAGE		CHANGE IN FLOOD COSTS					
Block Number	Without maintenance FRP	With maintenance FRP	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	GOOD Without -with	BAD Without -with	VERY BAD Without -with	GOOD TO BAD Without -with	BAD TO VERY BAD Without -with	GOOD TO VERY BAD Without -with
101	0.35	0.50	7.39	5.17	6.51	4.56	4.94	3.46	2.22	1.95	1.48	1.34	0.38	-0.23
102	0.35	1.00	36.20	12.67	35.23	12.33	29.34	10.27	23.53	22.90	19.07	22.56	17.01	16.67
103	0.35	1.00	18.00	6.30	8.71	3.05	6.83	2.39	11.70	5.66	4.44	2.41	3.78	0.53
105	1.00	4.00	21.13	5.28	20.54	5.14	17.28	4.32	15.85	15.40	12.96	15.26	12.14	12.00
302	0.35	1.00	3.43	1.20	3.20	1.12	2.91	1.02	2.23	2.08	1.89	2.00	1.79	1.71
303	0.50	1.00	0.55	0.28	0.50	0.25	0.38	0.19	0.27	0.25	0.19	0.22	0.13	0.10
401	1.00	1.00	1.27	1.27	1.15	1.15	0.77	0.77	0.00	0.00	0.00	-0.12	-0.38	-0.50
402	1.00	4.00	16.40	4.10	14.08	3.52	9.44	2.36	12.30	10.56	7.08	9.98	5.92	5.34
603	1.00	5.00	42.58	8.52	41.24	8.25	36.13	7.23	34.06	32.99	28.90	32.72	27.88	27.61
1001	0.80	3.00	0.49	0.13	0.45	0.12	0.41	0.11	0.36	0.33	0.30	0.32	0.29	0.28
1201	0.80	3.00	4.20	1.12	4.76	1.27	4.80	1.28	3.08	3.49	3.52	3.64	3.53	3.68

Table 5.4 Changes in net returns due to maintenance and climate, 1995/96 financial prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	14.60	0	1.95	2	0	1.95	2	0	0.00	0	23
102	8.00	0	22.90	23	0	22.90	23	0	23.53	24	184
103	11.00	0	5.66	6	0	5.66	6	103	2.41	106	272
104	17.80	0	0.00	0	0	0.00	0	68	0.00	68	231
105	9.70	0	15.40	15	68	15.26	84	0	15.85	16	613
106	18.50	26	0.00	26	26	0.00	26	0	0.00	0	390
201	64.00	35	0.00	35	35	0.00	35	35	0.00	35	2230
202	9.30	0	0.00	0	0	0.00	0	0	0.00	0	0
301	1.00	0	0.00	0	0	0.00	0	0	0.00	0	0
302	3.70	0	2.08	2	0	2.23	2	0	2.23	2	8
303	2.00	0	0.25	0	15	0.22	16	0	0.28	0	22
401	4.30	0	0.00	0	32	0.00	32	0	0.00	0	96
402	5.90	0	10.56	11	6	9.98	16	0	12.30	12	88
501	3.50	0	0.00	0	16	0.00	16	0	0.00	0	40
502	2.80	Caravan Park									
601	6.90	207	0.00	207	48	0.00	48	0	0.00	0	388
602	10.60	0	0.00	0	0	0.00	0	0	0.00	0	0
603	16.00	0	34.06	34	0	34.06	34	0	34.06	34	545
604	11.90	0	0.00	0	0	0.00	0	0	0.00	0	0
605	15.00	0	0.00	0	0	0.00	0	0	0.00	0	0
701	15.90	0	0.00	0	0	0.00	0	0	0.00	0	0
801	12.60	0	0.00	0	0	0.00	0	0	0.00	0	0
901	13.00	0	0.00	0	5	0.00	5	0	0.00	0	45
1001	6.90	0	0.33	0	0	0.36	0	0	0.36	0	2
1101	5.10	Orchard									
1201	6.80	0	3.49	3	540	3.64	544	0	3.08	3	2594
Total	297									Total	7771
Probability of :		Wet season		0.11						Benefit (£/ha)	**27**
		Average season		0.70							
		Dry season		0.19							

Table 5.5 Changes in net returns due to maintenance and climate, 1995/96 economic prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	14.60	0	1.95	2	0	1.95	2	0	0.00	0	23
102	8.00	0	22.90	23	0	22.90	23	0	23.53	24	184
103	11.00	0	5.66	6	0	5.66	6	103	2.41	106	272
104	17.80	0	0.00	0	0	0.00	0	39	0.00	39	132
105	9.70	0	15.40	15	39	15.26	54	0	15.85	16	414
106	18.50	13	0.00	13	13	0.00	13	0	0.00	0	199
201	64.00	15	0.00	15	15	0.00	15	15	0.00	15	973
202	9.30	0	0.00	0	0	0.00	0	0	0.00	0	0
301	1.00	0	0.00	0	0	0.00	0	0	0.00	0	0
302	3.70	0	2.08	2	0	2.23	2	0	2.23	2	8
303	2.00	0	0.25	0	5	0.22	6	0	0.28	0	8
401	4.30	0	0.00	0	17	0.00	17	0	0.00	0	51
402	5.90	0	10.56	11	-5	9.98	5	0	12.30	12	43
501	3.50	0	0.00	0	7	0.00	7	0	0.00	0	18
502	2.80	Caravan Park									
601	6.90	138	0.00	138	33	0.00	33	0	0.00	0	263
602	10.60	0	0.00	0	0	0.00	0	0	0.00	0	0
603	16.00	0	34.06	34	0	34.06	34	0	34.06	34	545
604	11.90	0	0.00	0	0	0.00	0	0	0.00	0	0
605	15.00	0	0.00	0	0	0.00	0	0	0.00	0	0
701	15.90	0	0.00	0	0	0.00	0	0	0.00	0	0
801	12.60	0	0.00	0	0	0.00	0	0	0.00	0	0
901	13.00	0	0.00	0	-53	0.00	-53	0	0.00	0	-482
1001	6.90	0	0.33	0	0	0.36	0	0	0.36	0	2
1101	5.10	Orchard									
1201	6.80	0	3.49	3	513	3.64	517	0	3.08	3	2466
Total	297									Total	5120
Probability of :		Wet season		0.11						Benefit (£/ha)	**18**
		Average season		0.70							
		Dry season		0.19							

Table 5.6 Farmer asessment of maintenance benefits

Block	Area (ha)	Average Season Financial Prices			Average Season Economic Prices		
		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
101	14.60	74	1.95	1109	67	1.95	1007
102	8.00	0	22.90	183	0	22.90	183
103	11.00	0	5.66	62	0	5.66	62
104	17.80	0	0.00	0	0	0.00	0
105	9.70	68	15.40	809	39	15.26	526
106	18.50	26	0.00	481	13	0.00	241
201	64.00	0	0.00	0	0	0.00	0
202	9.30	0	0.00	0	0	0.00	0
301	1.00	0	0.00	0	0	0.00	0
302	3.70	34	2.08	133	18	2.23	75
303	2.00	0	0.25	1	0	0.22	0
401	4.30	32	0.00	138	17	0.00	73
402	5.90	6	10.56	98	-5	9.98	29
501	3.50	16	0.00	56	7	0.00	25
502	2.80	Caravan Park					0
601	6.90	48	0.00	331	-5	0.00	-35
602	10.60	0	0.00	0	0	0.00	0
603	16.00	0	34.06	545	0	34.06	545
604	11.90	0	0.00	0	0	0.00	0
605	15.00	0	0.00	0	0	0.00	0
701	15.90	0	0.00	0	0	0.00	0
801	12.60	0	0.00	0	0	0.00	0
901	13.00	5	0.00	65	-53	0.00	-689
1001	6.90	0	0.33	2	0	0.36	2
1101	5.10	Orchard					
1201	6.80	540	3.49	543	513	3.64	517
Total	297	Total financial benefit (£)		4557	Total economic benefit (£)		2562
		Benefit (£/ha)		15	Benefit (£/ha)		9

5.3 Debris Dams

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 influence of debris dams on land drainage was determined by means of 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 equi-distant points along the reach, such that all the channel is affected in some way, but the dams are independent in their effect. The impacts in Table 5.7 are additional to those previously

attributed to desilting and tree and bush work, i.e. they are areas whose condition was not affected by a change in the original work. The annual financial cost of a single dam at location 1 for instance is £ 1111 in the case of a 50 % or £ 1456 for a 75 % blockage. If the whole channel was affected in some way by debris the annual financial costs would range between about £ 2600 and £ 4500 depending on the degree of blockage. Economic prices give total annual costs of £ 1100 and £ 2500.

The dams are 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 suggest that flood costs will double from those identified in Table 5.3, equivalent to an additional £ 2100/year in an average weather year. On this very rough assessment, a channel blocked with (75 %) debris dams would result in financial losses of about £ 6590 per year, about £ 22/ha, and economic losses of about £ 4600 per year (£ 16/ha).

5.3.1 Financial and economic impact of debris dams

Through simulation, the influence of debris dams on land drainage has been determined. Table 5.7 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	Area Affected (ha) 50 % Blockage	75 % Blockage	Drainage Status	Current Net Return (£/ha) F	E	Drainage Status With Dam	Net Return With Dam (£/ha) F	E	Total Change (£/yr) 50 % Blockage F	E	Total Change (£/yr) 75 % Blockage F	E
1	17.1	22.4	G	410	78	B	345	52	1111	445	1456	582
2	19.2	22.8	G	432	365	B	384	333	922	614	1094	730
3	27.9	31.1	G	192	-65	B	171	-67	586	56	653	62
4	0.0	0.0	No Change									
	0.0	8.6	B	714	557	VB	564	426	0	0	1290	1127
								Total	2619	1115	4493	2501

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 Arrow involve desilting every 7 years. Tree and bush work is carried out on a rolling programme with a return period of about 8 years. According to NRA records the cost of these operations was £ 15200 and £ 14800 in 1995 prices respectively. This is equivalent to an annual cost of £ 2715 and £ 2382 per year respectively when spread over the maintenance intervals at a 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 suggest average expenditure of £ 1500 in 1995 prices for the study reach. Total average costs for the reach are therefore £ 6597 per year.

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 present maintenance programme is viable in both financial and economic terms. Benefits exceed costs. Table 5.8 also shows that the current expenditure of about £ 1500 on debris removal is worth it, as not to remove debris would lead to retained water levels. 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 Arrow

Average Annual Benefit (£)	Average Annual Benefits (£)	Average Annual Costs (£)	Benefit: Cost Ratio
Modelled Estimates			
Tree and Bush Work Only			
Financial Prices	7771	5097	1.52
Economic Prices	5120	5097	1.00
Tree and Bush and Debris Removal (75% blockages)			
Financial Prices	14361	6597	2.18
Economic Prices	9720	6597	1.47
Farmer Estimates *(Tree and Bush Work Only)*			
Financial Prices	4557	5097	0.89
Economic Prices	2562	5097	0.50

Farmer assessment gave an average annual financial benefit of £ 4557 (£ 15/ha) and an economic benefit of £ 2562 (£ 9 ha). The scheme generates an annual benefit : cost ratio of 0.89 and 0.5 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.

6 ENVIRONMENT

6.1 Introduction

The environmental quality of the River Arrow 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 recorded.

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 maintenance of tree and bush vegetation on the banks (Appendix II).

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 EN, the Countryside Commission (CC) and Otter Haven Trust, are invited to attend. Objections to the proposed work can be raised and if necessary modifications to the work programme made.

Following this meeting, representatives of the various organisations are invited to attend an on-site meeting to discuss the planned maintenance in more detail. The organisations can make recommendations for example, as to which trees in particular are important for specific wildlife groups and should therefore be avoided or receive particular attention.

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. The majority were in favour of the maintenance scheme and thought that it was beneficial in encouraging wildlife to the river. Kingfishers, heron and swans were said to be frequent visitors to the river. The fish population, particularly trout, is said to be high. Otters and sand martins have been seen within the study reach and the NRA are encouraging them to nest through sensitive maintenance.

6.5 Channel and Bank Quality

The environmental quality of the River Arrow 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 channel is classed as medium. At times of low flow there is a well developed transitional zone between the river and channel edge. Sediments are varied and there is a well developed pool and riffle sequence.

The bank quality is also classed as medium. The banks are of complex structure and varied, being comprised of bare earth cliffs and shallow banks. Bank vegetation is composed of mosses, short and tall herbs and grasses, trees, bushes and scrub. Bank width is typically 5 - 10 m. There is a well developed transitional zone between the river and channel edge at times of low flow and sediments are exposed. Vegetation structure is varied in composition, structure and height. Overhanging trees and bushes and exposed tree roots provide many minor habitats for wildlife.

7 CONCLUSIONS

7.1 Scheme Appraisal

The existing maintenance scheme of tree and bush clearance every 8 years and desilting every 7 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 £ 5120. Average annual maintenance costs are £ 5097. The benefit : cost ratio is therefore 1.0.

Debris removal is also justifiable in financial and economic terms. The benefit : cost ratios are 2.18 and 1.47 respectively.

7.2 Maintenance Best Practice

The 'best practice' vegetation maintenance methods for the River Arrow were determined using the 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 :

- 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.

Tree and bush maintenance was performed on the River Arrow in 1992. It is scheduled to be repeated on an 8-10 year rotation. The channel is desilted through Eardisland approximately every 7 years and high spots and gravel shoals are removed as required.

As the River Arrow is predominantly a gravel bed channel, movement of the substrate during times of high flow inhibits the development of a lot of aquatic vegetation due to its inability to create a firm root hold. Selective cutting of vegetation every few years may be sufficient to keep the vegetation under control. Selective desilting every seven years may be sufficient to enable the channel to provide the required standard of service. This is in accordance with the channel maintenance regime recommended as best practice in environmental terms.

Bank

Best practice maintenance operations for bank vegetation are identified as :

- Mowing / flailing every 3 - 5 years leaving a toe strip over 1 m wide or selective cutting (< 20 %); and,
- Light grazing.

The majority of the banks under grassland land use are grazed lightly by sheep and cattle. The banks are not flail 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 is carried to examine and quantify :-

- 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

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APPENDIX I

Example of input and output data for the watertable model

River Arrow
Block Number 401
Cross-section 3

	Input Data	Output Data
	River height (m AOD)	Watertable height (m AOD)
Week 1994		
1	85.75	85.61
2	85.75	85.81
3	85.75	85.81
4	85.74	85.81
5	85.75	85.81
6	85.75	85.81
7	85.60	85.81
8	85.75	85.77
9	85.75	85.81
10	85.40	85.81
11	85.14	85.74
12	85.33	85.55
13	85.74	85.59
14	85.75	85.73
15	85.75	85.81
16	85.34	85.69
17	85.14	85.61
18	84.99	85.50
19	84.99	85.32
20	84.95	85.23
21	85.14	85.25
22	85.33	85.41
23	85.14	85.36
24	84.59	85.28
25	84.98	85.10
26	84.70	85.09
27	84.69	85.04
28	84.61	85.01
29	84.59	85.08

Example of drainage status classification, River Arrow

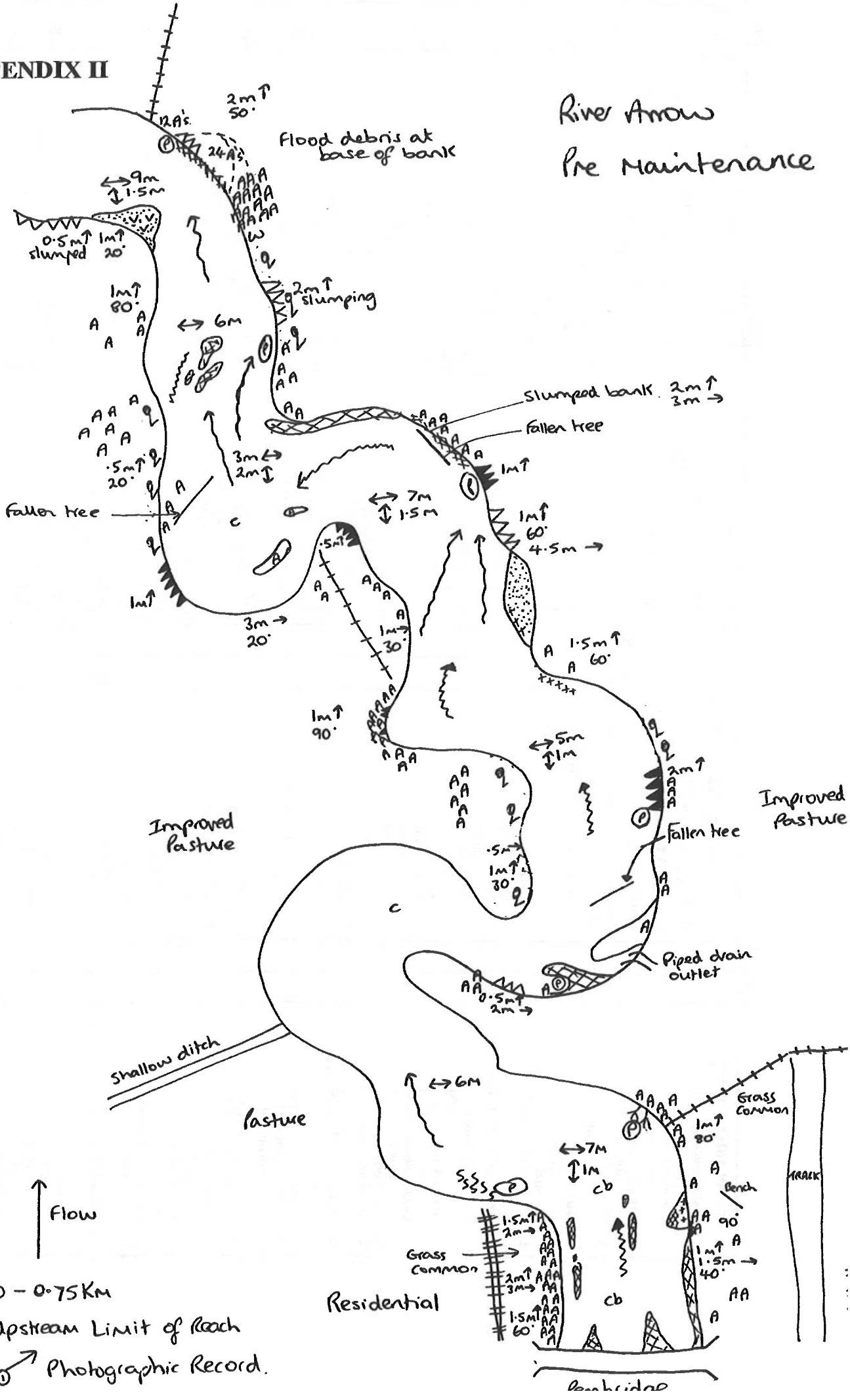
With maintenance

Block 401	Watertable depth (m)	No. of weeks 1994	Spring 1994	No. of weeks	Summer 1994	No. of weeks	Autumn 1994	No. of weeks
>0.5	85.34	33	85.34	3	85.34	13	85.34	11
0.3><0.5m	85.54	10	85.54	5	85.54	0	85.54	0
<0.3m	85.84	29	85.84	5	85.84	0	85.84	2
Drainage status classification, according to time watertable is within the G, B, VB drainage bands				Bad		Good		Good

Without maintenance

	Watertable depth (m)	No. of weeks 1994	Spring 1994	No. of weeks	Summer 1994	No. of weeks	Autumn 1994	No. of weeks
>0.5	85.34	28	85.34	3	85.34	11	85.34	10
0.3><0.5m	85.54	9	85.54	1	85.54	2	85.54	1
<0.3m	85.84	36	85.84	9	85.84	0	85.84	2
Drainage status classification, according to time watertable is within the G, B, VB drainage bands				Very Bad		Good		Bad

APPENDIX II


River Arrow
Pre Maintenance
Flood debris at base of bank
12A's
24A's
2m↑ 50°
9m ↔ 1.5m ↕
0.5m↑ slumped
1m↑ 20°
1m↑ 80°
2m↑ slumping
6m ↔
3m ↔ 2m ↕
.5m↑ 20°
Fallen tree
1m↑
3m→ 20°
7m ↔ 1.5m ↕
Slumped bank 2m↑ 3m→
Fallen tree
1m↑
1m↑ 60°
4.5m →
.5m↑
1m→ 30°
1m↑ 90°
1.5m↑ 60°
5m ↔ 1m ↕
2m↑
Improved Pasture
Improved Pasture
Fallen tree
.5m↑
1m↑ 30°
Piped drain outlet
0.5m↑ 2m→
Shallow ditch
Pasture
6M ↔
7M ↔ 1M ↕
cb
Grass Common
1m↑ 80°
Bench
90°
TRACK
1.5m↑ 2m→
Grass Common
2m↑ 3m→
1.5m↑ 60°
1m↑ 1.5m→ 40°
Residential
cb
Flow
0 - 0.75 Km
Upstream Limit of Reach
① Photographic Record.

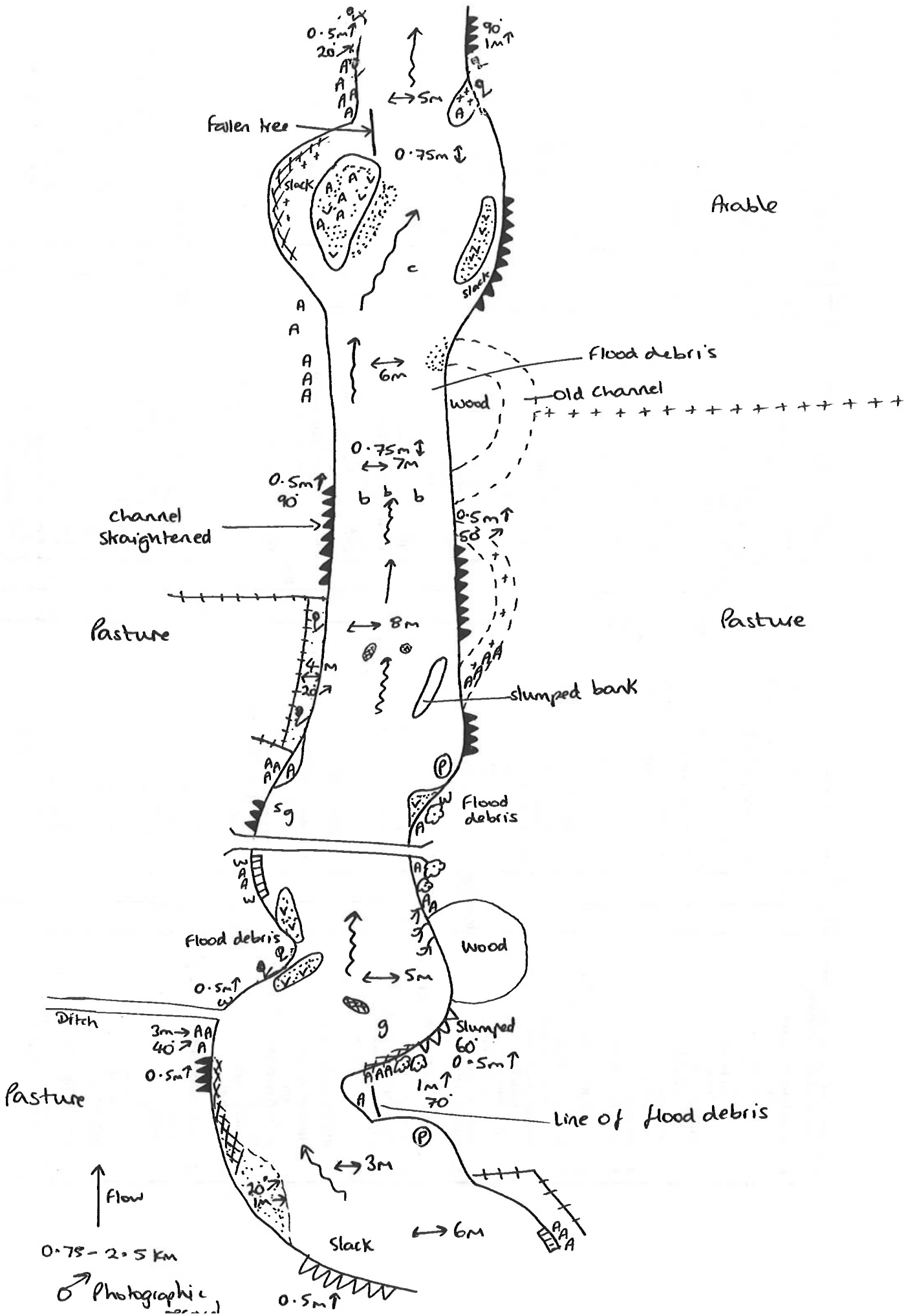
	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	80	90
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW
Km No. 0 – 0·75 km
Date 25/3/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	1	
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream <1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =	5	
fence on bank		
fence set back	5	
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden	10	
stick pile		2
flood debris		10
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff (m↑)	4	4
soft earth cliff >80°	4	4
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	40	20
1-<2m	60	80
>2m		
Width <1m		
1-<2.5m	90	90
2.5-<5m	10	10
>5m		
Slope <30°	40	
30-<60°	50	70
60-<90°	10	30
>90°		
mud		3
sand		
bare shingle		
vegetated shingle		
earth	100	97
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow - recent pollard		
W Willow old, not pollard		1
S Standard willows	6	
A Alder	57	90
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		5
Reed/Sedge %.		
Dense open %.	15	5
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		2
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	
>1.0m	100
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	3
c cobbles	20
p pebbles	
g gravel	70
s sand	
+ silt/mud	
clay	
peat	
Habitats and Flow	
pool	2
slack	5
riffle	2
rapids	
run	91
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	5
mud	2
sand	
FLORA %	
emergent veg <1m wide	15
emergent 1-2m wide	
emergent >2m wide	
total veget area	16
B bryophytes	
E emergents 90	
A submerged 10	(total to 100%)
F floating	
algae % of stretch	


Fallen tree
Slack
Arable
Flood debris
Old channel
Wood
channel straightened
Pasture
Pasture
slumped bank
Flood debris
Flood debris
Wood
Ditch
Slumped
Pasture
Line of flood debris
Flow
0·75 - 2·5 km
Photographic
Slack
0·5m↑
90°
1m↑
↔5m
0·75m↕
↔6m
↔7m
↔8m
0·5m↑
50°
20°
3m→
40°
1m↑
70°
↔3m
↔6m
20°
1m→

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		2
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	100	98
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW

Km No. 0·75 – 2·5 km

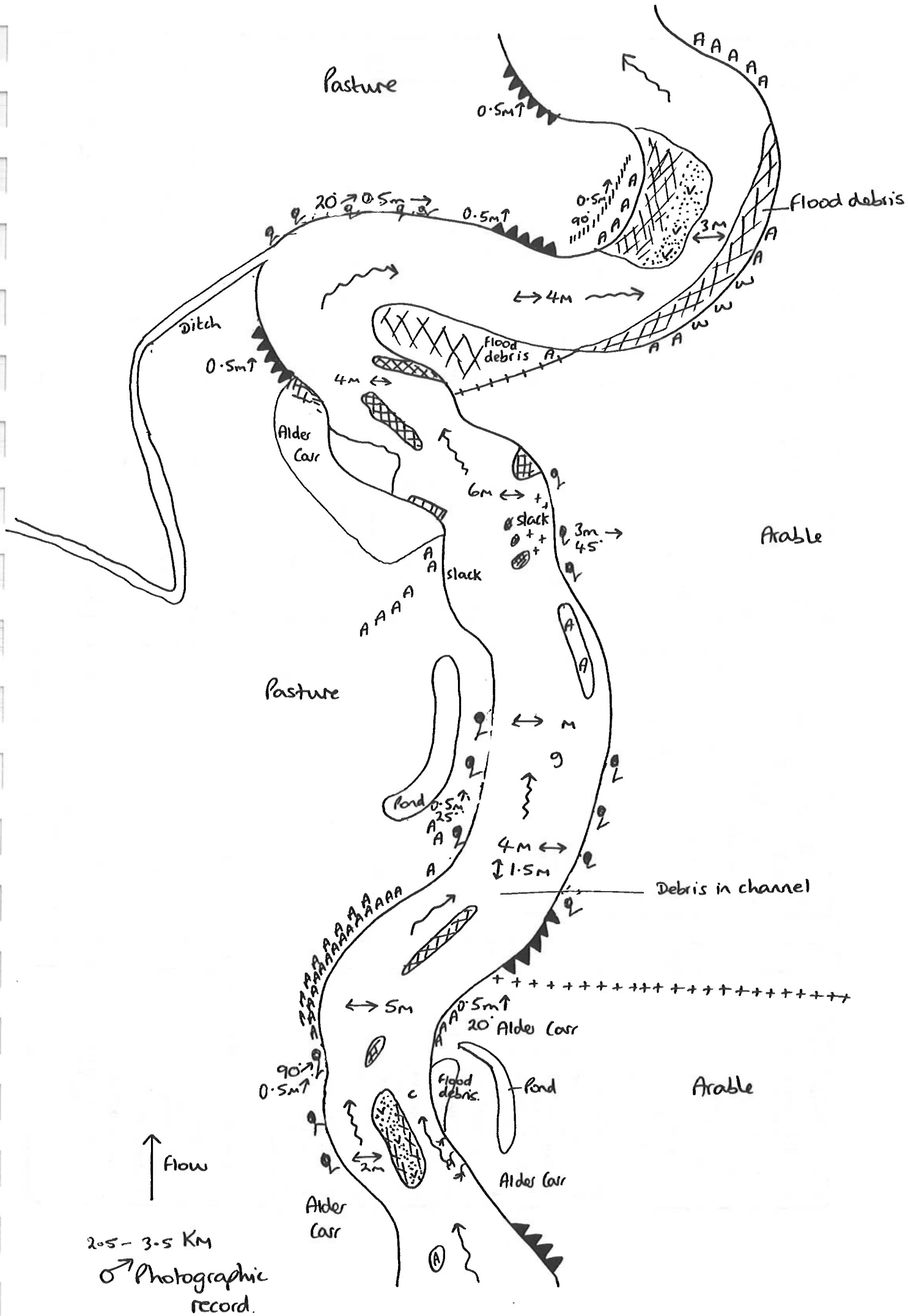
Date 25/3/92

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	1	
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		40
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	2	2
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris	1	1
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff (1m↑)	2	3
soft earth cliff (>80°)	1	1
rock cliff		
artificial	1	1
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	60
1·<2m		40
>2m		
Width <1m	5	
1·<2.5m		
2.5·<5m	95	100
>5m		
Slope <30°		
30·<60°	87	50
60·<90°	3	50
>90°		
mud	2	1
sand		
bare shingle	2	
vegetated shingle	1	1
earth	95	98
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow - recent pollard		
W Willow old, not pollard	3	1
S Standard willows		
A Alder	19	16
Other trees		5
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.	5	2
Dense open %.	10	1
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		3
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing	1	
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	
0.5·<1.0	100
>1.0m	
Width <1	
1·<5	
5·<10	100
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	5
c cobbles	20
p pebbles	
g gravel	70
s sand	5
+ silt/mud	
clay	
peat	
Habitats and Flow	
pool	2
slack	20
riffle	
rapids	2
run	76
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	2
mud	5
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total vegel area	0·5
B bryophytes	
E emergents	
A submerged 100	total to 100%
F floating	
algae % of stretch	


Pasture
0·5m↑
20°
0·5m
0·5m↑
90°
Flood debris
3m
4m
Ditch
0·5m↑
Flood debris
4m
Alder Carr
6m
slack
3m
45°
Arable
slack
Pasture
m
Pond
0·5m↑
25°
4m
1·5m
Debris in channel
5m
0·5m↑
20°
Alder Carr
90°
0·5m↑
Flood debris
Pond
Arable
2m
Alder Carr
Alder Carr
Flow
2·5 – 3·5 Km
Photographic record.

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder	15	10
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved	c	
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	85	
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW

Km No. 2-5 - 3-5 km.

Date 25/3/92

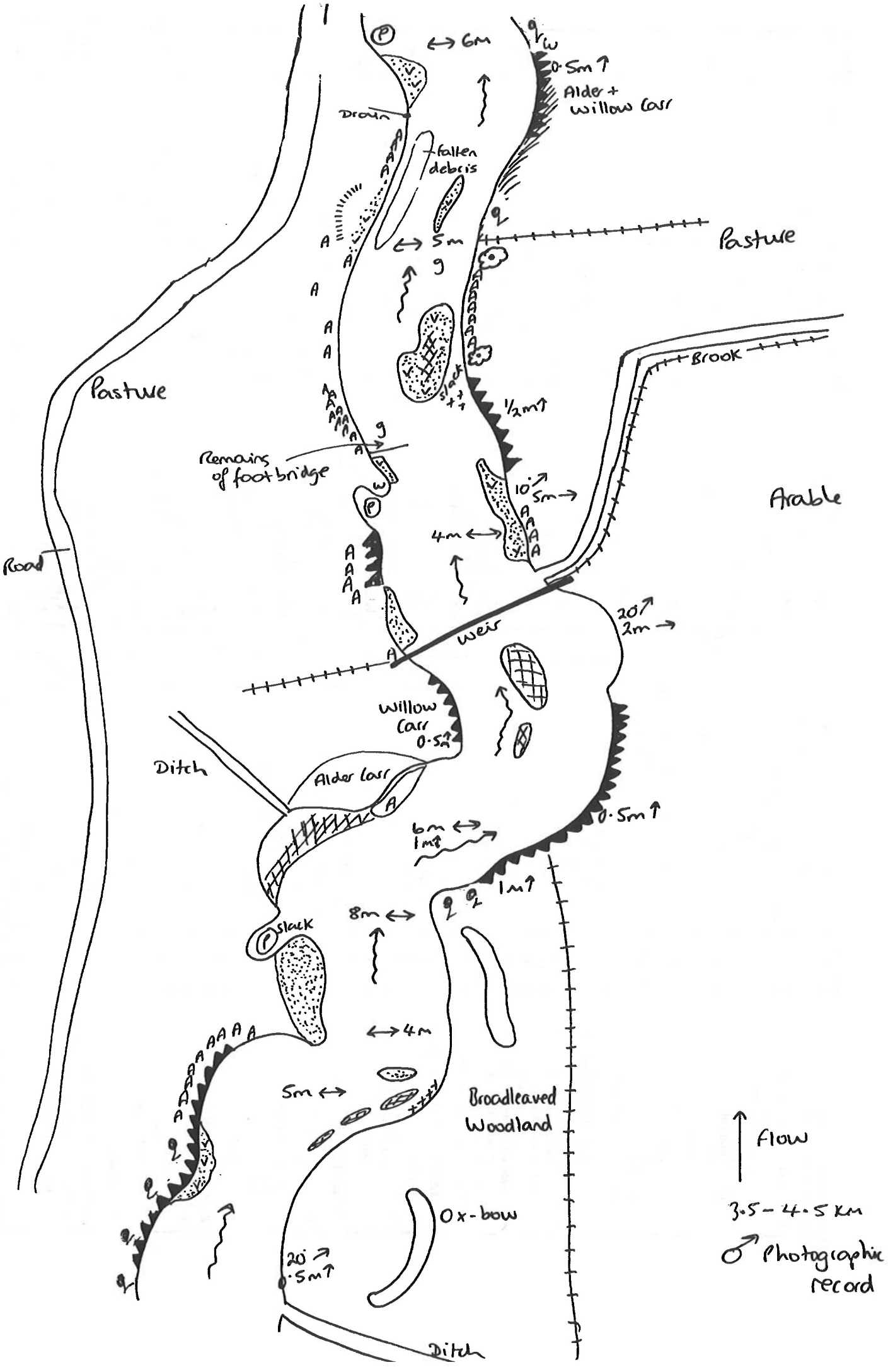
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		
ditch	1	
dyke		
pond, pool, cut-off %	1	1
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		100
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		10
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	2	1
soft earth cliff >80°		
rock cliff		
artificial	1	
FB flood bank adj.		
FB flood bank set back		
levee		
Height <1m	100	100
1-<2m		
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°	10	60
30-<60°	70	40
60-<90°	30	
>90°		
mud		
sand		
bare shingle		
vegetated shingle	2	
earth	98	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		3
S Standard willows		
A Alder	36	13
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	4	10
Dense open %	15	12
Sparse open %		
Reseeded or mown %		
Exposed tree roots		3
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing	2	
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		
0.5-<1.0		
>1.0m		100
Width <1		
1-<5		60
5-<10		40
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		8
p pebbles		
g gravel		90
s sand		
si silt/mud		2
cl clay		
peat		
Habitats and Flow		
pool		
slack		2
riffle		
rapids		
run		98
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		100
emergent 1-2m wide		
emergent >2m wide		
total veget area		2
B bryophytes		
E emergents	90	
A submerged	10	
F floating		
algae % of stretch		

total to 100%


6m
0·5m
Alder + Willow Carr
Drain
fallen debris
5m
Pasture
Brook
Pasture
1/2m
Remains of footbridge
10°
5m
Arable
4m
Road
20°
2m
Weir
Willow Carr
0·5m
Ditch
Alder Carr
0·5m
6m
1m
1m
8m
Slack
4m
5m
Broadleaved Woodland
Ox-bow
20°
0·5m
Ditch
Flow
3·5 - 4·5 km
Photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		35
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder	3	7
willow	3	7
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	100	30
5. Marsh/marshy grassland		
C. TALL HERB & FERN %		
1. Bracken		
2. Upland spp. rich vegetl.		
3. Other - tall ruderal		
non ruderal		
D. HEATHLAND %		
1. Dwarf scrub – dry		
wet		
3. Lichen/bryophyte		
4. Montane		
5. Heath/grassland – dry		
6. wet		
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		

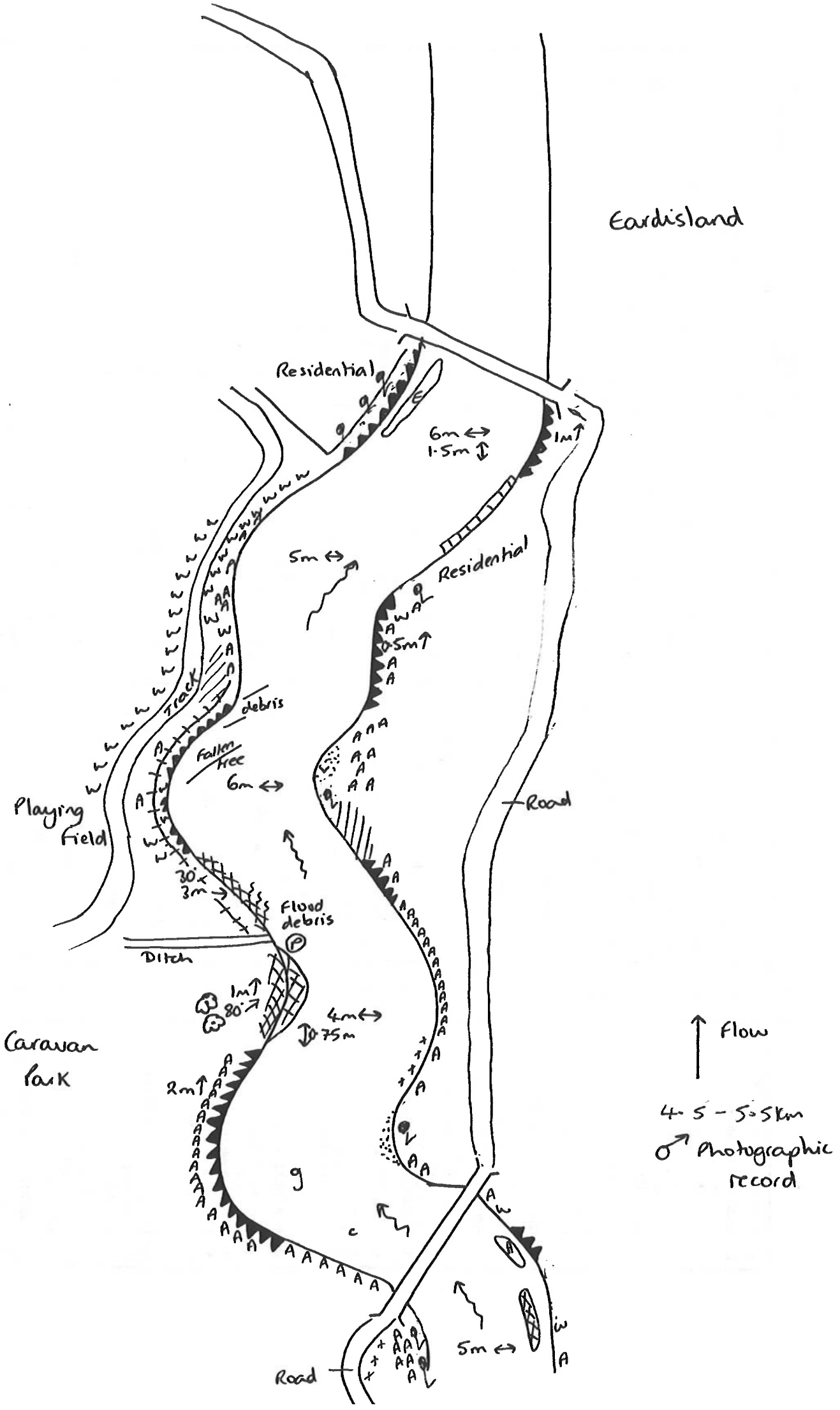
RIVER RIVER ARROW
Km No. 3·5 – 4·5 km
Date 26/3/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + % of adj land in each stretch		
canal =	1	2
ditch		
dyke		
pond, pool, cut-off %		10
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		100
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	1	1
fence set back		2
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris	1	
road	20	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	12	20
soft earth cliff > 80°		
rock cliff		
artificial		
FB flood bank adj.		
FB flood bank set back		
levee		
Height <1m	100	100
1-<2m		
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		100
30-<60°	88	
60-<90°	12	
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		2
P Willow recent pollard		
W Willow old, not pollard	1	1
S Standard willows		
A Alder	33	11
Other trees		
Young trees		
Thick Scrub/shrubs %		8
Sparse Scrub/shrubs %		
Reed/Sedge %	8	2
Dense open %	10	3
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
width etc too rocky, + bare		
shingle and rock		
shingle, rock + veg	1	
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		1
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		
0.5-<1.0		
>1.0m		100
Width <1		50
1-<5		
5-<10		50
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		98
s sand		
+ silt/mud		2
clay		
peat		
Habitats and Flow		
pool		1
slack		69
riffle		
rapids		
run		99
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		5
mud		1
sand		
FLORA %		
emergent veg < 1m wide		100
emergent 1-2m wide		
emergent >2m wide		
total veget. area		5
B bryophytes		
E emergents	100	
A submerged		
F floating		
algae % of stretch		

total to 100%


Eardisland
Residential
6m ↔
1·5m ↕
1m↑
5m ↔
Residential
5m↑
Track
debris
Fallen tree
6m ↔
Playing Field
Road
30°
3m
Flood debris
Ditch
1m↑
80°
4m ↔
75m
Caravan Park
2m↑
5m ↔
Road
Flow
4·5 - 5·5km
Photographic record

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

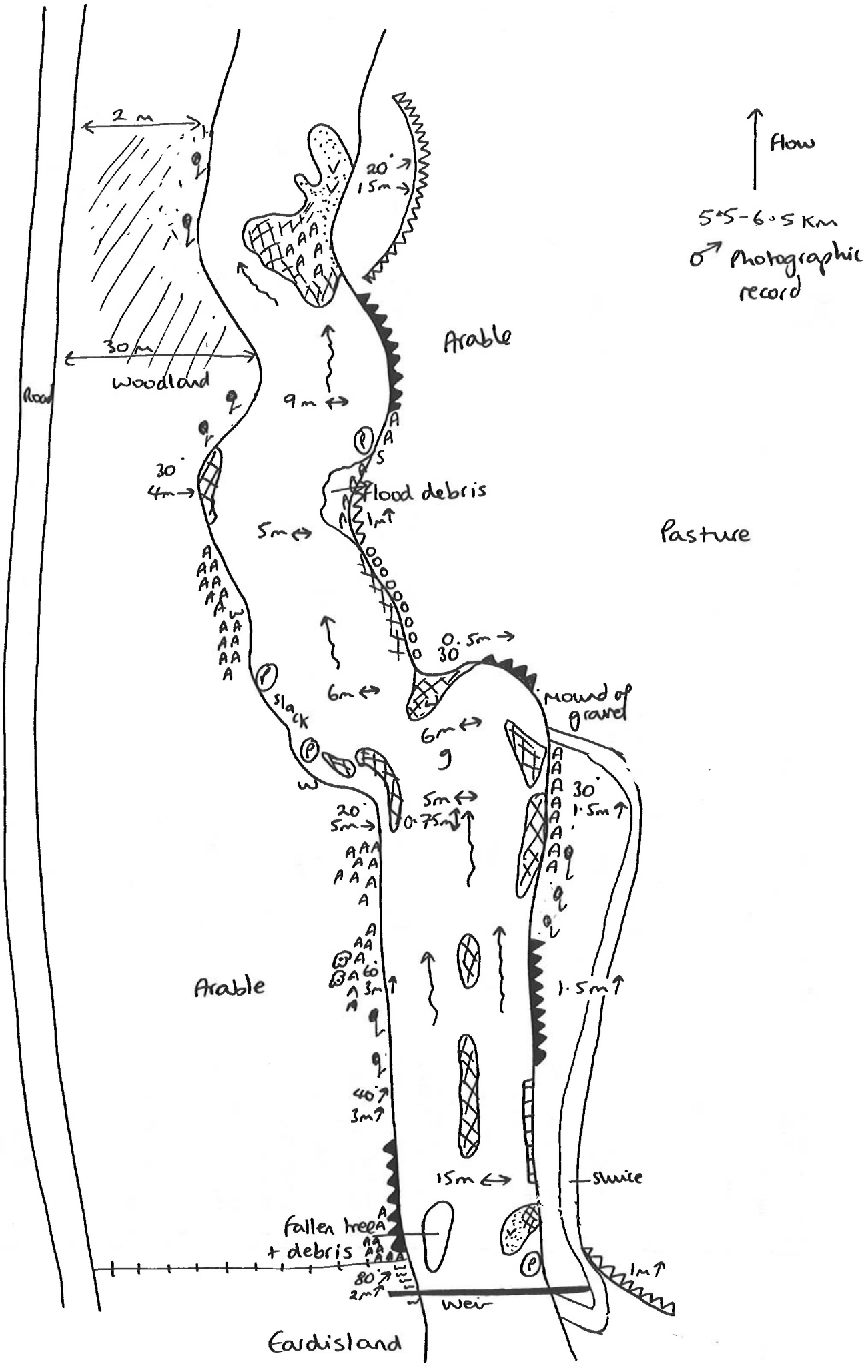
RIVER RIVER ARROW
Km No. 4·5 – 5·5 km
Date 26/3/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	1	
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream <1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland	30	
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	2	
fence set back		
wall		
building		
caravans	40	
fish farm		
silage clamp		
sewage works		
garden / W barn	30	100
stick pile		
flood debris		
road	2	5
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑	20	20
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj.		
FB flood bank set back		
levee		
Height <1m		10
1·<2m	60	90
>2m	40	
Width <1m		
1·<2.5m		
2.5·<5m	100	100
>5m		
Slope <30°		
30·<60°	60	100
60·<90°	40	
>90°		
mud	1	
sss sand		
bare shingle		
vegetated shingle		
earth	99	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore	2	
P Willow recent pollard		
W Willow old, not pollard	12	3
S Standard willows	3	
A Alder	39	33
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %	1	4
Reed/Sedge %	5	
Dense open %	10	5
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	70
0.5·<1.0	30
>1.0m	
Width <1	
1·<5	50
5·<10	50
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	10
p pebbles	
g gravel	90
s sand	
+ silt/mud	
clay	
peat	
Habitats and Flow	
pool	1
slack	94
riffle	
rapids	5
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	1
mud	1
sss sand	
FLORA %	
emergent veg <1m wide	100
emergent 1·2m wide	
emergent >2m wide	
total veget area	2
B bryophytes	
E emergents 100	
A submerged	
F floating	
algae % of stretch	

(total to 100%)


Flow
5·5-6·5 Km
Photographic record
2 m
30 m
woodland
Road
Arable
20°
15m
9m
30°
4m
Flood debris
1m
5m
Pasture
0.5m
30°
6m
Slack
Mound of gravel
6m
5m
0.75m
20°
5m
30°
1.5m
Arable
60°
3m
1.5m
40°
3m
15m
Sluice
Fallen trees
+ debris
80°
2m
1m
Weir
Eardisland

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	20	
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		60
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

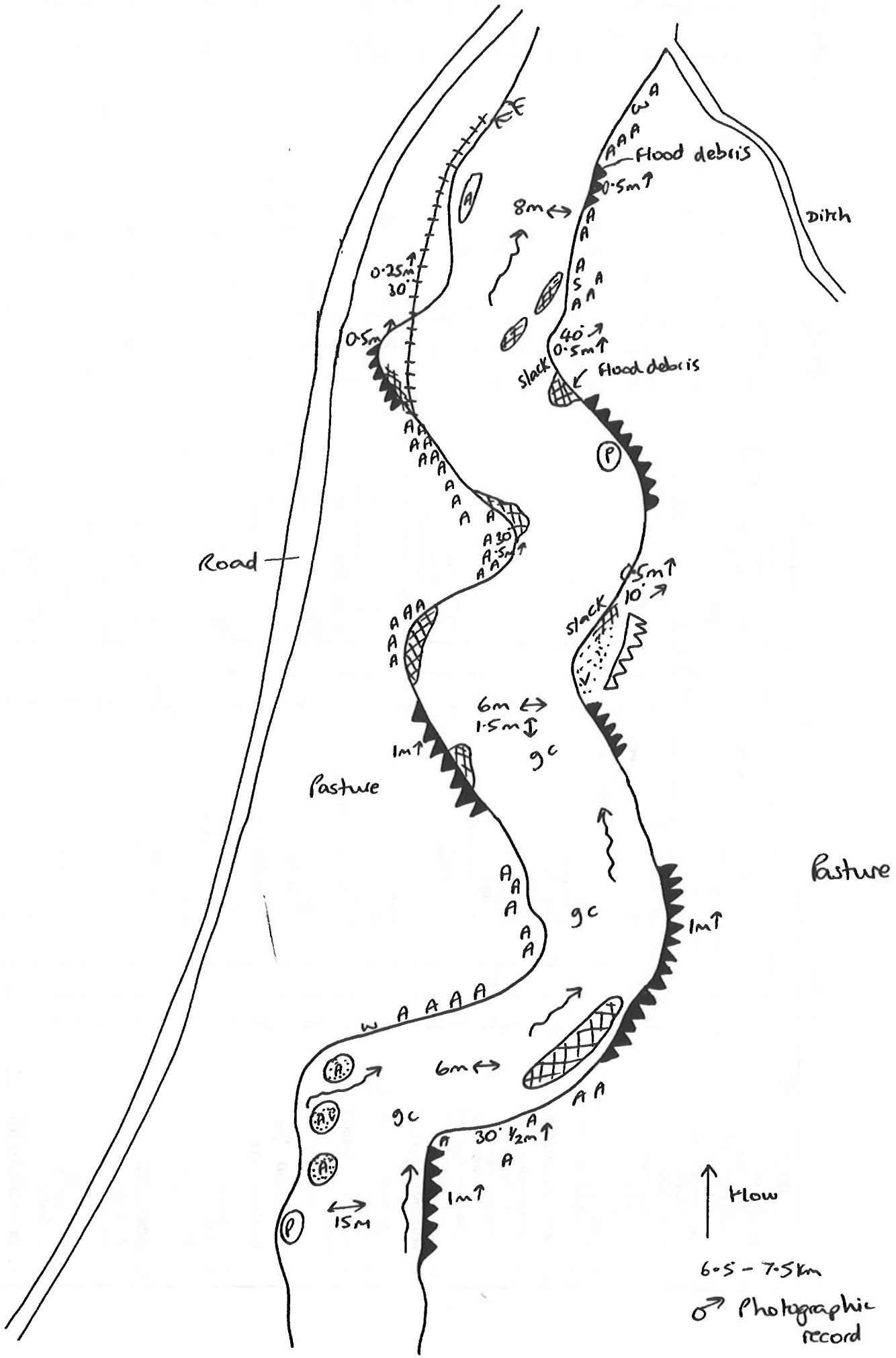
RIVER River Arrow
Km No. 5·5 – 6·5
Date 26/3/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream <1m wide		2
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable	80	40
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back	1	
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	10	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff (1M ↑)	5	10
soft earth cliff (>80°)		
rock cliff		
artificial		4
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m		
>2m	100	100
Width <1m		90
1-<2.5m		
2.5-<5m	100	10
>5m		
Slope <30°	20	100
30-<60°	80	
60-<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard	7	1
S Standard willows		
A Alder	40	20
Other trees	2	
Young trees		9
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	12	8
Dense open %		
Sparse open %	10	5
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		1
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		
.5-<1.0		100
>1.0m		
Width <1		
1-<5		
5-<10		90
10-<20		10
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		100
s sand		
+ silt/mud		
clay		
peat		
Habitats and Flow		
pool		1
slack		94
riffle		
rapids		5
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		5
mud		
sand		
FLORA %		
emergent veg <1m wide		100
emergent 1-2m wide		
emergent >2m wide		
total veget area		5
B bryophytes		
E emergents	100	
A submerged		
F floating		
algae % of stretch		

(total to 100%)


Road
Pasture
Flood debris
Ditch
8m ↔
0·5m ↑
0·25m ↑
30°
0·5m
40° ↗
0·5m ↑
Slack
Flood debris
30°
0·5m ↑
0·5m ↑
10° ↗
Slack
6m ↔
1·5m ↕
1m ↑
gc
Pasture
1m ↑
gc
6m ↔
gc
30° ½m ↑
1m ↑
15m ↔
Flow
6·5 - 7·5km
Photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved	100	100
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

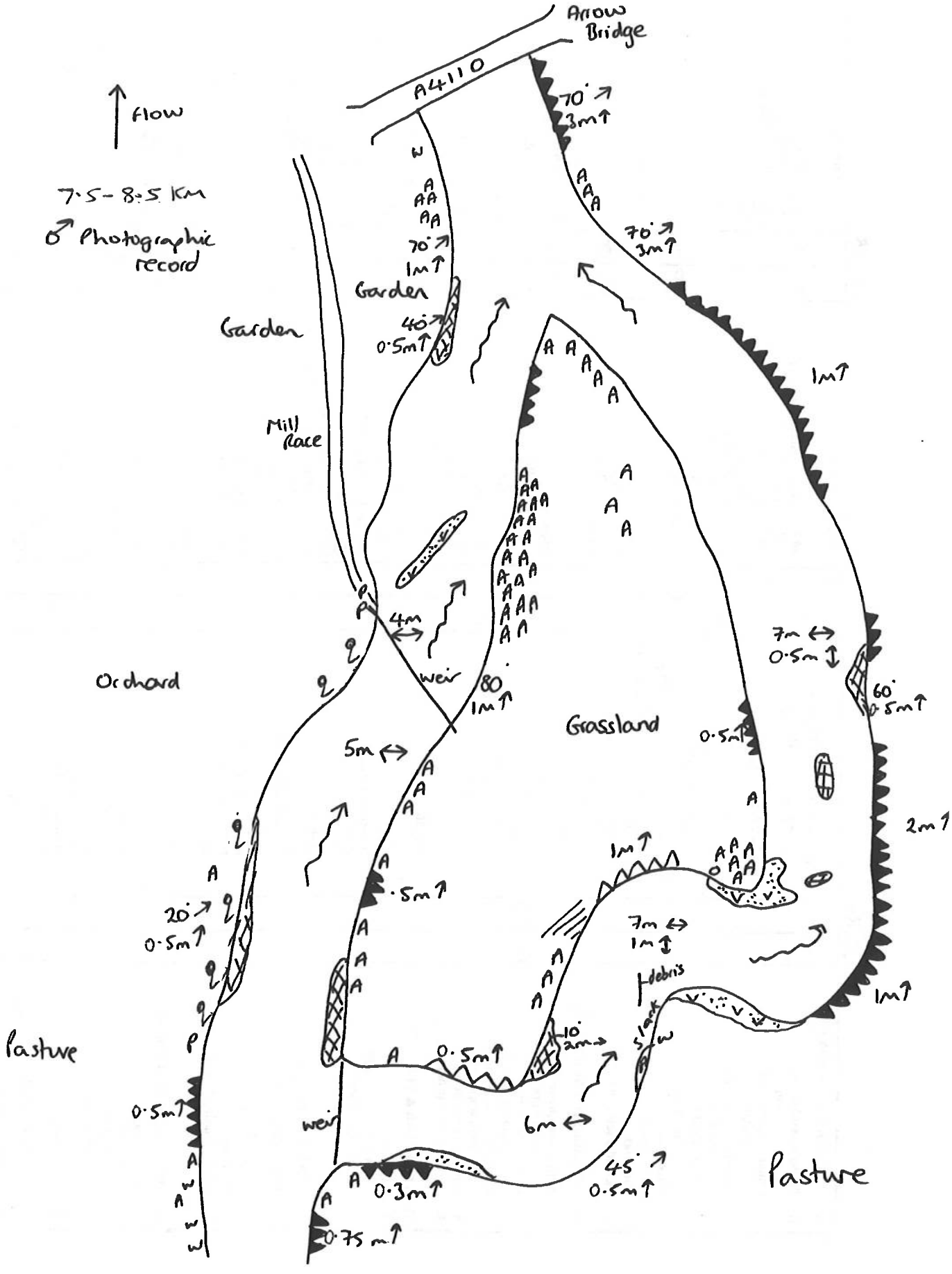
RIVER RIVER ARROW
Km No. 6·5 – 7·5 km
Date 27/3/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		1
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	10	
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	2	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1m↑	8	20
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj.		
FB flood bank set back		
levee		
Height <1m	100	100
1·<2m		
>2m		
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope <30°	100	60
30·<60°		40
60·<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		5
earth		
natural cobbles	100	95
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow - recent pollard		
W Willow old, not pollard	1	1
S Standard willows		1
A Alder	29	14
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots	2	
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg	2	
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		
weirs/500m		
locks/500m	1	
inlet/500m		
Depth <.25m	%	
.25·<.5		
0·5·<1.0		
>1.0m		100
Width <1		
1·<5		
5·<10		90
10·<20		10
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		20
p pebbles		80
g gravel		
s sand		
si silt/mud		
clay		
peat		
Habitats and Flow		
pool		1
slack		89
riffle		
rapids		
run		10
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		100
emergent 1·2m wide		
emergent >2m wide		
total veget area		1
B bryophytes		
E emergents	100	
A submerged		
F floating		
algae % of stretch		

total to 100%


Arrow Bridge
A4110
Flow
7·5 - 8·5 km
Photographic record
70° ↗ 3m↑
70° ↗ 1m↑
Garden
40° ↗ 0·5m↑
Garden
Mill Race
1m↑
4m ↔
weir
80° 1m↑
Orchard
5m ↔
·5m↑
20° ↗ 0·5m↑
Pasture
0·5m↑
weir
0·3m↑
0·75 m↑
Grassland
7m ↔ 0·5m ↕
60° 0·5m↑
0·5m↑
2m↑
1m↑
7m ↔ 1m ↕
debris
slack
10° 2m→
6m ↔
45° ↗ 0·5m↑
Pasture
1m↑

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved	40	100
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

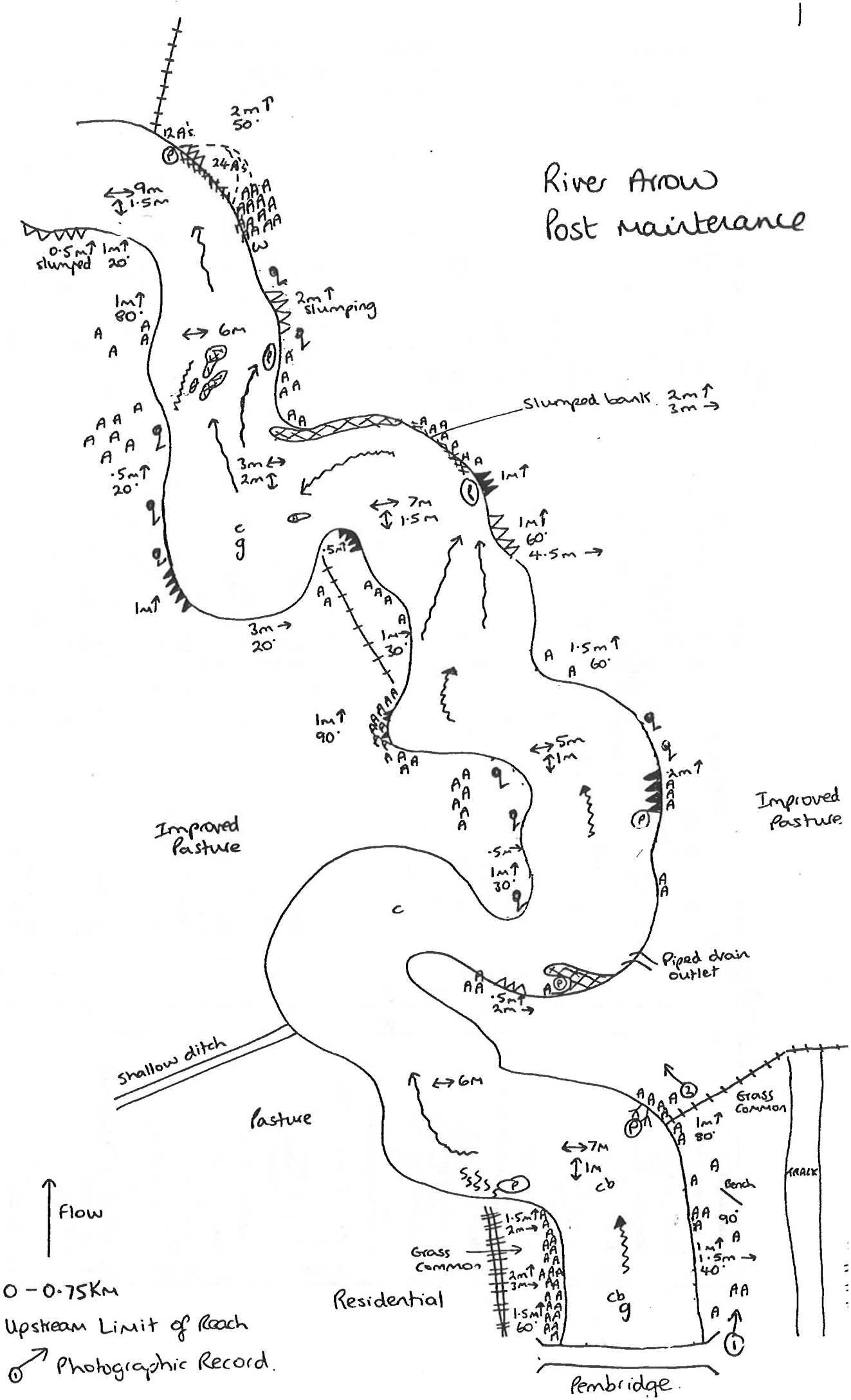
RIVER RIVER ARROW
Km No. 7-5 – 8-5
Date 27/3/92
Surveyor JALD.

	LB	RB
G. OPEN WATER		
1. Standing - canal + % of adj land in each stretch		
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m	2	
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden	30	
stick pile		
flood debris		
road		
railway disused		
used		
other	30	

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑	2	30
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj.		
FB flood bank set back		
levee		
Height <1m	100	90
1-<2m		
>2m		10
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°	60	
30-<60°	40	
60-<90°		10
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard	3	
W Willow old, not pollard	4	1
S Standard willows		
A Alder	8	6
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	8	2
Dense open %	12	
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed	60	

	RIVER
RIVER HABITATS	
bridges/500m	1
weirs/500m	2
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	100
>1.0m	
Width <1	
1-<5	20
5-<10	80
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	100
g gravel	
s sand	
si/mud	
clay	
peat	
Habitats and Flow	
pool	
slack	80
riffle	
rapids	
run	20
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	10
mud	
sand	
FLORA %	
emergent veg < 1m wide	100
emergent 1-2m wide	
emergent >2m wide	
total veget. area	0.5
B bryophytes	
E emergents 100	(total)
A submerged	to 100%
F floating	
algae % of stretch	

River Arrow
Post maintenance



	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	80	90
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

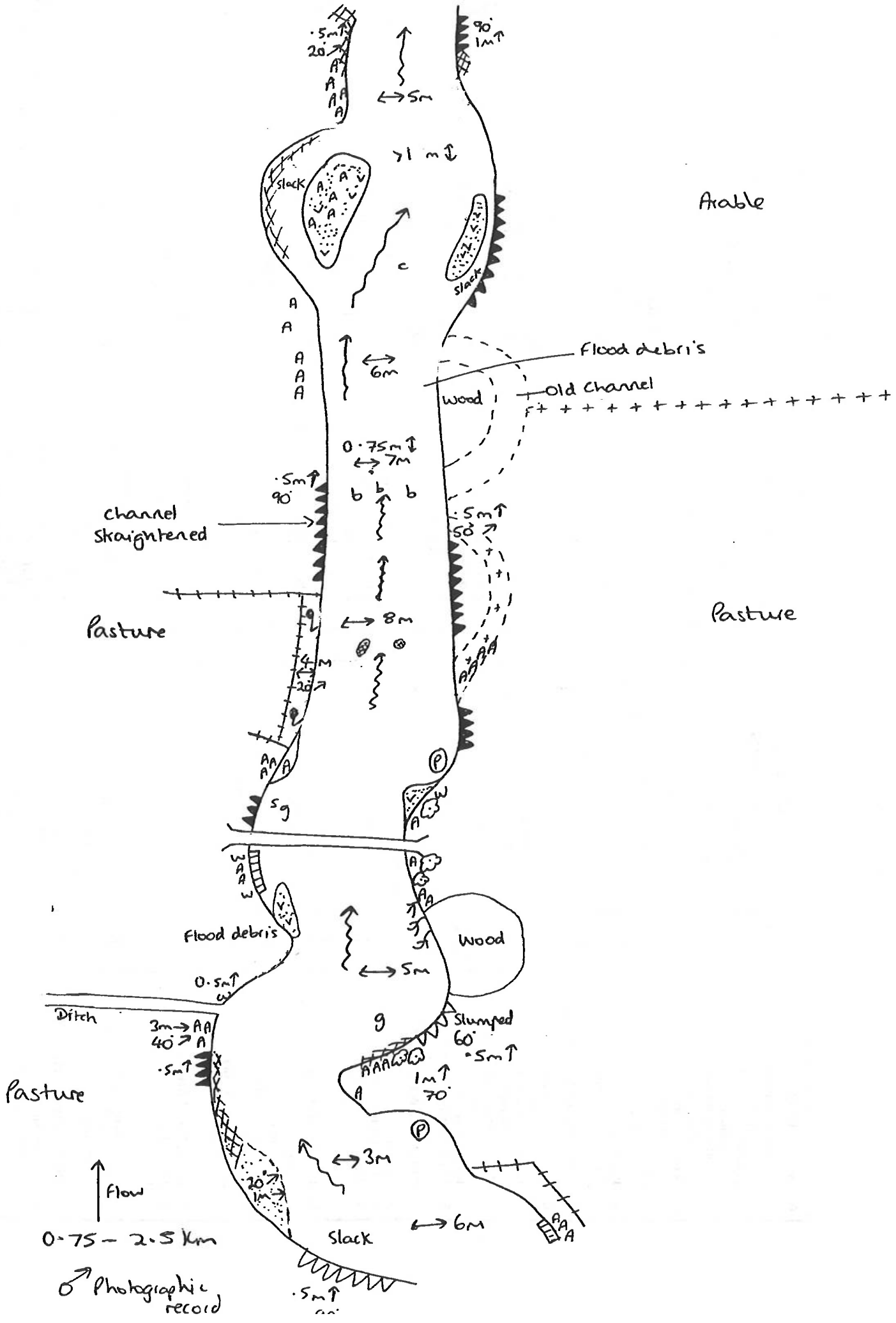
RIVER RIVER ARROW
Km No. 0-0-75
Date 6/4/93
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj. land in each stretch	
canal =	1	
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =	5	
fence on bank		
fence set back	5	
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden	10	
stick pile		
flood debris		
road		10
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑	4	4
soft earth cliff >80°	4	4
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	40	20
1-<2m	60	80
>2m		
Width <1m		
1-<2.5m	90	90
2.5-<5m	10	10
>5m		
Slope <30°	40	
30-<60°	50	70
60-<90°	10	30
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows	6	1
A Alder	57	90
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	15	5
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		2
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		1
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		
0.5-<1.0		10
>1.0m		90
Width <1		
1-<5		100
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		3
b boulders		
c cobbles		7
p pebbles		60
g gravel		30
s sand		
si silt/mud		
cl clay		
peat		
Habitats and Flow		
pool		2
slack		6
riffle		2
rapids		
run		90
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		4
emergent 1-2m wide		
emergent >2m wide		
total veget. area		4
B bryophytes		
E emergents	100	
A submerged		
F floating		
algae % of stretch		

total 10 100%


Arable
Flood debri's
Old channel
wood
channel straightened
Pasture
Pasture
Flood debris
Wood
Ditch
Pasture
Slumped
Slack
Flow
0·75 – 2·5 km
Photographic record

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		2
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	100	50
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW

Km No. 0·75 – 2·5

Date 6/4/93

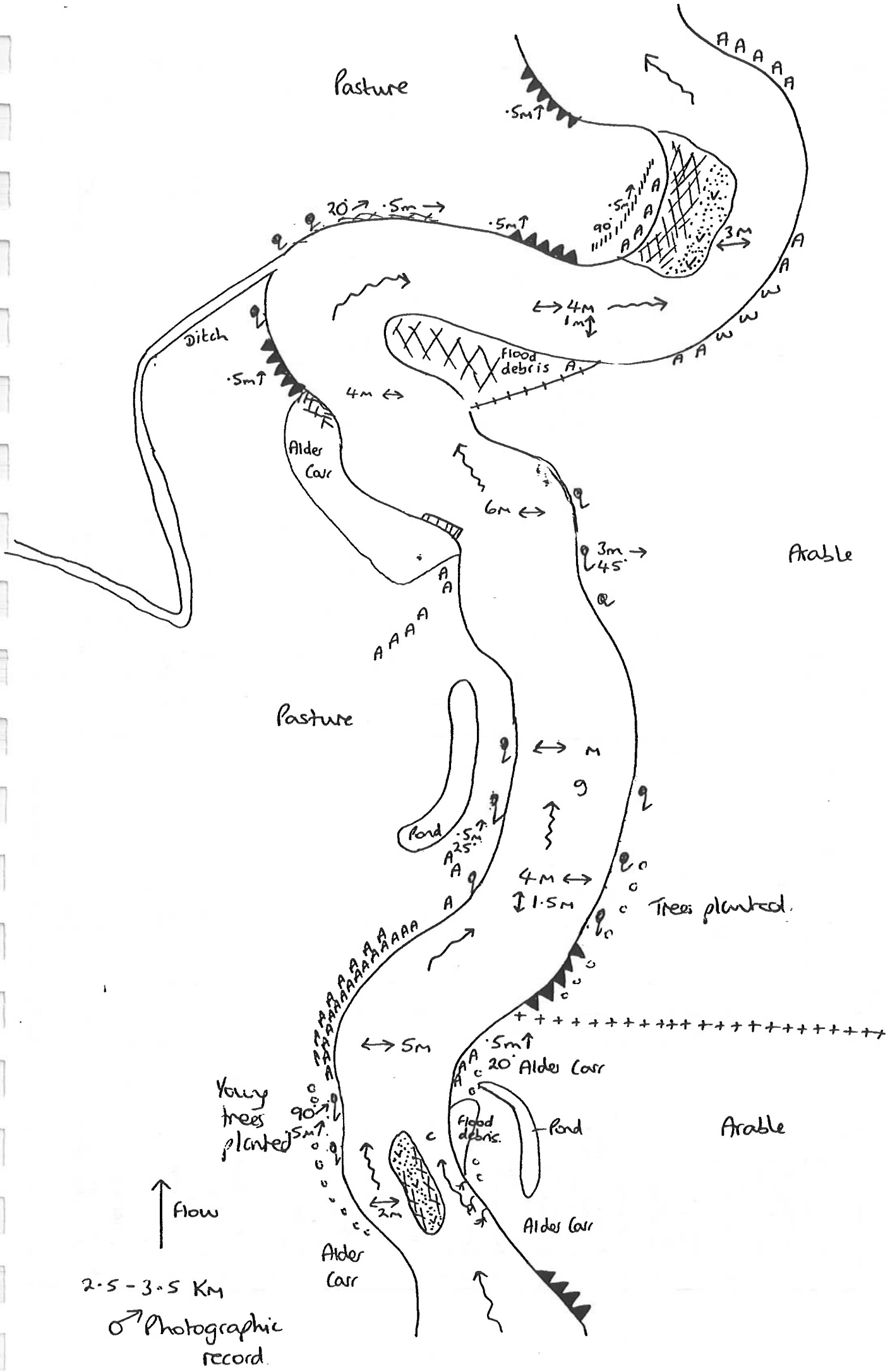
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal ↑ (% of adj bank in each stretch)		
canal =	1	
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		40
amenity grassland		
ephemeral/short herb		
hedge ↑		
hedge =		
fence on bank	2	2
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff (1m ↑)	2	3
soft earth cliff >80°	1	1
rock cliff	1	1
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	60
1-<2m		40
>2m		
Width <1m	5	
1-<2.5m		
2.5-<5m	95	100
>5m		
Slope <30°		
30-<60°	88	50
60-<90°	8	50
>90°		
mud		
sand		
bare shingle		
vegetated shingle		1
earth	99	98
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow – recent pollard		
W Willow old, not pollard	3	1
S Standard willows		
A Alder	19	15
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	10	2
Dense open %	5	
Sparse open %		
Reseeded or mown %		
Exposed tree roots		3
ISLANDS		
Rocky, vegetated		
rocky, ↑ bare		
shingle and rock		
shingle, rock ↑ veg		
earth – maturing		
earth – with trees	1	
developed		

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	90
>1.0m	10
Width <1	
1-<5	
5-<10	100
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	5
c cobbles	20
p pebbles	
g gravel	78
s sand	5
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	2
slack	20
riffle	
rapids	
run	78
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	2
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

(total 10 100%)


Pasture
.5m↑
20° .5m
.5m↑
90°
3M
4M
1M
Ditch
.5m↑
Flood debris
4m
Alder Carr
6M
3m
45°
Arable
Pasture
M
Pond
.5m
25°
4M
1.5M
Trees planted
5M
.5m↑
20°
Alder Carr
Young trees planted
90°
.5m↑
Flood debris
Pond
Arable
2m
Alder Carr
Alder Carr
Flow
2.5 - 3.5 Km
Photographic record

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder	15	10
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded	85	
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW

Km No. 2-5-3·5

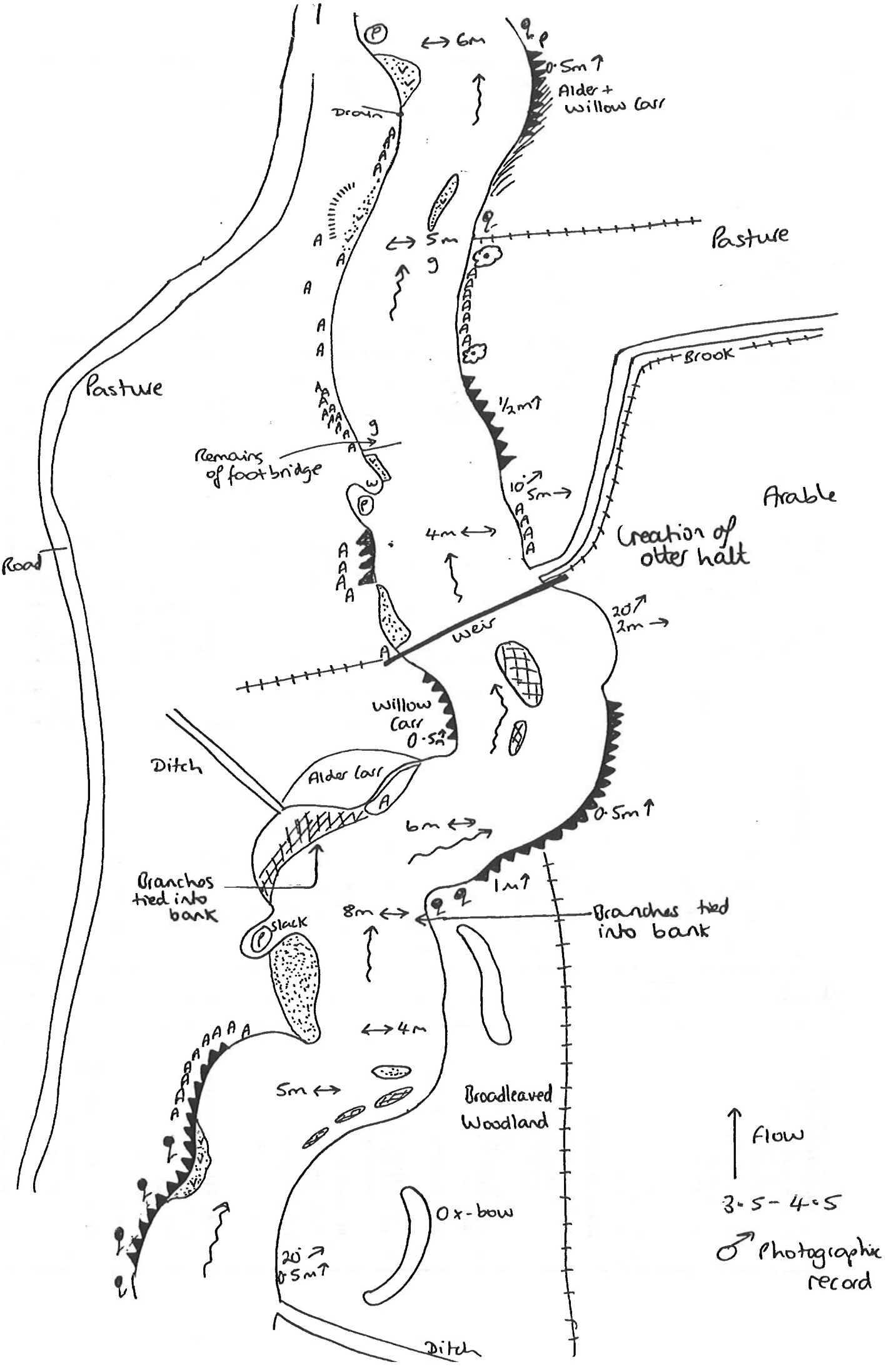
Date 6/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal ↕ % of adj land in each stretch		
canal =		
ditch	1	
dyke		
pond, pool, cut off %		
lake %	1	1
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		100
amenity grassland		
ephemeral/short herb		
hedge ↕		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		5
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1m↑	2	1
soft earth cliff >80°		
rock cliff		
artificial	1	
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	100
1-<2m		
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°	10	60
30-<60°	70	40
60-<90°	30	
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	2	
natural cobbles	98	100
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recept pollard		
W Willow old, not pollard		3
S Standard willows		
A Alder	36	13
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	4	10
Dense open %	15	12
Sparse open %		
Reseeded or mown %		
Exposed tree roots		3
ISLANDS		
Rocky, vegetated		
rocky, 1 bare		
shingle and rock		
shingle, rock ↕ veg		
earth – maturing	2	
earth – with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	
>1.0m	100
Width <1	
1-<5	60
5-<10	40
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	10
g gravel	90
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	
slack	
riffle	
rapids	
run	100
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	5
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	


↔ 6m
0·5m ↑
Alder + willow carr
Drain
↔ 5m
Pasture
Pasture
Brook
½m ↑
Remains of footbridge
10° ↗ 5m →
Arable
4m ↔
Creation of otter halt
Road
20° ↗ 2m →
Weir
Willow carr 0·5m ↑
Ditch
Alder carr
0·5m ↑
6m ↔
Branches tied into bank
1m ↑
8m ↔
Branches tied into bank
Slack
↔ 4m
5m ↔
Broadleaved Woodland
Ox-bow
20° ↗ 0·5m ↑
Ditch
Flow
3·5 - 4·5
Photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		35
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder	3	3
willow	7	7
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	100	30
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
E. MIRE, FLUSH AND SPRING %		
1. Mires – bog		
Fen – reed		
sedge		
sweet-grass		
mixed		
2. Dog flushes		
F. SWAMP/INUNDATION %		
1. Swamp – single sp. dom.		
Tall mixed assemblage		

RIVER RIVER ARROW

Km No. 3·5 – 4·5

Date 6/4/93

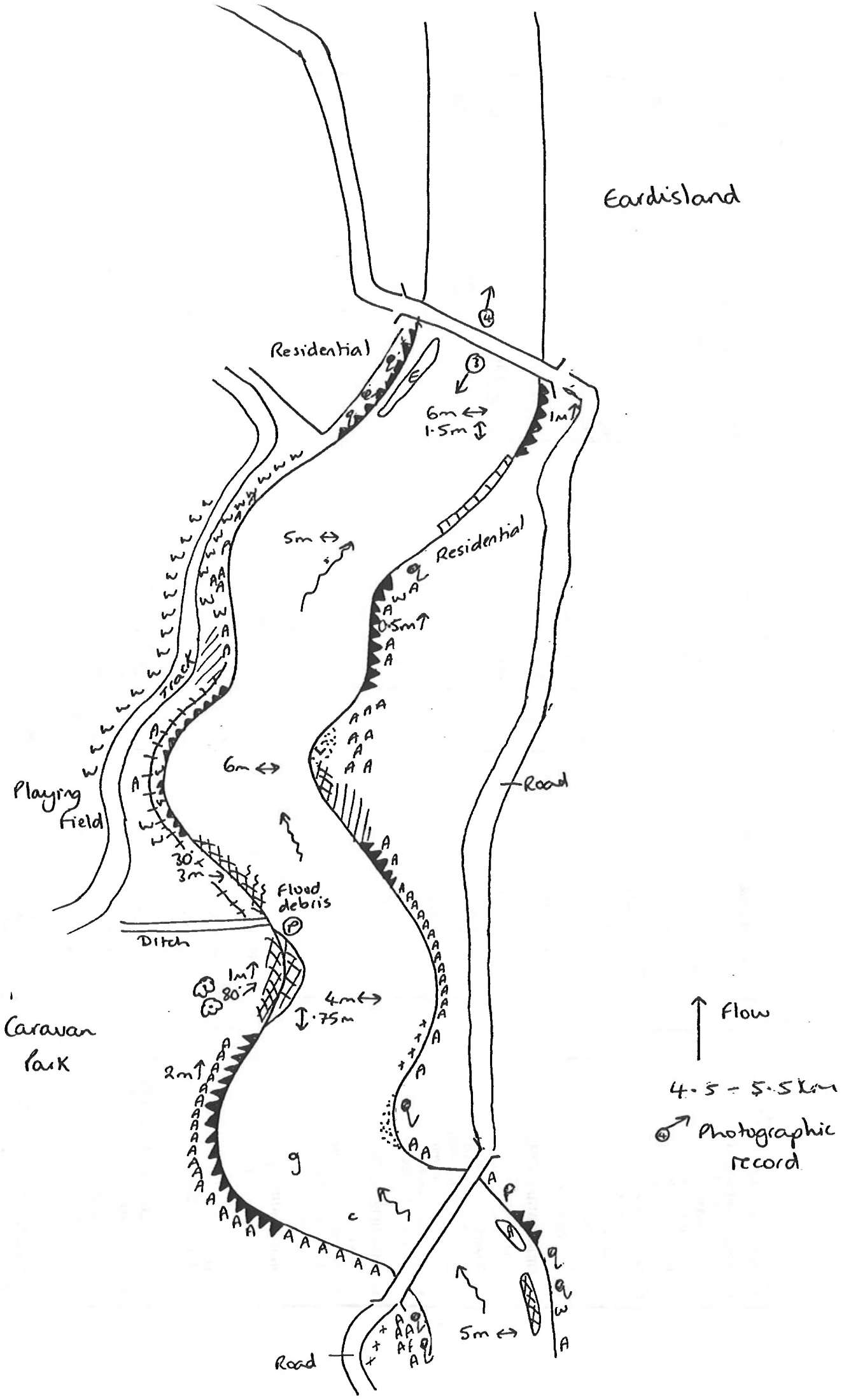
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal	% of adj.	
canal =	land in	
ditch	each stretch	
dyke	1	2
pond, pool, cut off %		10
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		100
amenity grassland		
ephemeral/short herb		
hedge |		
hedge =		
fence on bank	1	1
fence set back		2
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		20
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1m↑	12	20
soft earth cliff > 80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		100
30-<60°	88	
60-<90°	12	
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		2
P Willow recent pollard		1
W Willow old, not pollard	1	
S Standard willows		
A Alder	33	11
Other trees		
Young trees		
Thick Scrub/shrubs %		8
Sparse Scrub/shrubs %		
Reed/Sedge %	8	2
Dense open %	10	3
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing	1	
earth - with trees developed		

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	
>1.0m	
Width <1	
1-<5	50
5-<10	50
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	10
g gravel	90
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	1
slack	1
rifle	
rapids	
run	98
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	5
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

total = 100%


Eardisland
Residential
6m ↔
1.5m ↕
1m
5m ↔
Residential
0.5m
Track
6m ↔
Road
Playing Field
30'
3m
Flood debris
Ditch
1m
80'
4m ↔
.75m
Caravan Park
2m
5m ↔
Road
Flow
4.5 - 5.5km
Photographic record

LG | RB

A. WOODLAND & SCRUB %

1. Broad-leaved semi-nat. plantation
   Coniferous 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
   semi-improved
   Neutral unimproved
   semi-improved
   Calcareous unimproved
   semi-improved
4. Improved/reseeded
5. Marsh/marshy grassland

C. TALL HERB & 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. Heath/grassland – dry
6. wet

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

RIVER RIVER ARROW

Km No. 4·5 – 5·5

Date 5/4/93

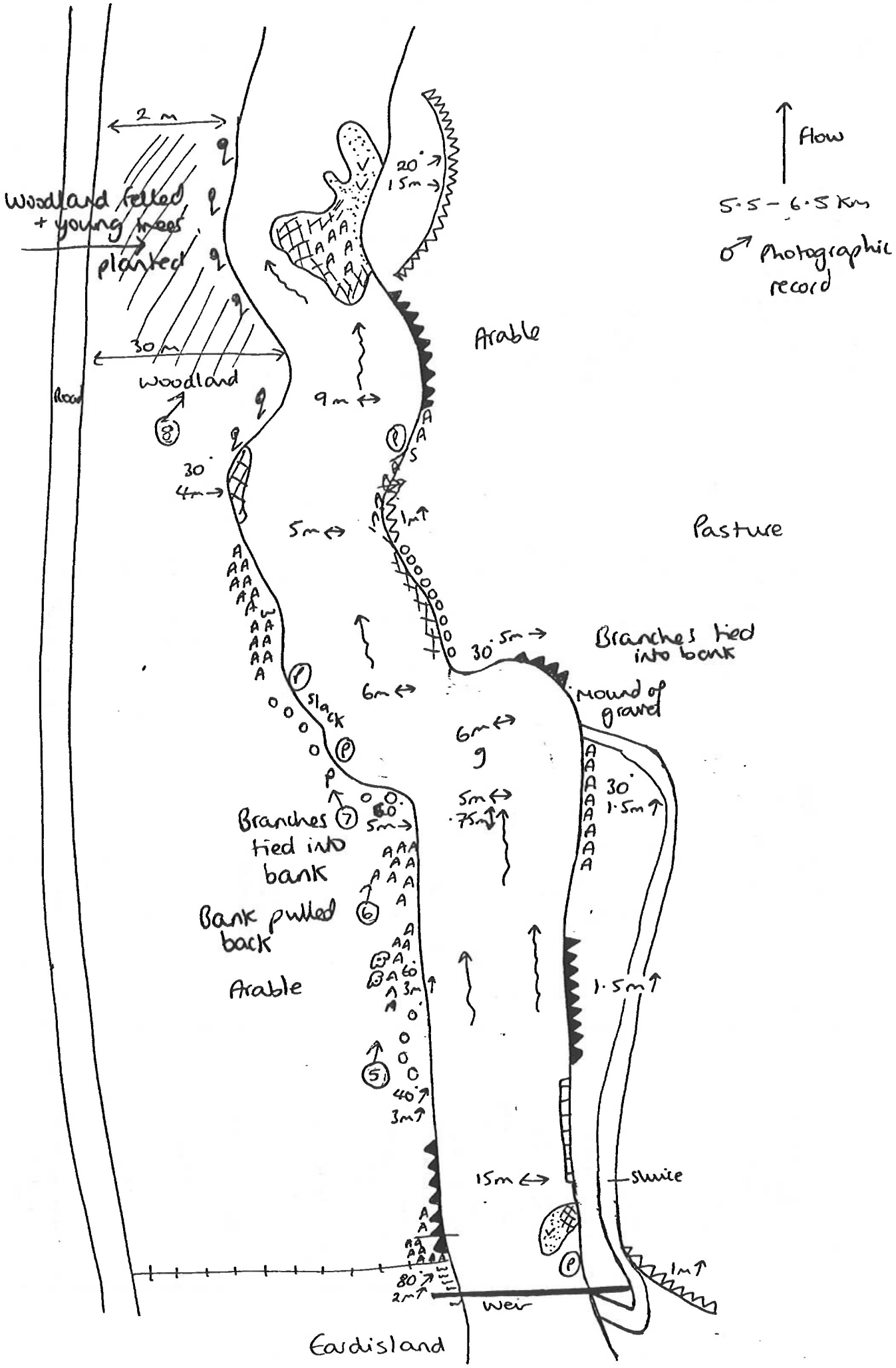
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal ↕	% of adj land in each stretch	
canal =		
ditch	1	
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland	30	
ephemeral/short herb		
hedge ↕		
hedge =		
fence on bank	2	
fence set back		
wall		
building		
caravans	40	
fish farm		
silage clamp		
sewage works		
garden	30	100
stick pile		
flood debris		
road		
railway disused	2	5
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m ↑	20	20
soft earth cliff >80°		
rock cliff		
artificial		12
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		10
1·<2m	60	90
>2m	40	
Width <1m		
1·<2.5m		
2.5·<5m	100	100
>5m		
Slope <30°		
30·<60°	60	100
60·<90°	40	
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	88
natural cobbles		
natural boulders		

BANK VEGETATION	LB	RB
Conifer		
Oak, Ash, Sycamore		
P Willow recept pollard		1
W Willow old, not pollard	15	2
S Standard willows		
A Alder	39	32
Other trees		
Young trees		
Thick Scrub/shrubs %	1	4
Sparse Scrub/shrubs %		
Reed/Sedge %	5	
Dense open %	10	5
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, ↕ bare		
shingle and rock		
shingle, rock ↕ veg		
earth – maturing		
earth – with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	
Depth <25m %	
.25·<.5	
.5·<1.0	70
>1.0m	30
Width <1	
1·<5	50
5·<10	50
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	10
p pebbles	
g gravel	90
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	1
slack	75
riffle	
rapids	
run	24
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	1
sand	1
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total veget. area	0·5
B bryophytes	
E emergents	
A submerged 100	10 (or) 10·100
F floating	
algae % of stretch	


Flow
5·5 – 6·5 Km
♂ Photographic record
2 m
Woodland felled + young trees planted
30 m
Woodland
Road
9m ↔
20°
15m →
Arable
30°
4m →
5m ↔
1m ↑
Pasture
Slack
6m ↔
30° 5m →
Branches tied into bank
Mound of gravel
6m ↔
5m ↔
75m ↑
30°
1·5m ↑
Branches tied into bank
5m →
Bank pulled back
Arable
60°
3m ↑
1·5m ↑
40°
3m ↑
15m ↔
Sluice
80°
2m ↑
Weir
1m ↑
Eardisland

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	20	
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		60
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW

Km No. 5·5 – 6·5

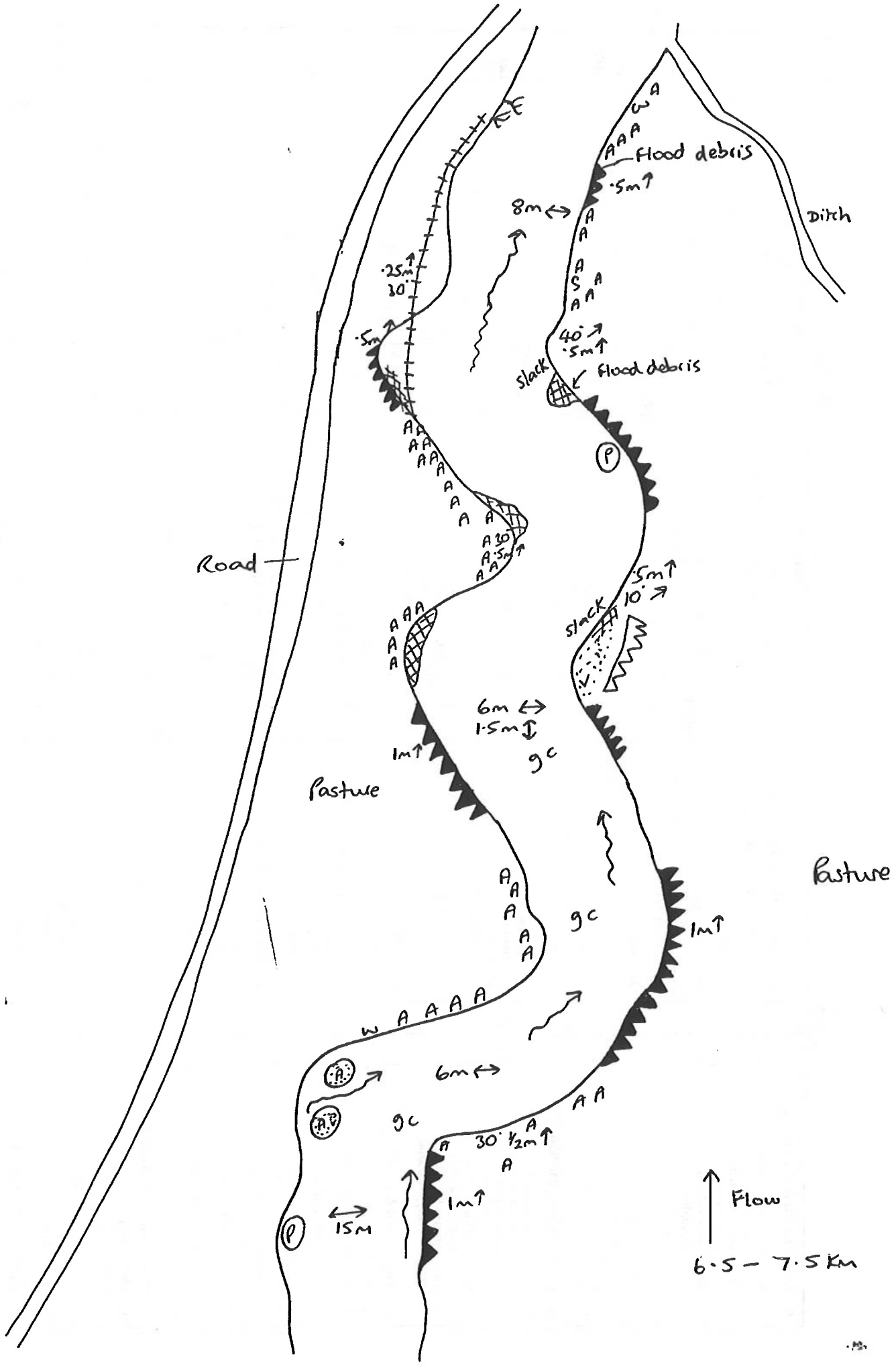
Date 15/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal ↑ % of adj land in each stretch		
canal =		
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		2
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable	80	40
amenity grassland		
ephemeral/short herb		
hedge ↑		
hedge =		
fence on bank		
fence set back	1	
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	10	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	5	10
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		4
Height <1m		
↑ 1-<2m		100
>2m	100	
Width <1m		90
→ 1-<2.5m		
2.5-<5m	100	
>5m		10
Slope <30°		
↗ 30-<60°	20	100
60-<90°	80	
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth		
natural cobbles	100	100
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard	7	1
S Standard willows		
Alder	40	20
Other trees		
Young trees	18	9
Thick Scrub/shrubs %		9
Sparse Scrub/shrubs %		
Reed/Sedge %	12	8
Dense open %		
Sparse open %	10	5
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
with tree rocky, ↑ bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
.5-<1.0	100
>1.0m	
Width <1	
1-<5	
↔ 5-<10	90
10-<20	10
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	100
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
P pool	1
slack	94
ripple	
rapids	
run	5
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	5
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	


Flood debris
·5m↑
8m↔
Ditch
·25m↑
30°
·5m
40°
·5m↑
Slack
Flood debris
Road
·5m↑
10°
Slack
6m↔
1·5m↕
gc
1m↑
Pasture
Pasture
gc
1m↑
6m↔
gc
30°
½m↑
1m↑
15m
Flow
6·5 – 7·5 Km

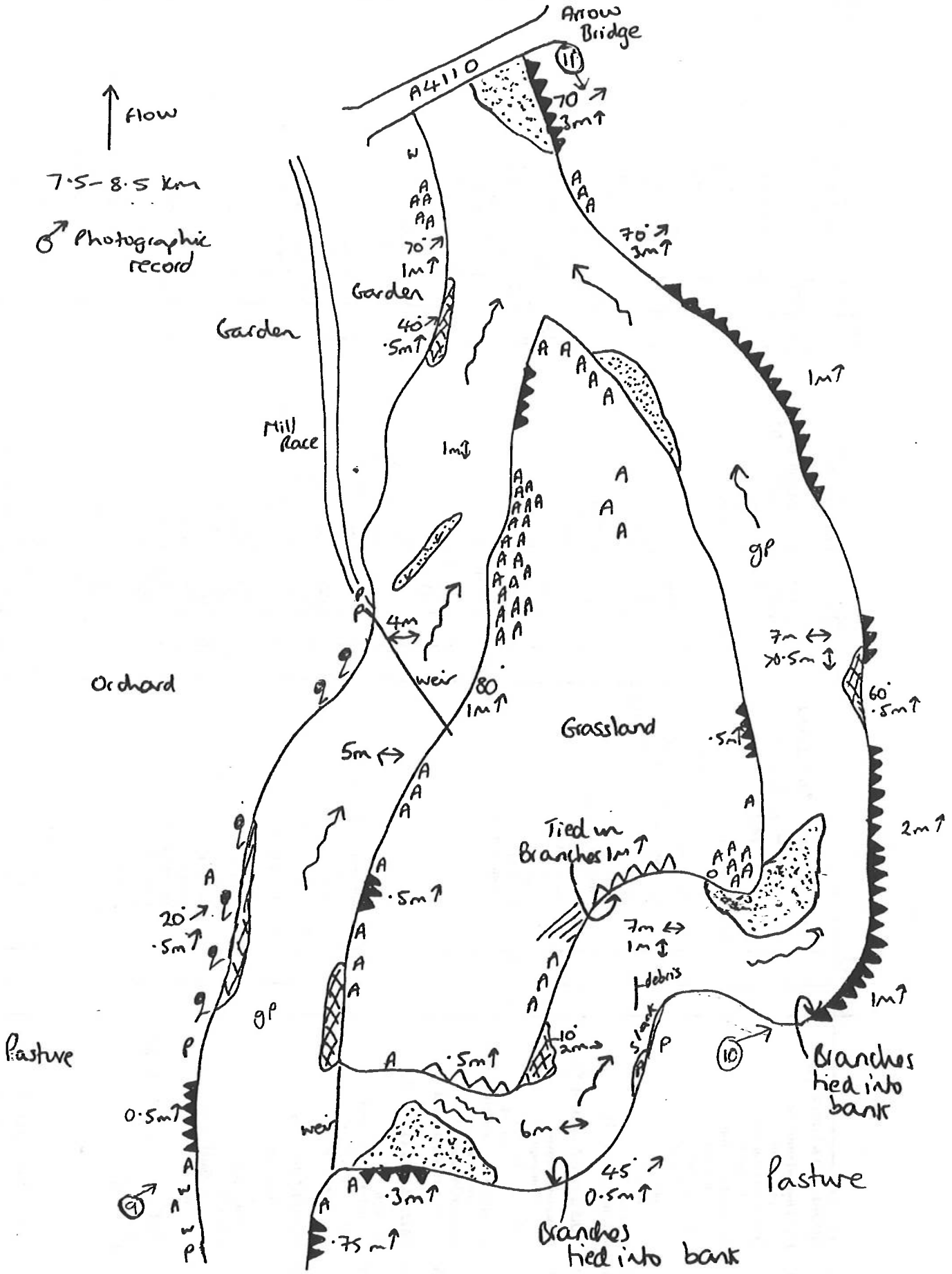
	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic uninproved		
semi-improved		
Neutral uninproved	100	100
semi-inptoved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW
Km No. 6·5 – 7·5
Date 14/4/93
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal ↑ % of adj land in each stretch		
canal =		1
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge ↑		
hedge =		
fence on bank		10
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		2
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1m↑	8	20
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	100
1·<2m		
>2m		
Width <1m	100	100
1·<2.5m		
2.5·<5m		
>5m		
Slope <30°	100	60
30·<60°		40
60·<90°		
>90°		
mud		5
sand	100	95
bare shingle		
vegetated shingle		
earth		
(c) natural cobbles		
(b) natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard	1	1
W Willow old, not pollard	1	1
S Standard willows	29	14
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots	2	
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg	1	
earth – maturing		
earth – with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	
weirs/500m	
locks/500m	
inlet/500m	1
Depth <.25m %	
.25·<.5	
0·5·<1.0	
>1.0m	100
Width <1	
1·<5	
5·<10	90
10·<20	10
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	20
p pebbles	80
g gravel	
s sand	
si silt/mud	
clay	
peat	
Habitats and Flow	
(P) pool	1
slack	79
riffle	
rapids	
run	20
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	100
emergent 1·2m wide	
emergent >2m wide	
total veget. area	0·5
B bryophytes	
E emergents 90	
A submerged 10	
F floating	
algae % of stretch	(100) to 100%


Arrow Bridge
A4110
11
Flow
7·5–8·5 km
Photographic record
70° 3m↑
Garden
40° ·5m↑
Garden
Mill Race
1m↑
4m ↔
weir
80 1m↑
Orchard
5m ↔
·5m↑
20° ·5m↑
gp
Pasture
0·5m↑
9
·3m↑
·75m↑
weir
6m ↔
10° 2m↑
·5m↑
Tied in Branches 1m↑
7m ↔ 1m ↕
debris
slack
10
Branches tied into bank
45° 0·5m↑
Branches tied into bank
Pasture
Grassland
7m ↔ >0·5m ↕
60° ·5m↑
2m↑
1m↑

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved	40	100
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER RIVER ARROW
Km No. 7·5 – 8·5 Km
Date 14/4/93
Surveyor JALJ

	LB	RB
G. OPEN WATER		
1. Standing - canal ↕ % of adj bnd in each stretch		
canal =		
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m	2	
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge ↕		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden	30	
stick pile		
flood debris		
road		
railway disused		
used		
other	30	

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	2	30
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	90
1-<2m		
>2m		10
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°	60	
30-<60°	40	90
60-<90°		10
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard	4	1
W Willow old, not pollard	3	
S Standard willows		
A Alder	8	6
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	8	2
Dense open %	12	
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, ↕ bare		
shingle and rock		
shingle, rock ↕ veg		
earth - maturing		
earth - with trees		
developed	60	

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	2
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
.5-<1.0	70
>1.0m	30
Width <1	
1-<5	20
5-<10	80
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	30
g gravel	70
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	
slack	38
riffle	2
rapids	
run	60
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

total = 100%

DRENEUYDD/BROADWAY REEN

R&D 317/22/ST

CONTENTS

DRENEUYDD / BROADWAY REEN

1. BACKGROUND 1

1.1 PHYSICAL BACKGROUND 1

1.2 STUDY REACH 1

1.3 RIVER CHARACTERISTICS 1

1.4 LAND DRAINAGE 1

1.5 GEOLOGY, SOILS AND LAND CAPABILITY 5

1.6 CAPITAL WORKS 7

1.7 RIVER MAINTENANCE 7

1.7.1 Farmers views on maintenance 7

1.7.2 Alternative maintenance strategies 7

1.8 CLIMATE 8

1.9 AQUATIC VEGETATION 9

1.9.1 Submerged vegetation 10

1.9.2 Emergent vegetation 10

1.9.3 Floating vegetation 10

1.9.4 Algae 11

2. FARM SURVEY 12

2.1 INTRODUCTION 12

2.2 FARM TYPE, SIZE AND TENURE 12

2.3 LIVESTOCK ENTERPRISES 12

2.4 ARABLE ENTERPRISES 13

2.5 LAND USE IN THE BENEFIT AREA 13

2.6 TURNOUT AND YARDING DATES 15

2.7 GRASS CONSERVATION 16

2.8 NITROGEN APPLICATION 16

2.9 FLOODING 17

2.10 WATERLOGGING 17

2.11 STATISTICAL ANALYSIS 20

3 HYDRAULIC AND HYDROLOGICAL INFORMATION 21

3.1 INTRODUCTION 21

3.2 CROSS-SECTION SURVEYS 21

3.3 FLOOD RETURN PERIOD 26

4. LAND DRAINAGE **28**

4.1 FIELD DRAINAGE STATUS 28

5 SCHEME APPRAISAL **31**

5.1 MAINTENANCE BENEFITS 31

5.2 MAINTENANCE COSTS 38

5.3 SCHEME APPRAISAL 39

6 ENVIRONMENT **40**

6.1 INTRODUCTION 40

6.2 SITE OF SPECIAL SCIENTIFIC INTEREST 40

6.3 RIVER CORRIDOR SURVEY 40

6.4 PUBLIC CONSULTATION 41

6.5 FARMER ASSESSMENT 41

6.6 WATER QUALITY 41

6.7 CHANNEL AND BANK QUALITY 42

7 CONCLUSIONS **43**

7.1 SCHEME APPRAISAL 43

7.2 GUIDELINES FOR RIVER MAINTENANCE 43

7.3 IMPACT OF MAINTENANCE ON CHANNEL VEGETATION 43

7.4 MAINTENANCE BEST PRACTICE 44

Channel *44*

Bank *45*

7.5 RECOMMENDATIONS 45

7.6 EPILOGUE 45

8. REFERENCES **46**

APPENDIX I Example of input and output data for the watertable model

APPENDIX II River corridor survey

LIST OF FIGURES

Figure 1 Site location 2
Figure 2 Land drainage and location of cross-sections and land blocks 4
Figure 3 Soil profiles 6
Figure 4 Land use in the benefit area 14
Figure 5 Areas prone to flooding 19
Figure 6 Channel information ..... 23 - 25
Figure 7 Flood return period curve 27

LIST OF TABLES

Table 1.1 Rainfall totals 9
Table 1.2 Probability of climatic condition 9
Table 2.1 Land use within the benefit area 13
Table 2.2 Turnout dates 15
Table 2.3 Yarding dates 15
Table 2.4 Grass conservation 16
Table 2.5 Nitrogen application rates 16
Table 2.6 Farmer assessment of wetness condition 17
Table 3.1 Bankfull capacity and return periods 22
Table 3.2 Flood return periods and flooded areas 26
Table 4.1 Drainage status for wet, average and dry seasons, with/without maintenance 29
Table 5.1 Financial net returns 33
Table 5.2 Economic net returns 34
Table 5.3 Flood costs 35
Table 5.4 Change in financial net returns 36
Table 5.5 Change in economic net returns 37
Table 5.6 Farmer assessment of maintenance benefits 38
Table 5.7 Maintenance scheme appraisal: Dreneuydd / Broadway Reen 39

1. BACKGROUND

1.1 Physical Background

The Dreneuydd and Broadway Reen forms part of the drainage system of the Wentlooge Levels in the Newport District of Gwent. The reen rises at Duffryn (GR. 294 848) and forms an arterial drain through the small upland catchment. The catchment area of the Dreneuydd and Broadway Reen is estimated to be 15.5 km^2 and is mainly rural in character.

1.2 Study Reach

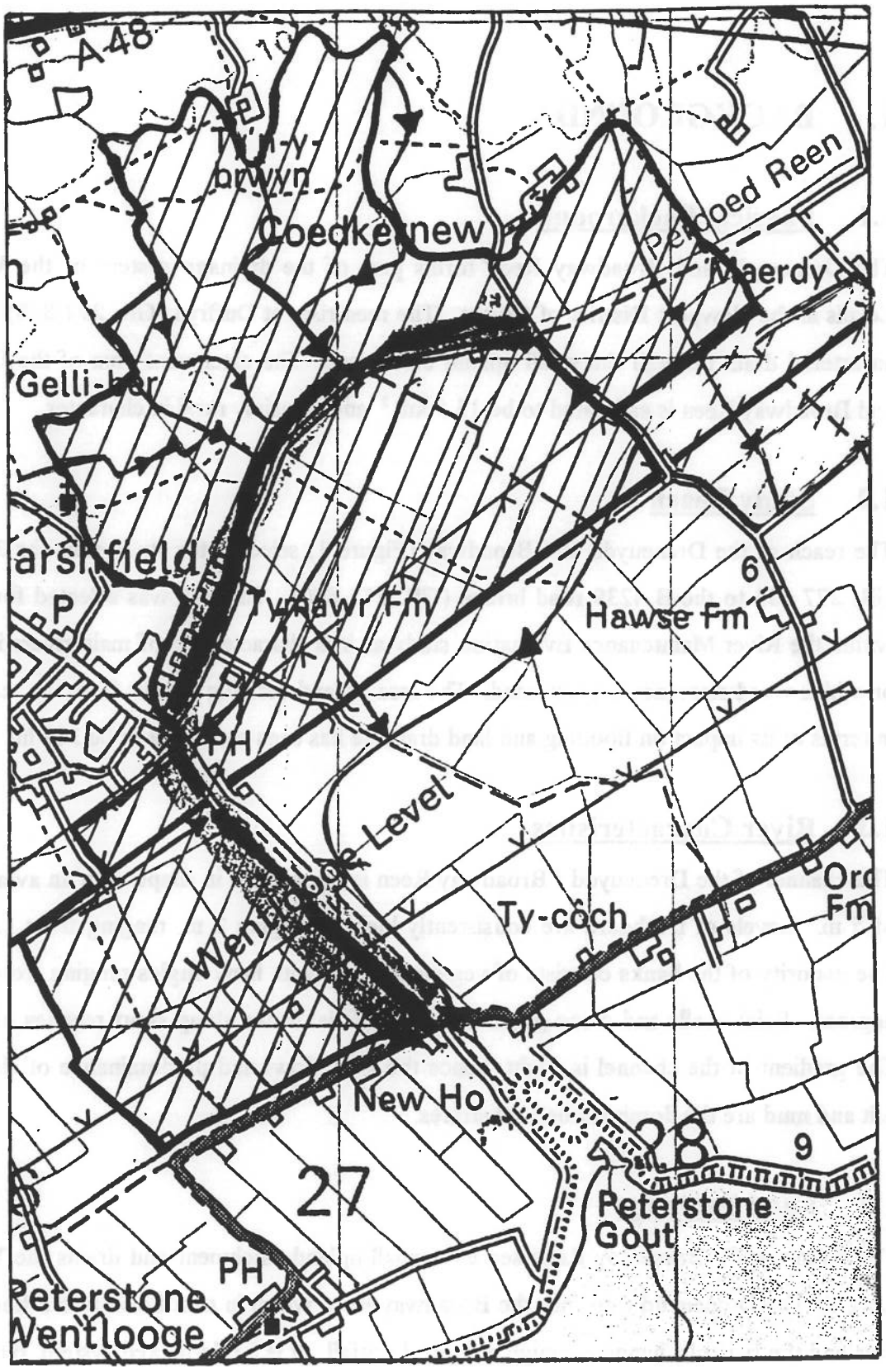
The reach of the Dreneuydd and Broadway (Figure 1) selected for study runs for 3 km from GR. 277 831 to the B 4239 road bridge (GR. 273 810). This site was selected for inclusion within the River Maintenance Evaluation study as it is characteristic of main rivers in the area on which weed clearance is performed. The area of land deriving benefit from the maintenance in terms of its impact on flooding and land drainage has been estimated to be 312 ha.

1.3 River Characteristics

The channel of the Dreneuydd / Broadway Reen is trapezoidal in shape with an average width of 5 m. Levels of freeboard are consistently high, averaging 2 m, ranging from 1.5 to 5 m. The majority of the banks consists of vegetated earth with bank angles ranging from 45 to 90 degrees. Brick walls and stone gabions form artificial banks along short reaches of the reen. The gradient of the channel is slight, hence the slow flows and predominance of slack water. Silt and mud are the dominant bed substrates.

1.4 Land Drainage

The Dreneuydd / Broadway Reen serves a small upland catchment and drains the Wentlooge Levels. The Dreneuydd runs into the Broadway Reen which in turn flows into a flood storage area and the Bristol Channel through a flapped outfall. It is a tide-locked system, the reen only draining at low tide. An automatic sluice towards the downstream end of the Broadway Reen controls water levels, keeping them high in summer in order for the reens to act as fences for livestock and lower in the winter.



Legend :

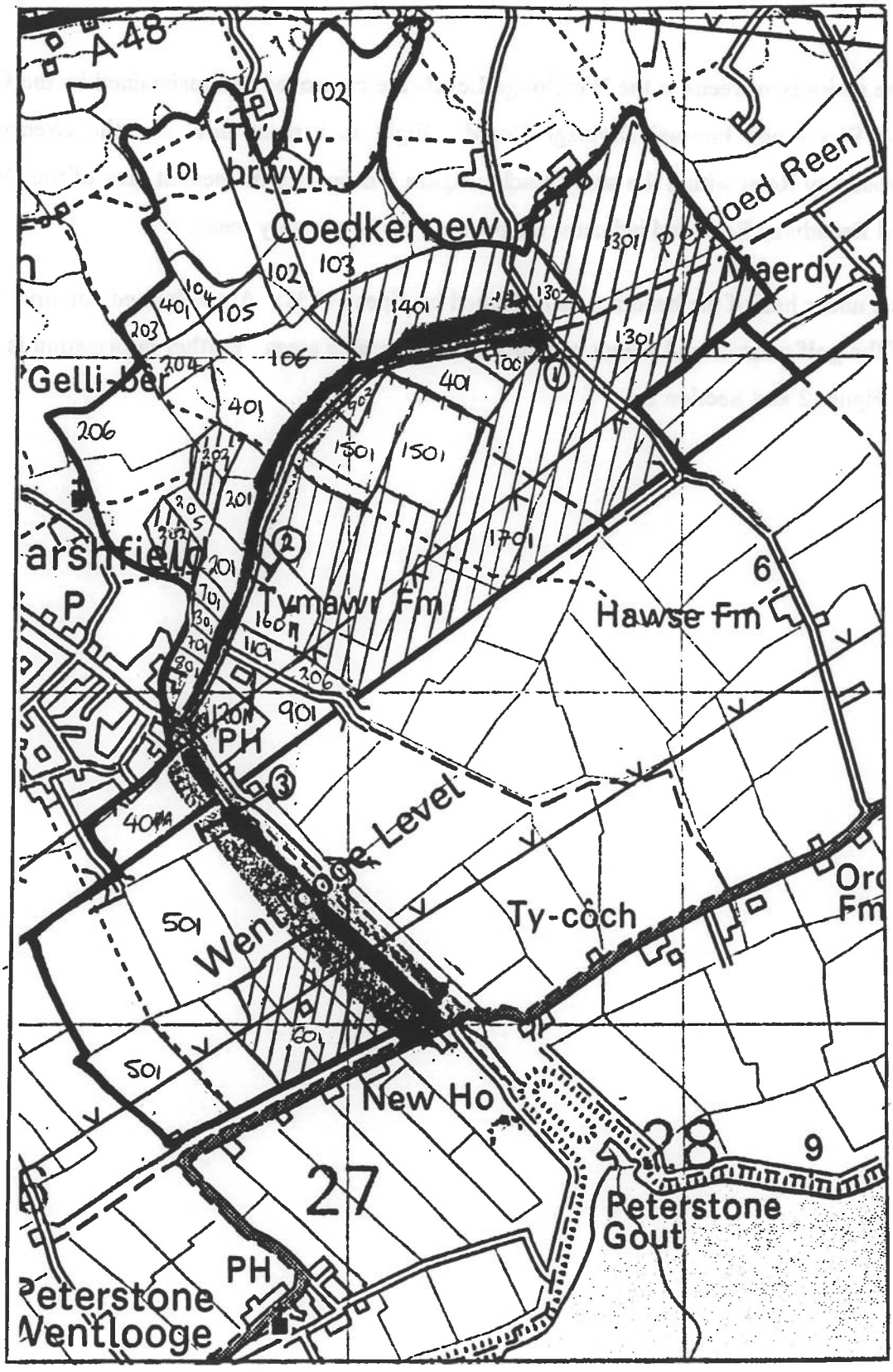
Scale 1 : 7500

Benefit area

Figure 1 Location of the Dreneuydd / Broadway Reen, tributaries and benefit area

The majority of reens in the Wentlooge Levels are controlled and maintained by the Caldecote and Wentlooge Internal Drainage Board. Eight such reens flow into the Dreneuydd and Broadway Reen within the study reach. Figure 1 delineates the benefit area of the Dreneuydd and Broadway Reen and indicates the position of the tributary reens.

Just under half of the benefit area is drained by pipes (49 %). Areas drained comprise the areas of the golf courses and a high proportion of the arable areas. Further information is provided in Figure 2 and Section 2.5.



Piped drainage

Natural drainage

101 Land use blocks

1 Location of cross-sections

Figure 2 Land drainage, land use blocks and location of cross-sections

1.5 Geology, Soils and Land Capability

The geology of the study reach and the Wentlooge Levels is characterised by mudstones of Permo-Triassic age. The argillaceous sedimentary rocks of this period outcrop extensively in Gwent. They are overlain by clayey alluvium of riverine and marine origin.

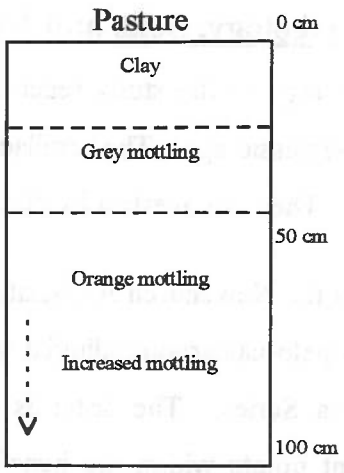
Soils of the Newchurch Association are present within the study reach. The Newchurch series of this pelo-calcareous alluvial gley soil dominates the Association which also contains the Wallasea Series. The latter is a clayey non-calcareous soil. Three soil profiles taken at different points within the benefit area are presented in Figure 3. The soils are of a dark brown/grey colour with a clayey texture. Some mottling and gleying was evident at the time of the soil survey.

The land is low lying and protected from high spring tides by sea defences. Throughout much of the winter the land is waterlogged due to high groundwater levels. Typically the soil profile is waterlogged within 40 cm of the ground surface for 180 to 335 days in most years. The Soil Survey of England and Wales (SSEW) attribute a Wetness Class of V to this soil wetness regime (Rudeforth et al, 1984). Most soils are moderately permeable and where field drainage is installed the Wetness Class may improve to Class IV when the soil is waterlogged within 40 cm of the surface for more than 49 % but less than 92 % of the year.

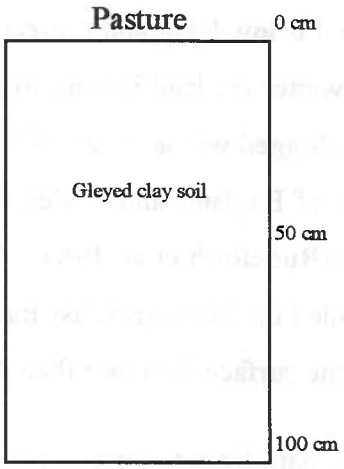
Rainfall data from the nearest meteorological station to the site, Redwick, Usk (GR. 413 841, station reference 481 380) suggests that the mean annual rainfall is approximately 1030 mm.

The land is classed as Grade 3 agricultural land in accordance with the classification of the Ministry of Agriculture, Fisheries and Food (MAFF). Permanent grassland is the dominant land use within the area and is used for the grazing of sheep and livestock. Some cereals, commonly spring crops and oilseed rape are also grown. Moderate limitations affect the choice of crops, timing and type of cultivation, harvesting and yield.

Grid Reference	274 832
Soil Core Number	1
Soil Colour	Dark brown
Comments	Clay texture



Grid Reference	265 824
Soil Core Number	2
Soil Colour	Dark grey
Comments	Clay texture, uniform profile



Grid Reference	274 808
Soil Core Number	3
Soil Colour	Dark brown
Comments	Clay loam texture, uniform profile

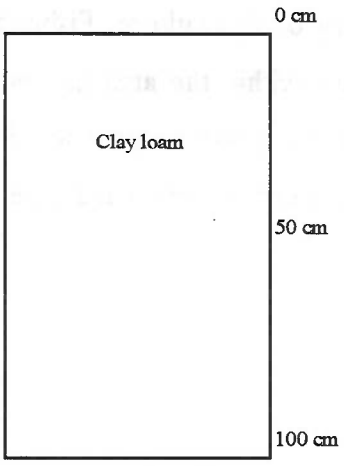


Figure 3 Soil profiles in the Dreneuydd/Broadway Reen benefit area

1.6 Capital Works

Capital works were performed along the entire length of the Dreneuydd and Broadway Reen in 1961. A channel improvement scheme involving the re-grading and re-sectioning of the entire reen took place. Structures were also replaced at this time.

1.7 River Maintenance

The Dreneuydd and Broadway Reen is subject to a programme of regular river maintenance for the benefit of land drainage and flood alleviation. Desilting (casting) and weed clearance using a Bradshaw bucket take place every 18 months towards the middle to end of the year.

The main reason for the current level of maintenance on the reens is that it is scheduled into a regular work programme. Inspection of the watercourse condition also determines the maintenance frequency. Standards of service for the level of maintenance are based on custom and practice and a survey by engineers. Methods of maintenance adopted are based on proven suitability, watercourse conditions, cost effectiveness and environmental factors.

Landowners and occupiers with frontages along the watercourse are notified of maintenance schemes through letters and verbally. Conservation bodies with interest in the environmental aspects of the watercourse are invited to an annual meeting at which the maintenance programme is discussed. Objections may be raised and if necessary, the maintenance programmes may be modified in order to accommodate specific environmental features.

1.7.1 Farmers views on maintenance

During the interviews held with farmers within the benefit area, the majority expressed satisfaction with the type and level of maintenance performed. It is appreciated that maintenance is necessary in order to ensure the reen remains free flowing. However, the view that the sluice on the Broadway Reen controls the water levels rather than the in-channel vegetation was expressed. Desilting of the channel is also thought to undermine the river banks and increase their instability.

1.7.2 Alternative maintenance strategies

Various alternative maintenance strategies were suggested by farmers during the course of discussions. Some expressed the view that some of the channel vegetation should be left for

the benefit of wildlife. Others stated that the water levels in the reen are kept too low during the summer months and do not act as effective fences to livestock. There were many reported cases of lambs and sheep falling into the reen and drowning as they were unable to climb out due to low water levels.

The automation of the sluice gate on the Broadway Reen was suggested as a method for more effective control of water levels than the current manual method. Automation would enable the sluice to be lowered more rapidly in times of high water levels in the reens. The opinion that the outfall of major ditches into the Dreneuydd and Broadway Reens should be flapped was also expressed. It is thought that this would prevent the 'backing up' of water from the main reen up the tributary ditches and hence field drainage pipes during the winter months.

1.8 Climate

The impact of river maintenance on the watertable and river levels depends on the particular weather conditions, especially rainfall, which varies between seasons and years. The seasonal and yearly totals of rainfall for the period of the study are presented in Table 1.1. The seasons of 1992, 1993 and 1994 were all average when compared to the long term rainfall records. However, the spring of 1994 was towards the wet side of average and just falls outside the wet classification band.

The probability of wet, average and dry seasons and years occurring has been determined through analysis of long term monthly rainfall figures from the meteorological station at Redwick (GR. 413 841) which cover a 23 year period. The classification system of the Food and Agricultural Organisation (FAO) was used to determine the rainfall class 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. The probability of each type of season and year occurring are shown in Table 1.2.

Table 1.1 Rainfall totals

Period	Season	Actual Rainfall (mm)	Average * Rainfall (mm)	% Average Rainfall
1992	Spring	133.0	263.5	50.5
	Summer	258.4	273.7	94.4
	Autumn	303.1	366.5	82.7
1993	Spring	182.2	263.5	69.1
	Summer	198.8	273.7	72.6
	Autumn	189.4	366.5	51.7
1994	Spring	257.6	263.5	97.8
	Summer	190.9	273.7	69.7
	Autumn	293.3	366.5	80.0
1995	Spring	122.1	263.5	46.3
Total	1992	831.7	871.7	95.4
	1993	1001.4	871.7	114.9
	1994	1151.0	871.7	132.0

* Based on 23 Year record from 1970 to 1993, Redwick (GR. 413 841)

Table 1.2 Probability of climatic condition

Season	Dry *	Average *	Wet *
Spring	0.12	0.75	0.13
Summer	0.21	0.71	0.08
Autumn	0.17	0.71	0.12
Year	0.31	0.52	0.17

* Based on records since 1970

The Main Report (Section 3.5.4) describes the process by which financial benefits of maintenance are calculated according to the probability of average, dry and wet seasons and years occurring.

1.9 Aquatic Vegetation

Prior to river maintenance, the aquatic vegetation within the Dreneuydd and Broadway Reen was identified. Submerged, emergent and floating vegetation were present in addition to algae.

1.9.1 Submerged vegetation

The dominant aquatic plants in the study reach are *Potamogeton* sp. (waterweed) and *Elodea* sp. (Canadian pondweed). *Elodea* is a submerged plant characterised by branched stems which can range in length from 10 cm to 3 m. *Potamogeton* is a rooted plant with oval dark green leaves. Although it is classed as a floating broad-leaved aquatic plant it often has some submerged leaves.

Weed cutting is an effective method of controlling the Canadian pondweed. The waterweed however, reproduces through rhizomes and is therefore more difficult to control. Desilting may be necessary in order to reduce or remove the seed bank of *Potamogeton* from the river bed.

1.9.2 Emergent vegetation

Apium (Fools water-cress) is classed as a broad-leaved emergent plant. It is an umbellifer with compound leaves and may grow up to a metre in height. *Apium* grows along the water margins, forming large stands in the Dreneuydd Reen. It is less common within the Broadway Reen.

The tall emergent grasses *Glyceria* (Reed Sweet-grass) and *Phragmites* (Common reed) are also common within the reens. These grasses may reach up to 2 m in height and grow in dense stands in slow moving water. They provide greater resistance to flow than some submerged plants as they can create a fairly impermeable barrier to the flow of water, depending on the density of the vegetation stand.

Control of *Glyceria* may be difficult as it reproduces through a system of rhizomes (underground stems) which are buried in the mud and silt of the channel bed. Any form of control which leaves these rhizomes intact will have only a short term benefit. Unless these are removed through desilting, *Glyceria* will regrow the following year.

1.9.3 Floating vegetation

Lemna (Duckweed) is a small free-floating plant with many rootlets on the underside. *Azolla* (Water fern) is similar to the duckweed in that it too, is a free-floating plant made up of fronds with rootlets on the undersides. Both commonly form extensive floating mats on the water surface. In the autumn, the floating mats of *Azolla* commonly turn red. They multiply and

spread through vegetative reproduction. *Azolla* is able to withstand temperatures of up to -10 degrees centigrade and it over winters well.

Control methods which disturb the plants and create open areas of water which are free from *Azolla* or *Lemna* serve to prevent the development of a plant mat. The impact of herbicides on the control of the weed is restricted. If the mat is multi-layered, the herbicides destroy the outside layers, but do not penetrate to the inner layers. The inner layers are thus still able to reproduce.

1.9.4 Algae

Filamentous algae is also found within the Dreneuydd/Broadway Reen. The long chains of this algae grow up from the hydrosoil. It is difficult to control as it can be found anywhere and grows rapidly through simple fission by which each cell divides. Algae is common in nutrient rich waters and frequently invades areas where other aquatic plants have been controlled or eradicated.

2. FARM SURVEY

2.1 Introduction

Through structured interviews and discussions with farmers along the selected reach and through a topographical survey, the area deriving benefit from river maintenance works in terms of its effect on flooding and land drainage is estimated to be 312 ha (Figure 1).

2.2 Farm Type, Size and Tenure

Of the 17 farms surveyed within the benefit area, two are classed as cereal farms according to the European Union (EU) classification system. Four are classed as lowland and livestock enterprises and one as pig and poultry. The remaining holdings are classed as 'other'. These include golf courses, small holdings which provide grazing for horses and grass which is cultivated for turf production.

The management status of all the farms is sole proprietorship. The average farm size is 43 ha although small holdings of less than 2 ha are common. The Standard Man Day (SMD) or Man-Work-Unit requirement ranges from one to 1128. The average SMD value is 190. This SMD value may be used to assess the labour requirement of agricultural enterprises. Generally, the higher the SMD value, the greater the amount of labour required. All farmers have one holding. The majority of land within the benefit area is owner occupied; only 13 ha is rented under a 364 day tenancy agreement.

2.3 Livestock Enterprises

Five of the farms have some sheep enterprise. Flock sizes range from 80 to 250 sheep and the breeds kept are Buellers or Scotch Mule mixed. The latter are kept under a tack system. These 'tack sheep' are brought off the Welsh mountains during the winter to graze the lowland pastures. Lambing rates range from 1.3 to 1.5 lambs/ewe tupped. Both the fat lamb and store lamb systems are followed.

Black Hereford store cattle are kept on four farms. Herd sizes range from 3 to 36 beasts and are aged between one and two years. A further 60 cattle are reared to 18 months and fattened off under a grass/cereal system. They are typically sold at 475 kg live weight.

One poultry enterprise is located within the benefit area. Forty birds are kept under a free range system.

2.4 Arable Enterprises

Three farms have arable land within the benefit area. This consists of winter cereals, commonly wheat and barley and oilseed rape. On two of the farms, a six year rotation is followed under which two years of winter wheat are followed by one year of a break crop such as winter field beans then more winter wheat and an oilseed crop. Yields for the wheat and beans average 2.9 t/ha and 4.1 t/ha respectively. The other farm follows a grass/arable rotation under which winter wheat, field beans and spring barley are followed by two years of grass.

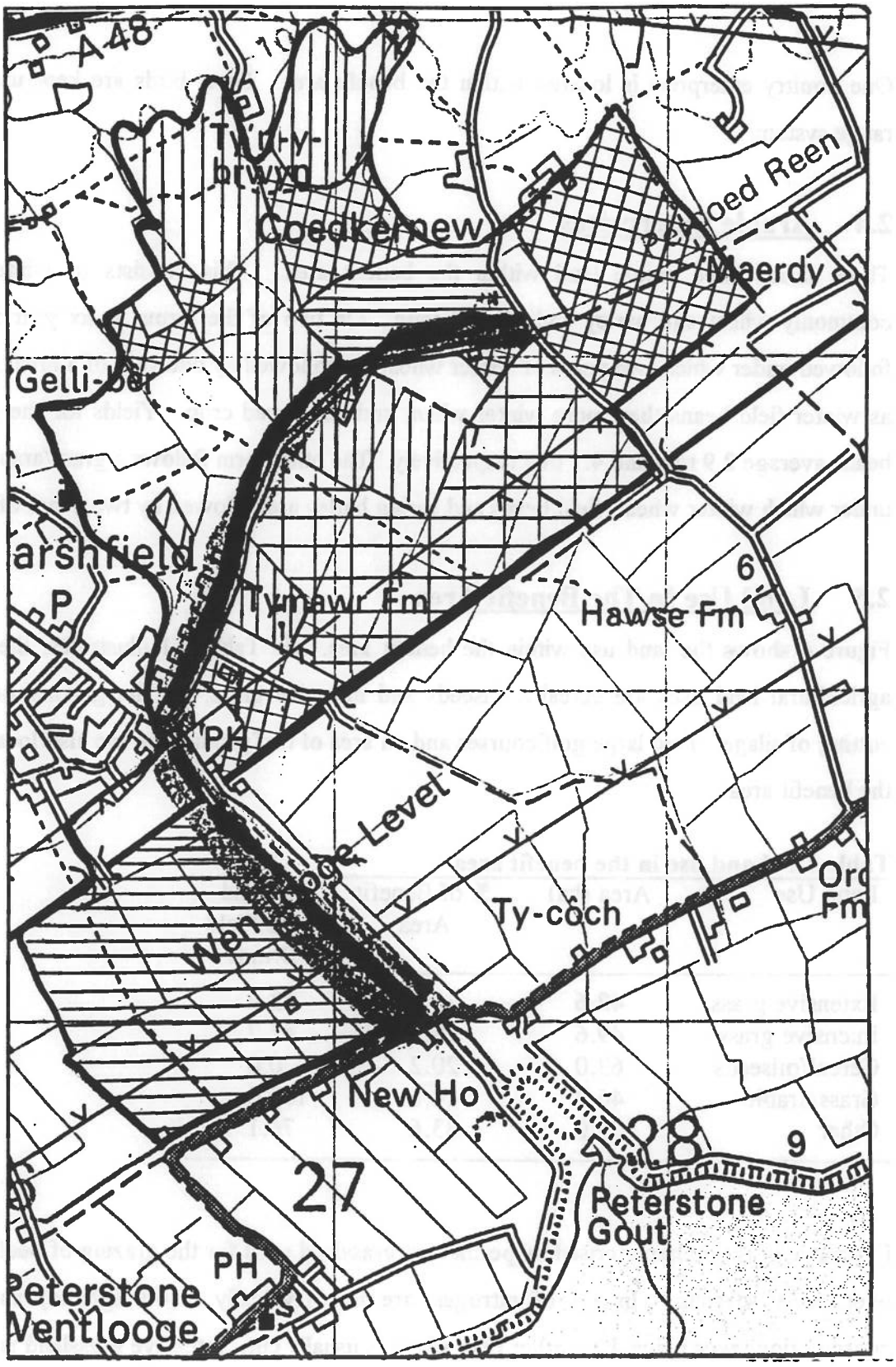
2.5 Land Use In The Benefit Area

Figure 4 shows the land use within the benefit area. As Table 2.1 illustrates, the dominant agricultural land uses are cereal / oilseeds and intensive grass, for the grazing of beef and cutting of silage. Two large golf courses and an area of turf production are also located within the benefit area.

Table 2.1 Land use in the benefit area

Land Use	Area (ha)	% of Benefit Area	% Land With Field Drains
Extensive grass	48.6	15.5	13.9
Intensive grass	49.6	15.9	42.7
Cereal/oilseeds	63.0	20.2	0.0
Grass/arable	46.2	14.8	100.0
Other	105.0	33.6	76.1

Extensive grass is characterised by permanent grassland used for the grazing of beef and sheep over short seasons. Inputs of nitrogen are low (typically < 40 kgN/ha) and if grass conservation takes place, hay rather than silage is usually cut. Intensive grassland is associated with long grazing seasons, multiple grass cutting for silage and higher inputs of nitrogenous fertiliser (> 40 kg/N/ha).



Intensive grass

Extensive grass

Cereal / oilseed rotation

Grass / arable rotation

Other

Figure 4 Land use in the benefit area

The areas which have field drainage pipes installed are also shown in Table 2.1. All the land under a grass/arable rotation is drained by pipes. A higher proportion of intensive grass is drained than the extensive grass. Land under a cereal/oilseed rotation is naturally drained. Further information is presented in Figure 2.

2.6 Turnout and Yarding Dates

Throughout the benefit area, turnout dates for livestock fall into two main categories: April, and after grass has been cut for hay or silage. Forty one percent of the grassland area is not grazed. Table 2.2 provides further information regarding turnout dates.

Table 2.2 Turnout dates

Turnout Date	% Grassland Area
Mid/late March	3.4
Early/mid April	6.9
Mid/late April	10.4
Early/mid May	10.3
After 1 st silage cut	13.9
After 1st hay cut	3.4
Overwintered	10.3
Not grazed	41.4

Yarding dates are commonly October and November. Land which remains relatively well drained during the winter months and that which is not prone to flooding is grazed over the winter by sheep under the 'tack system'. This is a system whereby sheep are brought off highland areas of Wales to graze the lowland pastures of the Levels throughout the winter months. Further information on the dates livestock are taken off the land for the winter are provided in Table 2.3.

Table 2.3 Yarding dates

Yarding Date	% Grassland Area
Mid/late October	31.1
Early/mid November	6.9
Mid/late November	10.3
Overwintered	10.3
Not grazed	41.4

2.7 Grass Conservation

Thirty six percent of the grassland is not grazed or subject to grass conservation . This land is composed of small holdings which are kept for the grazing of horses. Of the land which is conserved, one cut of silage is the most common. Multiple cutting is not practised as Table 2.4 indicates. Thirty nine percent of the grassland is grazed only and is not cut for hay or silage. Cutting takes place in mid to late June.

Table 2.4 Grass conservation

Conservation System	Grassland Area (ha)
1 cut hay	7.1
1 cut silage	17.9
Grazed only	39.3
No grazing or conservation	35.7

2.8 Nitrogen Application

The majority of the grassland within the benefit area receives no inputs of nitrogen. Both straight and compound fertilisers are applied to 31 % of the benefit area. The NPK fertiliser ICI number 5 in the proportions 17:17:17 is commonly applied. The proportions 20:10:10 are also used. Levels of nitrogen application are restricted due to the Site of Special Scientific Interest (SSSI) status of the Wentlooge and Caldicot Levels. Table 2.5 provides further information regarding the application rates of nitrogenous fertiliser.

Table 2.5 Nitrogen application rates

Rate (kg N/ha)	Grassland Area (ha)
0.0	66.7
4 - 10	3.5
11 - 20	14.0
49 - 70	13.9

The golf courses receive the lowest application of nitrogen. A slow releasing nitrogenous fertiliser is applied at the rate of 4 kg N/ha,

2.9 Flooding

Within the study reach only three farmers report the occurrence of flooding on their land ; covering a 5 ha area (Figure 5). In all cases, flooding is attributed to high water levels in the channel due to the sluice gate on the Broadway Reen retaining levels. In each case, the duration of flooding is said to be 2 to 3 days.

No damage is generally incurred as a result of the flooding, although in the past, sheep have been lost if they have fallen into the reen and been unable to climb out due to the sheer weight of their wet wool. One farmer stated that no crop damage was incurred as the flood waters do not linger on the land but drain away quickly due to the control exerted by the sluice gate.

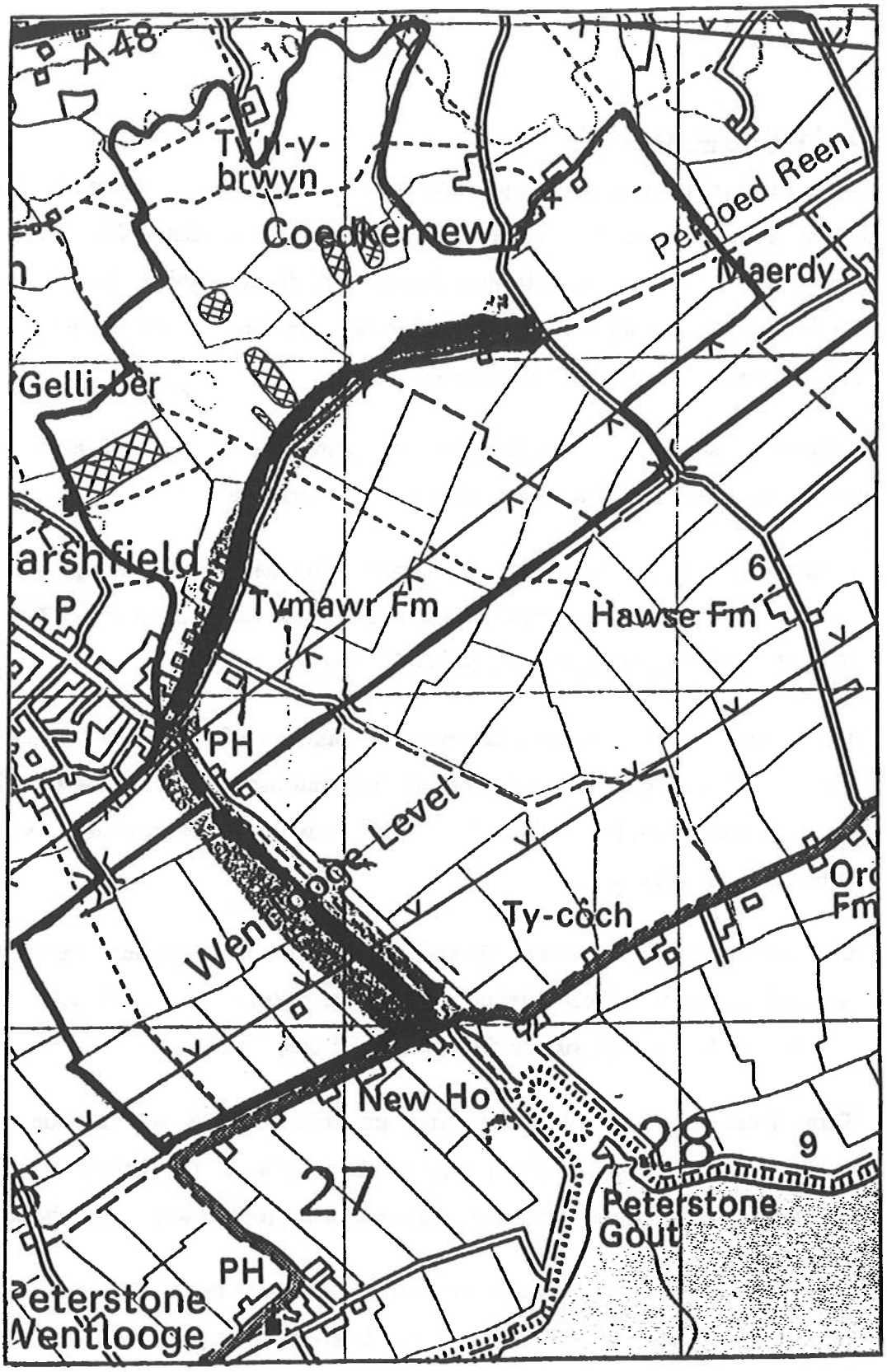
2.10 Waterlogging

The land wetness condition of the benefit area throughout the spring, summer and autumn has been classified by the farmers and is shown in Table 2.6. Throughout the spring and summer the majority of the land is well drained being rarely or occasionally wet. During the autumn only 17 % of the benefit area remains well drained (rarely wet). Forty percent is classed as often wet and 7 % as permanently wet. These wetter conditions in the autumn have been attributed to excess precipitation and the clayey nature of the soil which is slow to drain and remains waterlogged for long periods.

Table 2.6 Farmer assessment of wetness condition

Season	Wetness Condition	Area (ha)	% of Benefit Area
Spring	Rarely wet	96.7	31.0
	Occasionally wet	172.2	55.2
	Often wet	43.1	13.8
	Permanently wet	0.0	0.0
Summer	Rarely wet	193.8	62.1
	Occasionally wet	96.7	31.0
	Often wet	21.5	6.9
	Permanently wet	0.0	0.0
Autumn	Rarely wet	53.7	17.2
	Occasionally wet	118.2	37.9
	Often wet	118.2	37.9
	Permanently wet	21.9	7.0

Prior to the capital work scheme, the wetness condition of the land is reported by some farmers to have been much worse. In the autumn, larger areas were subject to permanently wet conditions and increased incidence of flooding.



Legend :

Scale 1 : 7500

Flooded areas

Figure 5 Areas prone to flooding

2.10 Statistical Analysis

It is apparent that land use, farming practice, soil type, 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 Dreneuydd and Broadway Reen maintenance programme:

- Land use is strongly associated with soil type. Grassland systems are predominantly on clay soils and cereals are located on loam soils. (Statistically there is an 87 % chance of correctly predicting land use on the basis of soil type).

- The presence of land drainage however is a function of the farming system and land management, not soil type. Areas of intensive land use such as cereals and oilseeds are grown on land which is well drained naturally. Only the wetter areas of certain fields tend to be artificially drained.

- Land use and flood risk are strongly associated. Flood risk is higher on grassland. Most land under a cereal / oilseed rotation is flood free. (Statistically there is a 77 % chance of correctly predicting flood risk on the basis of land use).

- Turnout dates for livestock in the spring are earlier on drier land than on wetter land. Livestock are overwintered out at grass on the drier land. (Statistically there is a 60 % chance of correctly predicting turnout dates according to field wetness condition).

- Levels of application are a function of the farming system followed. Levels of application are restricted by the Site of Special Scientific Interest (SSSI) status of the area.

3 HYDRAULIC AND HYDROLOGICAL INFORMATION

3.1 Introduction

Hydraulic and hydrological information has been used to determine the impact of maintenance on channel capacity and flood return periods.

3.2 Cross-sections Surveys

Cross sectional surveys of the river channel were taken at three points along the study reach at an average interval of 1150 m (Figure 2). Channel capacity and freeboard were determined from these cross-sections. The channel cross-section remained unchanged following the regular weed clearance programme and so a post-maintenance cross-sectional survey was not necessary.

Prior to weed clearance, channel roughness was expressed in the form of the 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 predominant bed material. The same procedure was followed post-maintenance in order to determine friction values for the 'with' and 'without' maintenance situation. Further details of this methodology are contained within the R&D Note 456 (Appendix IV).

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.

Table 3.1 Bankfull capacity and return periods

Cross-Section	Without Maintenance		With Maintenance	
	Bankfull Capacity (m^3/s)	Return Period (years)	Bankfull Capacity (m^3/s)	Return Period (years)
1	0.32	0.18	0.9	0.45
2	1.03	0.60	2.02	3.50
3	0.74	0.39	1.42	1.20

Source : Modelled estimates

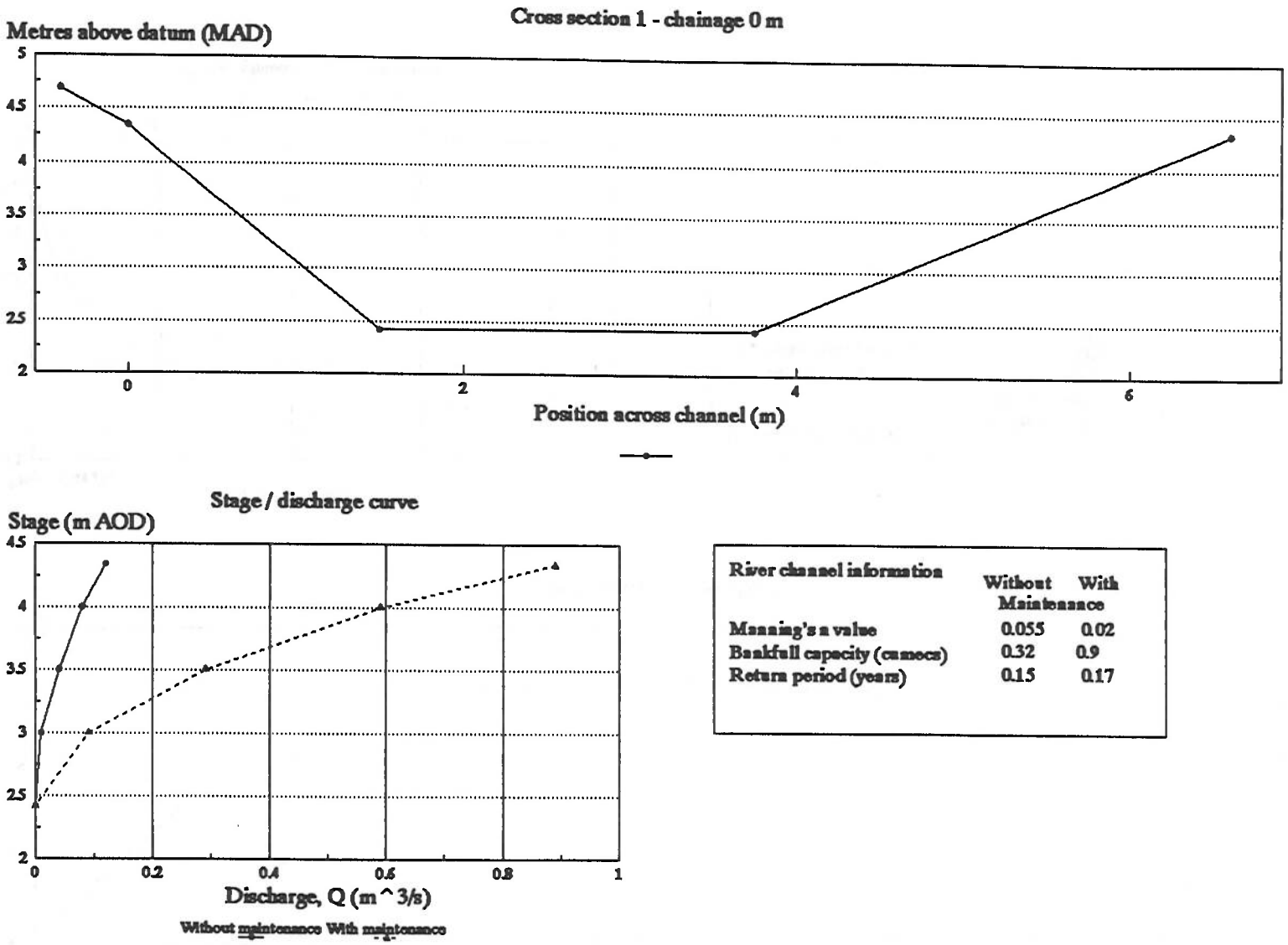
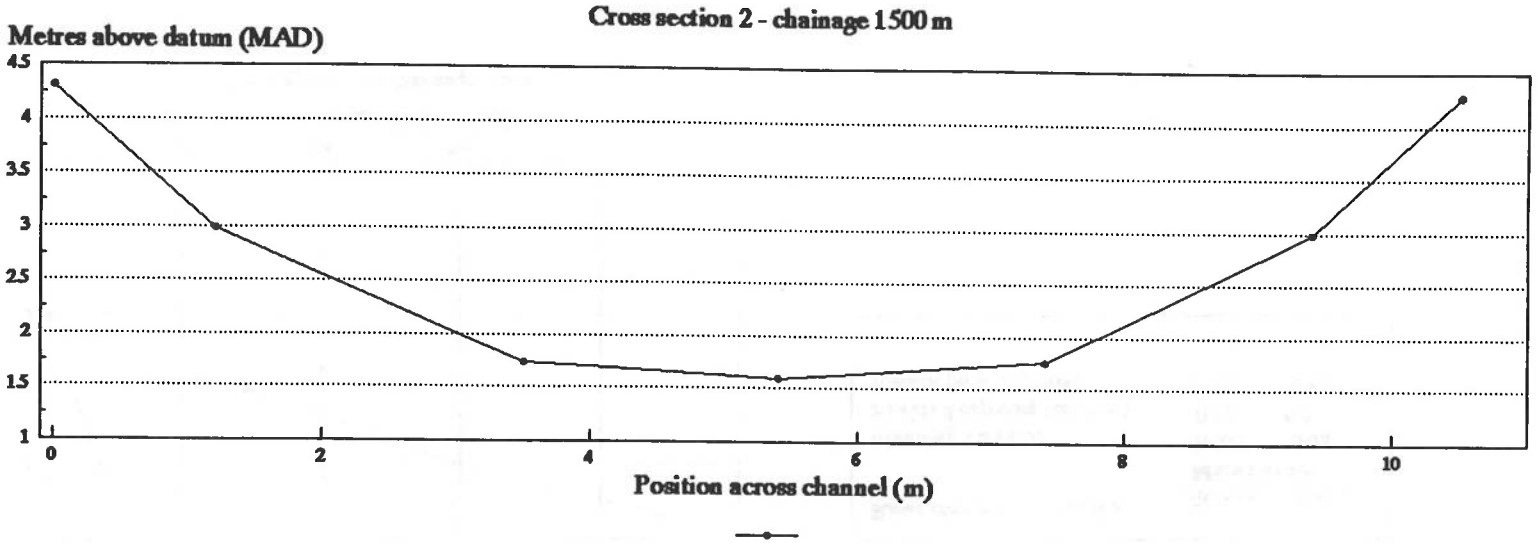
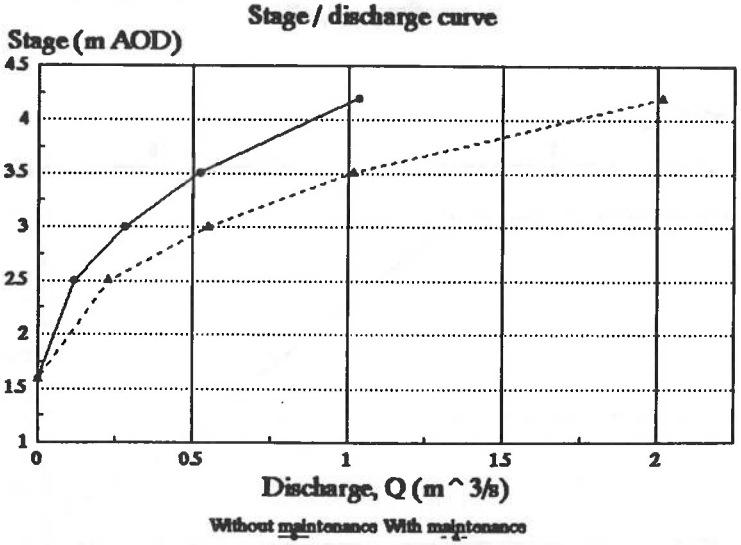
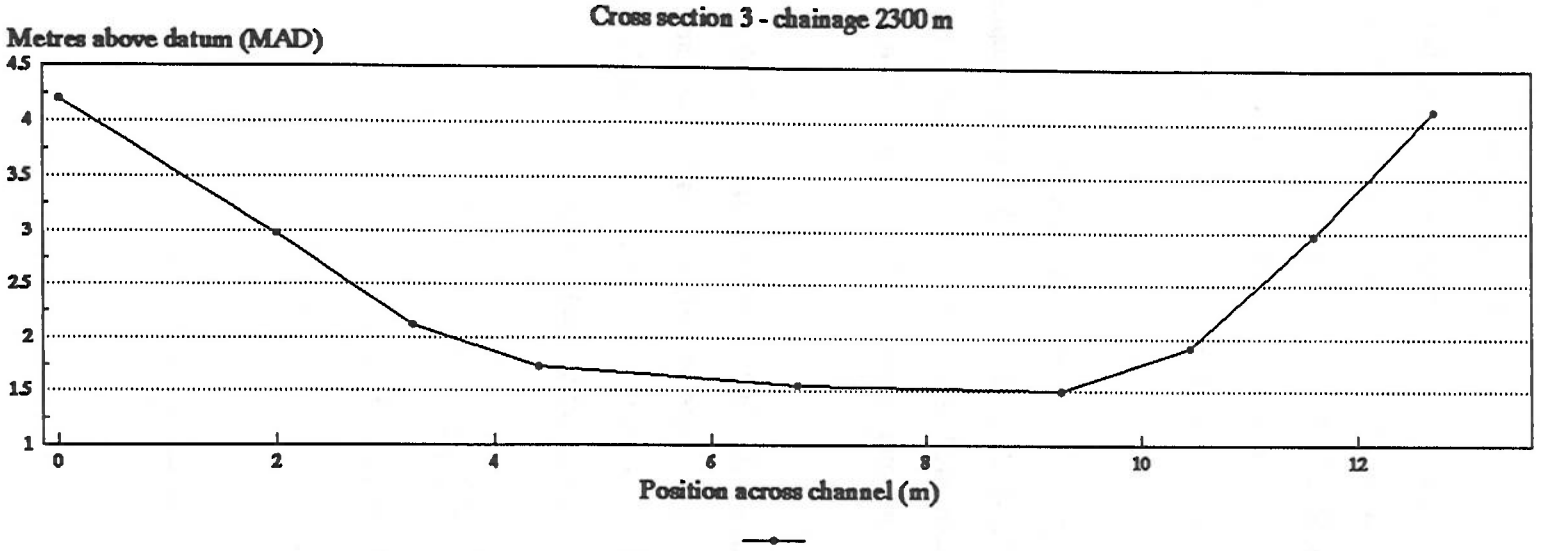


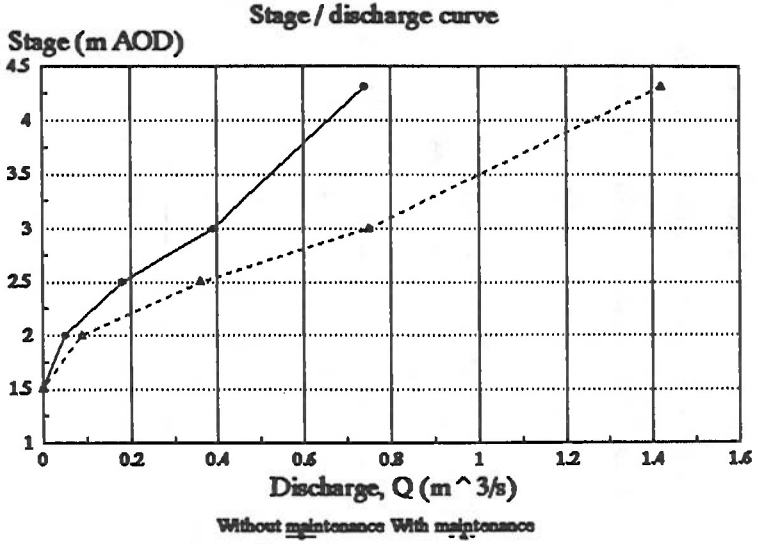
Figure 6 Dreneuydd/Broadway Reen cross-section information





River channel information	Without Maintenance	With
Manning's n value	0.08	0.041
Bankfull capacity (cumecs)	1.03	2.02
Return period (years)	0.18	0.35





River channel information	Without Maintenance	With
Manning's n value	0.083	0.043
Bankfull capacity (cumecs)	0.74	1.42
Return period (years)	0.16	0.23

3.3 Flood Return Periods

The bankfull capacity figures obtained from the cross-sections indicate an average increase in capacity attributable to maintenance of 53 % and an average increase in the interval between flood events of 70 %.

Throughout the period of study (1992 to 1995) river water level information was collected ; initially from a gauge board at Cidwely Arch, towards the upper limit of the study reach. However, this gauge board was subject to repeated vandalism and was removed. A level recorder was installed in the Broadway Reen at GR. 271 830 in September 1993. This has also been subject to vandalism and unfortunately the measurement of water levels in the reen has been disrupted and intermittent. Sufficient data does exist however, to enable some analysis.

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 and flooded areas for each block which floods is 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.	Block Size (ha)	Area Flooded (ha)	Flood Return Period (Years)	
			Without Maintenance	With Maintenance
102	13.4	0.4	0.18	0.5
103	5.50	1.1	0.18	0.5
104	5.10	1.0	0.18	0.5
106	8.50	0.9	0.18	0.5
204	1.80	1.8	0.6	1.0

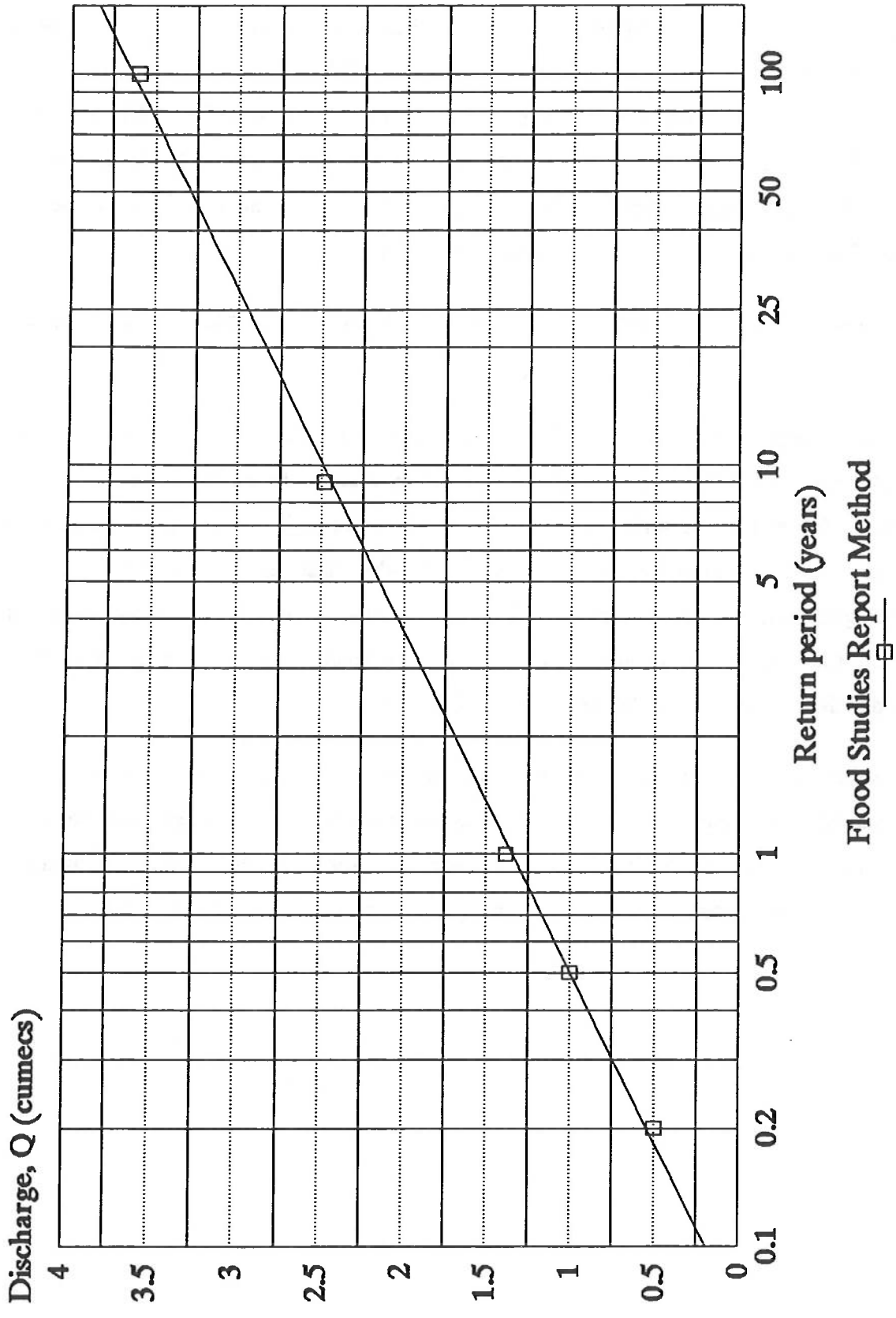


Figure 7 **Flood return period curve**

4. LAND DRAINAGE

4.1 Field Drainage Status

The drainage status of the land 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 situation and using the same climatic data to enable the isolation of the impact of weed clearance on drainage status.

The results of the watertable modelling and the assessment of drainage status made by farmers are shown in Table 4.1.

The drainage status of land has been classified into three standards according to watertable depth. An extensive literature review and farmer survey enabled three watertable bands to be identified:- > 0.5 m from the surface, between 0.3 m and 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), bad (B) or very bad (VB). An example of this classification system for one block of land within the Dreneuydd/Broadway Reen benefit area is shown in Appendix I. Further details are presented in the R&D Note 456 Section 3.5.2.

In some cases, there may be a change in the number of weeks that the watertable lies within the three drainage status bands as a result of 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.

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

Block No		Wet Season *		Average Season *		Dry Season *		Farmer Assessment With Maintenance			Without
		Without	With	Without	With	Without	With	Wet	Average	Dry	
101	N	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
102	N	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
103	N	**VB**	**B**	B	B	G	G	B	*G*	G	B
104	N	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
105	N	**VB**	**B**	**B**	**G**	G	G	*VB*	*B*	G	B
106	N	**VB**	**B**	**VB**	**B**	G	G	*VB*	B	G	B
201	N	B	B	**B**	**G**	G	G	*VB*	*B*	G	B
202	Y	B	B	**B**	**G**	G	G	B	*B*	G	B
203	N	B	B	**B**	**G**	G	G	B	*B*	G	B
204	N	B	B	**B**	**G**	G	G	*VB*	*B*	G	B
205	N	VB	VB	**VB**	**B**	G	G	VB	B	G	B
206	N	VB	VB	**VB**	**B**	G	G	*B*	B	G	B
301	N	G	G	G	G	G	G	*B*	G	G	B
401	N	**B**	**G**	**B**	**G**	G	G	*B*	G	G	B
501	N	B	B	**B**	**G**	G	G	B	G	G	B
601	N	B	B	**B**	**G**	G	G	B	G	G	B
701	N	B	B	**B**	**G**	G	G	B	G	G	B
801	N	B	B	**B**	**G**	G	G	*VB*	G	G	G
901	N	**VB**	**B**	**B**	**G**	G	G	*VB*	*B*	G	B
902	N	**VB**	**B**	VB	VB	G	G	*VB*	*B*	G	B
1001	N	**VB**	**B**	VB	VB	G	G	B	*G*	G	B
1101	N	VB	VB	VB	VB	G	G	*B*	*G*	G	B
1201	N	VB	VB	VB	VB	G	G	*B*	*G*	G	B
1301	Y	VB	VB	B	B	G	G	*B*	*G*	G	B
1302	Y	**VB**	**B**	B	B	G	G	B	*G*	G	B
1401	Y	**B**	**G**	B	B	G	G	*B*	*G*	G	G
1501	N	VB	VB	VB	VB	G	G	*B*	*G*	G	B
1601	N	**VB**	**B**	B	B	G	G	B	*G*	G	B
1701	Y	**VB**	**B**	B	B	G	G	B	*G*	G	B

NB : * Modelled results
Y or N refers to the presence or absence of field drainage
Bold type indicates a change in drainage status classification due to maintenance
Italics indicate a difference in farmer and modelled assessment of drainage conditions with maintenance

The results from the watertable model are 100 % consistent with the farmer assessment of drainage condition under dry weather conditions for the 'with' maintenance situation. Under average and wet conditions, there is 41 % and 45 % agreement between farmer and modelled

assessments respectively. In the 'without' maintenance situation, there is 62 % agreement between farmer assessment of field drainage conditions and those predicted by the model under average weather conditions. However, farmers seem unable to distinguish between bad and very bad drainage conditions and classify most land as bad in the absence of maintenance.

Statistical analysis confirms this agreement between modelled and farmer assessment for the 'with' maintenance situation, with a Phi value of 1 and a Chi Square value of 35 with 4 degrees of freedom at the 99 % confidence limit. The calculated value of Chi Square (35) is greater than the critical value of 13.28 and so the hypothesis that there is a strong association between farmer assessment and modelled predictions of drainage status is accepted.

These assessments of watertable position in various seasons confirm that with maintenance, drainage status in the benefit area is good under dry climatic conditions but bad under wet conditions. Under average conditions, 41 % of the benefit area is classed as being under good drainage. If no maintenance were performed, the drainage status would deteriorate and a higher percentage of the benefit area would be classed as having bad and very bad drainage.

Current levels of maintenance activity prevent the deterioration of drainage status on 31 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 deterioration in drainage status from :

  G to B over 33.2 ha (11 % of BA)
  G to VB over 5.1 ha (2 % of BA)
  B to VB over 109.8 (35 % of BA)

- in a normal season maintenance prevents deterioration in drainage status from :

  G to B over 153 ha (49 % of BA)
  B to VB over 23.3 ha (7 % of BA).

Farmer perception of drainage deterioration due to lack of maintenance (under average conditions) was good to bad on 79 % of the benefit area.

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 associated with maintenance have also been determined. Estimates have been derived of the monetary value of changes in field management and productivity associated with these 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 about £ 6208 in 1995 financial prices, equivalent to about £ 20/ha per year on 312 ha. 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 approximately £ 4211 in economic prices for the benefit area, equivalent to £ 13/ha. On this basis, the benefit to the national economy is about 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. These financial and economic benefit estimates show the limits which farmers and the nation respectively should justifiably spend on maintenance. These estimates require cautious interpretation as explained in the R&D Note 456 Section 2.7.2.

Table 5.1 Financial net returns

Block	Net Return (£/ha) G	B	VB	Change in Net Return (£/ha) G-B	B-VB	G-VB
101	441	372	261	69	111	179
102	441	372	261	69	111	179
103	105	82	51	23	32	55
104	489	372	273	117	99	216
105	441	372	261	69	111	179
106	441	372	261	69	111	179
201	151	109	91	42	19	60
202	151	120	91	31	29	60
203	114	95	64	19	31	50
204	103	85	58	18	27	44
205	114	95	64	19	31	50
206	132	105	85	27	20	47
301	101	91	80	10	11	21
401	120	100	81	20	19	39
501	120	100	81	20	19	39
601	120	100	81	20	19	39
701	116	96	75	19	21	40
801	96	80	75	16	5	21
901	168	118	95	49	23	72
902	167	123	95	44	28	71
1001	317	282	246	35	36	71
1101	83	75	66	7	9	16
1201	101	91	80	10	11	21
1301	349	298	206	51	91	142
1302	384	321	269	63	52	116
1401	384	321	269	63	52	116
1501	382	327	249	54	78	133
1601	179	155	132	23	24	47
1701	300	249	193	51	56	107

Table 5.2 Economic net returns

Block	Net Return (£/ha) G	B	VB	Change in Net Return (£/ha) G-B	B-VB	G-VB
101	404	335	227	70	108	178
102	404	335	227	70	108	178
103	-89	-70	-57	-20	-13	-32
104	129	92	61	37	31	67
105	404	335	227	70	108	178
106	404	335	227	70	108	178
201	58	25	15	33	9	43
202	58	35	35	23	0	23
203	4	-4	-11	9	7	15
204	3	-5	-13	8	8	16
205	4	-4	-11	9	7	15
206	48	30	21	18	8	27
301	5	3	2	1	1	3
401	5	1	-4	5	4	9
501	5	1	-4	5	4	9
601	5	1	-4	5	4	9
701	31	21	12	10	9	19
801	25	17	12	8	5	13
901	50	24	11	25	14	39
902	38	18	11	19	8	27
1001	102	86	72	16	14	30
1101	2	2	0	1	1	2
1201	5	3	2	1	1	3
1301	30	22	9	8	13	21
1302	113	90	71	23	19	42
1401	113	90	71	23	19	42
1501	341	288	199	53	89	142
1601	86	71	57	15	14	29
1701	174	141	90	33	51	84

Table 5.3 Flood costs

			GOOD DRAINAGE		BAD DRAINAGE		VERY BAD DRAINAGE		CHANGE IN FLOOD COSTS					
Block Number	Without maintenance FRP	With maintenance FRP	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	GOOD Without -with	BAD Without -with	VERY BAD Without -with	GOOD TO BAD Without -with	BAD TO VERY BAD Without -with	GOOD TO VERY BAD Without -with
102	0.18	0.50	10.50	3.78	8.94	3.22	9.11	3.28	6.72	5.72	5.83	5.16	5.89	5.33
103	0.18	0.50	15.53	5.59	12.14	4.37	8.44	3.04	9.94	7.77	5.40	6.55	4.07	2.85
104	0.18	0.50	9.17	3.30	7.31	2.63	5.75	2.07	5.87	4.68	3.68	4.01	3.12	2.45
106	0.18	0.50	34.97	12.59	29.83	10.74	30.42	10.95	22.38	19.09	19.47	17.24	19.68	17.83
204	0.60	1.00	12.35	7.41	11.15	6.69	8.72	5.23	4.94	4.46	3.49	3.74	2.03	1.31

Table 5.4 Changes in net returns due to maintenance and climate, 1995/96 financial prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	13.90	111	0.00	111	69	0.00	69	0	0.00	0	855
102	13.40	111	5.89	117	69	5.16	74	0	6.72	7	898
103	5.50	32	4.07	36	0	7.77	8	0	9.94	10	62
104	5.10	216	2.45	219	117	4.01	121	0	5.87	6	572
105	4.60	111	0.00	111	69	0.00	69	0	0.00	0	283
106	8.50	111	19.68	130	111	19.68	130	0	22.38	22	952
201	2.70	0	0.00	0	42	0.00	42	0	0.00	0	81
202	3.30	0	0.00	0	31	0.00	31	0	0.00	0	74
203	3.90	0	0.00	0	19	0.00	19	0	0.00	0	53
204	1.80	0	3.49	3	18	3.74	21	0	4.94	5	30
205	4.40	0	0.00	0	31	0.00	31	0	0.00	0	98
206	10.40	0	0.00	0	20	0.00	20	0	0.00	0	148
301	0.80	0	0.00	0	0	0.00	0	0	0.00	0	0
401	13.20	20	0.00	20	20	0.00	20	0	0.00	0	221
501	25.10	0	0.00	0	20	0.00	20	0	0.00	0	361
601	59.90	0	0.00	0	20	0.00	20	0	0.00	0	863
701	1.80	0	0.00	0	19	0.00	19	0	0.00	0	25
801	0.90	0	0.00	0	16	0.00	16	0	0.00	0	11
901	3.80	23	0.00	23	49	0.00	49	0	0.00	0	145
902	1.00	28	0.00	28	0	0.00	0	0	0.00	0	3
1001	2.90	36	0.00	36	0	0.00	0	0	0.00	0	12
1101	9.00	0	0.00	0	0	0.00	0	0	0.00	0	0
1201	3.00	0	0.00	0	0	0.00	0	0	0.00	0	0
1301	21.20	0	0.00	0	0	0.00	0	0	0.00	0	0
1302	3.60	52	0.00	52	0	0.00	0	0	0.00	0	21
1401	20.00	63	0.00	63	0	0.00	0	0	0.00	0	139
1501	16.10	0	0.00	0	0	0.00	0	0	0.00	0	0
1601	6.50	23.55	0.00	24	0	0.00	0	0	0.00	0	17
1701	46.20	56.15	0.00	56	0	0.00	0	0	0.00	0	285
Total	312.50									Total	6208
Probability of :		Wet season		0.11						Benefit (£/ha)	**20**
		Average season		0.72							
		Dry season		0.17							

Table 5.5 Changes in net returns due to maintenance and climate, 1995/96 economic prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	13.90	108	0.00	108	70	0.00	70	0	0.00	0	861
102	13.40	108	5.89	114	70	5.16	75	0	6.72	7	904
103	5.50	-13	4.07	-9	0	7.77	8	0	9.94	10	35
104	5.10	67	2.45	70	37	4.01	41	0	5.87	6	193
105	4.60	108	0.00	108	70	0.00	70	0	0.00	0	285
106	8.50	108	19.68	128	108	19.68	128	0	22.38	22	933
201	2.70	0	0.00	0	33	0.00	33	0	0.00	0	65
202	3.30	0	0.00	0	23	0.00	23	0	0.00	0	54
203	3.90	0	0.00	0	9	0.00	9	0	0.00	0	24
204	1.80	0	3.49	3	8	3.74	12	0	4.94	5	17
205	4.40	0	0.00	0	7	0.00	7	0	0.00	0	21
206	10.40	0	0.00	0	8	0.00	8	0	0.00	0	62
301	0.80	0	0.00	0	0	0.00	0	0	0.00	0	0
401	13.20	5	0.00	5	5	0.00	5	0	0.00	0	50
501	25.10	0	0.00	0	5	0.00	5	0	0.00	0	83
601	59.90	0	0.00	0	5	0.00	5	0	0.00	0	198
701	1.80	0	0.00	0	10	0.00	10	0	0.00	0	13
801	0.90	0	0.00	0	8	0.00	8	0	0.00	0	5
901	3.80	14	0.00	14	25	0.00	25	0	0.00	0	75
902	1.00	8	0.00	8	0	0.00	0	0	0.00	0	1
1001	2.90	14	0.00	14	0	0.00	0	0	0.00	0	4
1101	9.00	0	0.00	0	0	0.00	0	0	0.00	0	0
1201	3.00	0	0.00	0	0	0.00	0	0	0.00	0	0
1301	21.20	0	0.00	0	0	0.00	0	0	0.00	0	0
1302	3.60	19	0.00	19	0	0.00	0	0	0.00	0	8
1401	20.00	23	0.00	23	0	0.00	0	0	0.00	0	51
1501	16.10	0	0.00	0	0	0.00	0	0	0.00	0	0
1601	6.50	14.35	0.00	14	0	0.00	0	0	0.00	0	10
1701	46.20	50.69	0.00	51	0	0.00	0	0	0.00	0	258
Total	312.50									Total	4211
Probability of :		Wet season		0.11						Benefit (£/ha)	**13**
		Average season		0.72							
		Dry season		0.17							

Table 5.6 Farmer asessment of maintenance benefits

Block	Area (ha)	Average Season Financial prices: Benefit due to drainage (£/ha/yr)	Benefits of flood alleviation (£/ha)	Change in net return due to maintenance	Average Season Economic prives: Benefit due to drainage (£/ha/yr)	Benefits of flood alleviation (£/ha)	Change in net return due to maintenance
101	13.90	69	0.00	959	70	0.00	973
102	13.40	69	5.89	1004	70	5.16	1007
103	5.50	0	4.07	22	0	7.77	43
104	5.10	117	2.45	609	37	4.01	209
105	4.60	69	0.00	317	70	0.00	322
106	8.50	0	19.68	167	0	19.68	167
201	2.70	42	0.00	113	33	0.00	89
202	3.30	31	0.00	102	23	0.00	76
203	3.90	19	0.00	74	9	0.00	35
204	1.80	18	3.49	39	8	3.74	21
205	4.40	0	0.00	0	0	0.00	0
206	10.40	0	0.00	0	0	0.00	0
301	0.80	10	0.00	8	1	0.00	1
401	13.20	20	0.00	264	5	0.00	66
501	25.10	20	0.00	502	5	0.00	126
601	59.90	20	0.00	1198	5	0.00	300
701	1.80	19	0.00	34	10	0.00	18
801	0.90	0	0.00	0	0	0.00	0
901	3.80	49	0.00	186	25	0.00	95
902	1.00	28	0.00	28	8	0.00	8
1001	2.90	36	0.00	104	14	0.00	41
1101	9.00	9	0.00	81	1	0.00	9
1201	3.00	11	0.00	33	1	0.00	3
1301	21.20	0	0.00	0	0	0.00	0
1302	3.60	0	0.00	0	0	0.00	0
1401	20.00	63	0.00	1260	23	0.00	460
1501	16.10	78	0.00	1256	89	0.00	1433
1601	6.50	0	0.00	0	0	0.00	0
1701	46.20	0	0.00	0	0	0.00	0
Total	312.50	Total financial benefit (£)		8362	Total economic benefit (£)		5501
		Benefit (£/ha)		27	Benefit (£/ha)		18

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.

5.2 Maintenance Costs

Maintenance activities on the Dreneuydd / Broadway Reen involve the control of in-channel and bankside vegetation. Actual annual costs for the study reach varied according to need, averaging £ 4650/year in 1995 prices.

5.3 Scheme Appraisal

The estimated benefits attributable to maintenance can be compared with estimated costs to determine the justification for expenditure. Because the maintenance activity is performed every 18 months, the maintenance cost has been amortised at the 6 % discount rate to determine the annual cost. For the purpose of this analysis, the areas of turf production and golf courses have been included as areas of extensive grassland. These areas do benefit from maintenance in terms of the standard of drainage service provided. It must be noted however, that these benefits may be under-estimated. Various land blocks have also been grouped together for the purpose of analysis, providing they meet the same criteria of land use, drainage and flooding.

Table 5.7 Maintenance scheme appraisal: Dreneuydd / Broadway Reen

Average Annual Benefit (£)	Average Annual Benefits (£)	Average Annual Costs (£)	Benefit: Cost Ratio
Modelled Estimates			
Financial Prices	6208	4650	1.33
Economic Prices	4211	4650	0.91
Farmer Estimates of Benefits in an Average Year			
Financial Prices	8362	4650	1.79
Economic Prices	5501	4650	1.18

Table 5.7 shows that the existing maintenance scheme is viable in financial terms. Benefits to farmers exceed the costs of the scheme. In economic terms, however, the benefits to the economy do not appear to fully recover the costs of maintenance.

Farmer assessment gave an average annual financial benefit of £ 8362 (£ 27 /ha) and an economic benefit of £ 5501 (£ 18/ha).

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 Dreneuydd and Broadway Reen is outlined in this chapter. Reference is made to the Site of Special Scientific Interest (SSSI) status of the area and to the channel and bank quality.

6.2 Site of Special Scientific Interest

The Wentlooge Levels along with the Caldicot Levels form the Gwent Levels SSSI. These levels are low-lying coastal areas which have been reclaimed. The Gwent Levels are an example of one of the largest areas of reclaimed wet pasture in Great Britain They are dissected by an extensive network of drainage ditches which have a secondary function of marking field boundaries. These ditches are locally known as reens.

The SSSI notification on the Wentlooge Levels is dated May 1991 and covers an area of 1322 ha. The reens are rich in flora providing a home for many species which are absent from other Levels. Emergent plants such as the Arrowhead (*Sagittaria sagittifolia*) have the opportunity to thrive. Reen banks on the Wentlooge Levels are important areas for meadow plant species such as the common meadow-rue (*Thalictrum flavum*) and the regionally notable grass vetchling (*Lathyrus nissolia*).

Numerous rare and notable aquatic invertebrates are present within the reens in the Gwent Levels. The area is important in Wales for dragonflies and snails such as *Brachytron pratense* and *Physa heterostropha*. The hedgerows add to the diversity of the area, providing valuable habitats and areas of retreat for numerous birds and mammals. The Levels around St Brides are the only location within the Gwent Levels where the rare fly *Stenomicra cogani* has been sighted.

6.3 River Corridor Survey

Prior to the river maintenance work of 1992, a river corridor survey was completed for the study reach. The methodology of the Nature Conservancy Council (NCC, now English

Nature, EN) was followed. A sketch map and record card was completed for each 500 m section within the study reach. These are presented in Appendix II.

The corridor survey concentrated on the physical features of the river channel, banks and adjacent land. Information relating to many features such as the location and type of aquatic vegetation, channel dimensions, substrates and habitat were recorded.

Following maintenance, it was not necessary to complete a second corridor survey as channel dimensions were not altered. A vegetational survey which concentrated on the location and percentage cover of aquatic vegetation was completed. This post-maintenance survey is presented in Appendix II.

6.4 Public Consultation

An annual conservation liaison meeting is held between the NRA and conservation bodies who have an interest with river maintenance work in the area. The work programme for the following year is discussed. The SSSI status of the area does not greatly affect the river management in the area although a second meeting is held to discuss maintenance of reens on the Levels.

Various organisations such as the Countryside Commission for Wales are invited to send a representative to these meetings. Any objections to the maintenance programme may be raised. If necessary, modifications to the programme can be made.

6.5 Farmer Assessment

All the farmers interviewed within the benefit area were aware of the SSSI designation of the area. The majority of farmers were aware of wildlife within the reens and reported swans, herons, kingfishers and oyster catchers as regular visitors. One farmer rears pheasants which are set free in the wild.

6.6 Water Quality

According to the National Water Classification (NWC) system, the water quality of the Dreneuydd and Broadway Reen is Class 2; fair quality. The water is suitable for potable

supply after advanced treatment. It is of moderate amenity value and capable of supporting coarse fish.

6.7 Channel and Bank Quality

The environmental quality of the reen channel and banks 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 reen channel and banks is classed as medium. At times of low flow there is a well developed transitional zone between the river and channel edge. Extensive fringes of emergent vegetation line the channel margins and four or more types of aquatic macrophyte plants can be found within a 500 m stretch.

The banks are simple in form consisting of predominantly two or three vegetation types with no trees or areas of scrub. The banks are typically 2 - 5 m in width. In the spring and summer a wide variety of flowering herbs are found on the banks indicating a good botanical quality. Dense stands of single species such as tall grasses are also present which provide good habitats for birds. Some areas of the bank are also grazed at low intensities by sheep and horses.

7 CONCLUSIONS

7.1 Scheme Appraisal

The existing maintenance scheme of regular weed clearance is viable in financial terms. The average annual benefit of maintenance in terms of its prevention in a deterioration in drainage status and increase in flooding is £ 6208. Average annual maintenance costs are approximately £ 4650. The benefit : cost ratio is therefore 1.33.

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 the Dreneuydd / Broadway Reen.

According to this method, the economic benefit : cost ratio is 1.0. This value is slightly greater than the 0.91 value obtained through detailed analysis ; the results of which are summarised in Section 7.1. Using these maintenance guidelines, the current maintenance scheme breaks even between costs and benefits in economic prices.

7.3 Impact of Maintenance on Channel Vegetation

The types of vegetation found within the Dreneuydd / Broadway Reen are discussed in Section 1.9. The impact of the submerged, emergent and floating vegetation on channel capacity is also discussed. Different vegetation types respond to maintenance in different ways.

The Canadian pondweed (*Elodea*) and sweet-grass (*Glyceria*) reproduce through a system of rhizomes (underground stems). The current method of maintenance - regular cutting, actually stimulates regrowth of this vegetation. The waterweed (*Potamogeton*) is a rooted plant. Desilting of the channel every few years is necessary in order to remove the rhizomes and to reduce the *Potamogeton* seed bank in the channel sediments.

The floating vegetation *Lemna* reproduces vegetatively and unless every fragment of this vegetation is removed from the channel, reproduction will occur and the weed will rapidly regrow. Chemical control is the most effective method of control in this case. However,

Lemna does not affect channel capacity as it is a free-floating plant and offers no resistance to flow. It can however, reduce water quality.

The current maintenance regime therefore is appropriate in controlling the channel vegetation. The vegetation is cut and removed from the channel every 18 months and some channel sediment is removed with the vegetation roots. This will reduce the rhizome and seed bank in the channel sediments.

7.4 Maintenance Best Practice

The 'best practice' vegetation maintenance methods for the Dreneuydd / Broadway Reen were determined using the 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 :

- 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, annual weed maintenance in the autumn has taken place. The majority of vegetation is removed although some areas of emergent, marginal vegetation may be left un-touched.

Generally, the maintenance regimes recommended as best practice in environmental terms for vegetation management are currently being applied to this reach of the Dreneuydd / Broadway Reen. However, if some more 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 :

- Single annual mowing / flailing in autumn / winter leaving a toe strip over 1 m wide; and,
- Light grazing.

The majority of the banks in the grassland areas are grazed by sheep and cattle and are not flail mown. Grazing regimes are relatively extensive and if the bank is un-fenced, the bank vegetation is moderately grazed. Single annual mowing of the banks may enhance the environmental quality of the channel.

7.5 Recommendations

It is recommended that further research examines :-

- the impact of a reduced maintenance frequency on land drainage and flooding within the benefit area;
- the impact of reduced channel maintenance on channel environmental quality; and,
- the impact of cutting the vegetation on one bank only on channel hydraulics, flooding, land drainage and 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

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APPENDIX I

Example of input and output data for the watertable model

Dreneuydd/Broadway Reen
Block Number 104
Cross-section 1

	Input Data	Output Data
	River height (m AOD)	Watertable height (m AOD)
Week 1994		
1	3.13	4.50
2	3.04	4.50
3	3.07	4.45
4	3.41	4.34
5	3.52	4.50
6	3.02	4.50
7	3.03	4.45
8	3.12	4.50
9	2.98	4.27
10	2.95	4.35
11	3.20	4.50
12	3.12	4.50
13	2.92	4.29
14	2.82	4.14
15	2.87	4.18
16	2.98	4.50
17	2.82	4.50
18	2.82	4.48
19	2.87	4.06
20	3.02	4.05
21	3.12	3.99
22	3.12	3.99
23	3.13	4.03
24	3.27	4.15
25	3.22	3.80
26	3.12	3.80
27	3.10	3.76
28	3.06	3.84
29	3.07	3.79

Example of drainage status classification, Dreneuydd/Broadway Reen

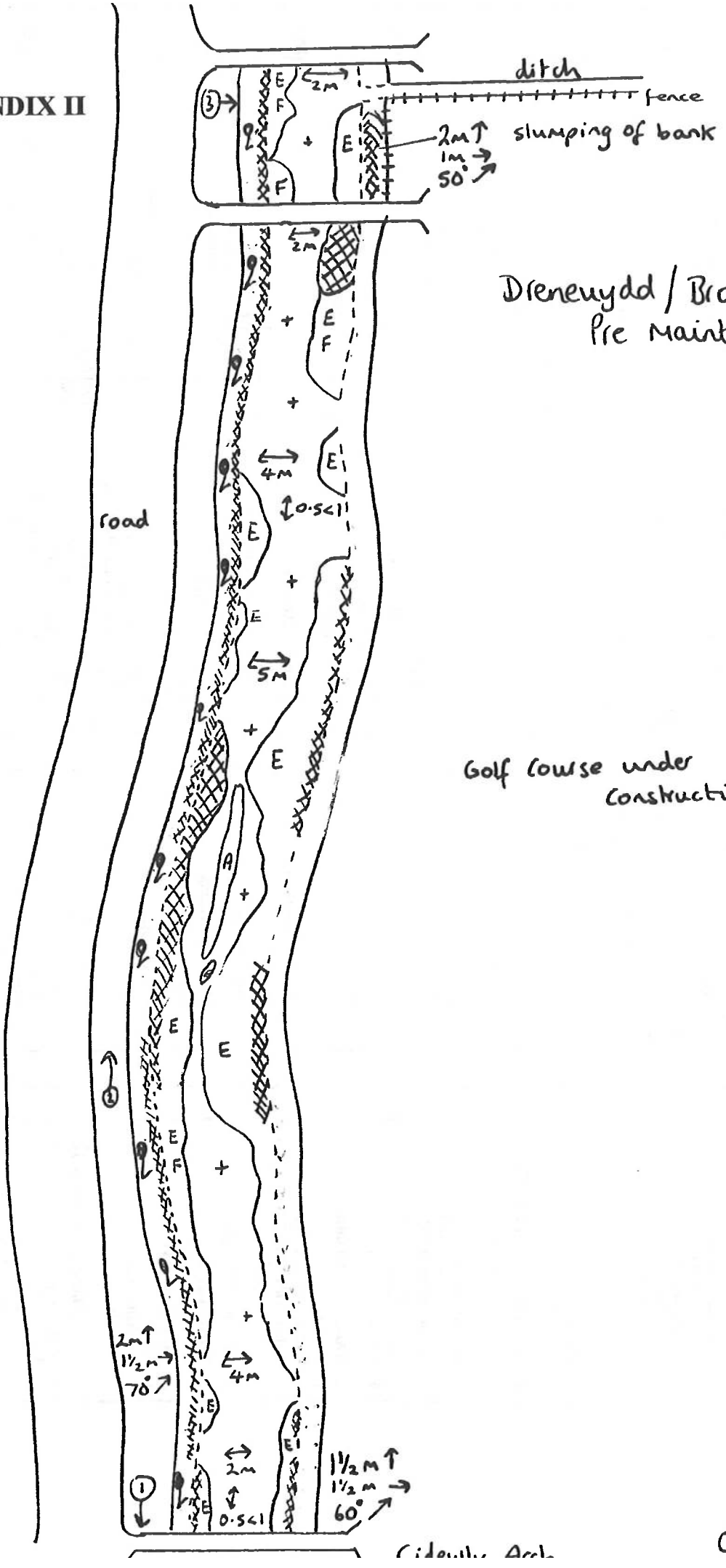
With maintenance

Block 104	Watertable depth (m)	No. of weeks 1994	Spring 1994	No. of weeks	Summer 1994	No. of weeks	Autumn 1994	No. of weeks
>0.5	4.05	22	4.05	5	4.05	13	4.05	6
0.3><0.5m	4.25	12	4.25	6	4.25	0	4.25	7
<0.3m	4.55	18	4.55	2	4.55	0	4.55	0
Drainage status classification, according to time watertable is within the G, B, VB drainage bands				Bad		Good		Bad

Without maintenance

	Watertable depth (m)	No. of weeks 1994	Spring 1994	No. of weeks	Summer 1994	No. of weeks	Autumn 1994	No. of weeks
>0.5	4.05	8	4.05	0	4.05	8	4.05	3
0.3><0.5m	4.25	10	4.25	4	4.25	4	4.25	8
<0.3m	4.55	34	4.55	9	4.55	1	4.55	2
Drainage status classification, according to time watertable is within the G, B, VB drainage bands				Very Bad		Bad		Bad

APPENDIX II


ditch
fence
2m ↑ slumping of bank
1m →
50°
Drenewydd / Broadway Reen
Pre Maintenance
road
Golf course under construction
2m ↑
1½m →
70°
1½m ↑
1½m →
60°
Flow
0-0·5Km
photographic

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD/BROADWAY REEN

Km No. 0 - 0·5

Date 31/3/92

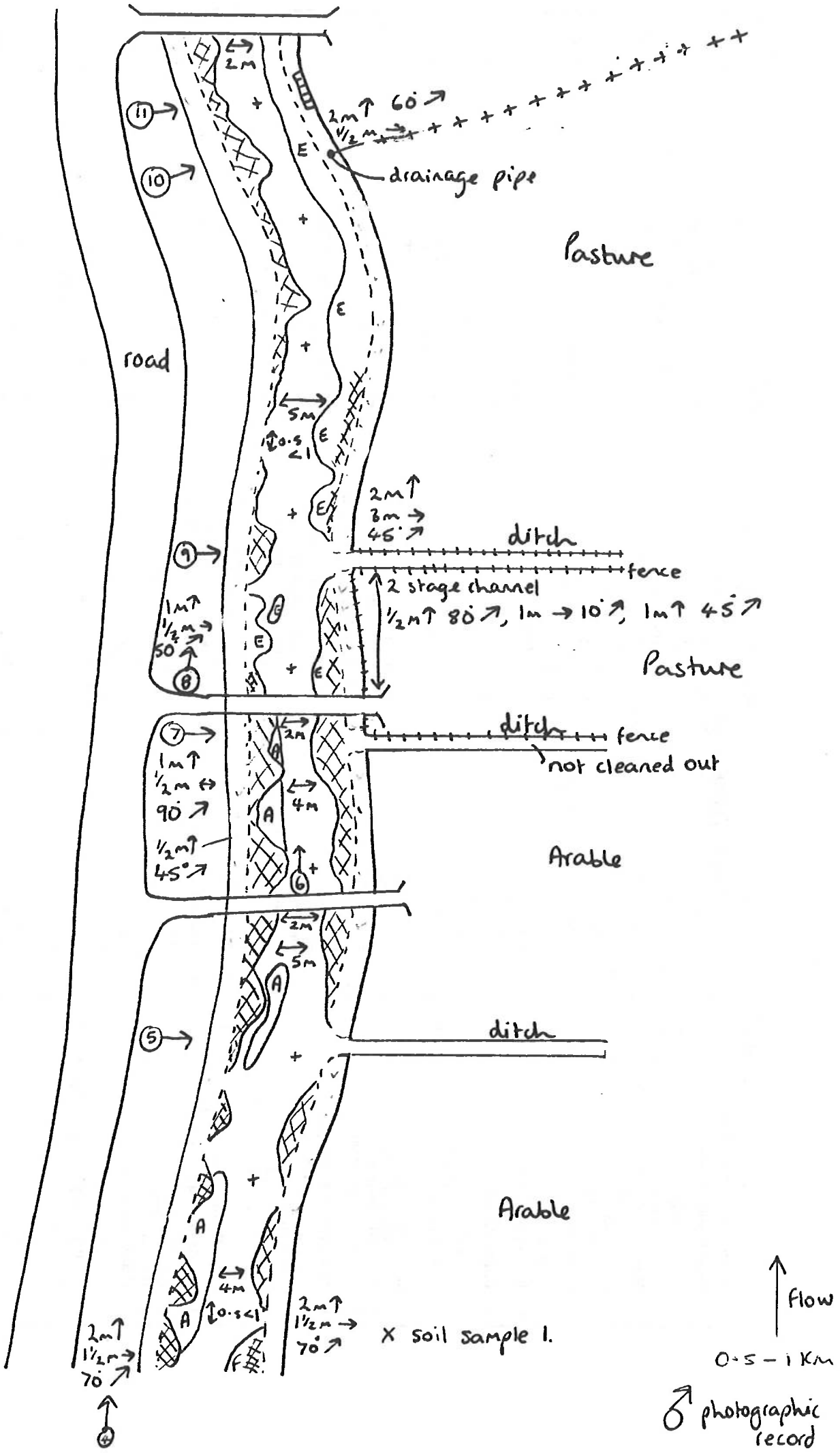
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		1
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		9
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	100	
railway disused		
used		
other		100

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m		
>2m	100	100
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope <30°		10
30·<60°	100	90
60·<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.	100	60
Dense open %.	100	
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		3
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25·<.5		
0.5·<1.0		100
>1.0m		
Width <1		100
1·<5		
5·<10		
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
+ silt/mud		100
clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		20
emergent 1·2m wide		30
emergent >2m wide		
total veget area		50
B bryophytes		
E emergents	90	
A submerged	10	
F floating		
algae % of stretch	5	

total to 100%


road
Pasture
drainage pipe
ditch
fence
2 stage channel
½m↑ 80↗, 1m → 10↗, 1m↑ 45↗
Pasture
ditch
fence
not cleaned out
Arable
ditch
Arable
X soil sample 1.
Flow
0·5 – 1 Km
photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		50
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REEN

Km No. O 5 – 1

Date 31/3/92

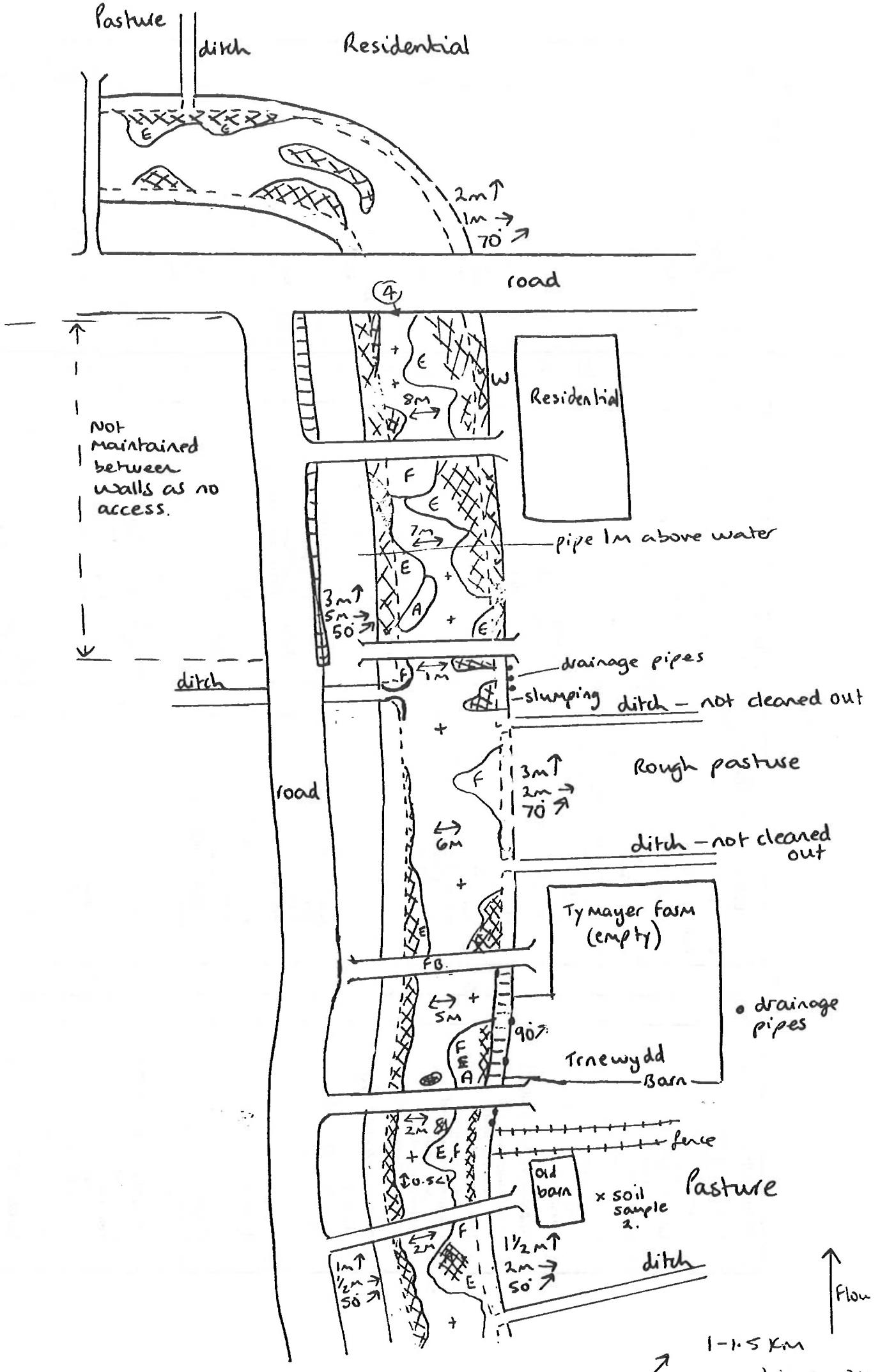
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj. land in each stretch	
canal =		3
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		50
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		10
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	100	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		1
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m		
1-<2.5m	100	70
2.5-<5m		30
>5m		
Slope <30°		
30-<60°	60	30
60-<90°	40	50
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	3
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	100
0.5-<1.0	
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	80
emergent 1-2m wide	20
emergent >2m wide	
total veget. area	40
B bryophytes	
E emergents	20
A submerged	
F floating	
algae % of stretch	

total 10-100%


Pasture
ditch
Residential
2m
1m
70°
road
4
Residential
8m
Not maintained between walls as no access.
pipe 1m above water
3m
5m
50°
drainage pipes
ditch
slumping ditch – not cleaned out
road
3m
2m
70°
Rough pasture
6m
ditch – not cleaned out
Ty Mayer Farm (empty)
FB
5m
90°
drainage pipes
Trnewydd Barn
2m
fence
E,f
0.5m
old barn
× soil sample 2.
Pasture
1½m
2m
50°
ditch
1m
½m
50°
Flow
1-1.5 km
Photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		50
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REEN

Km No. 1 – 1·5 Km

Date 31/3/92

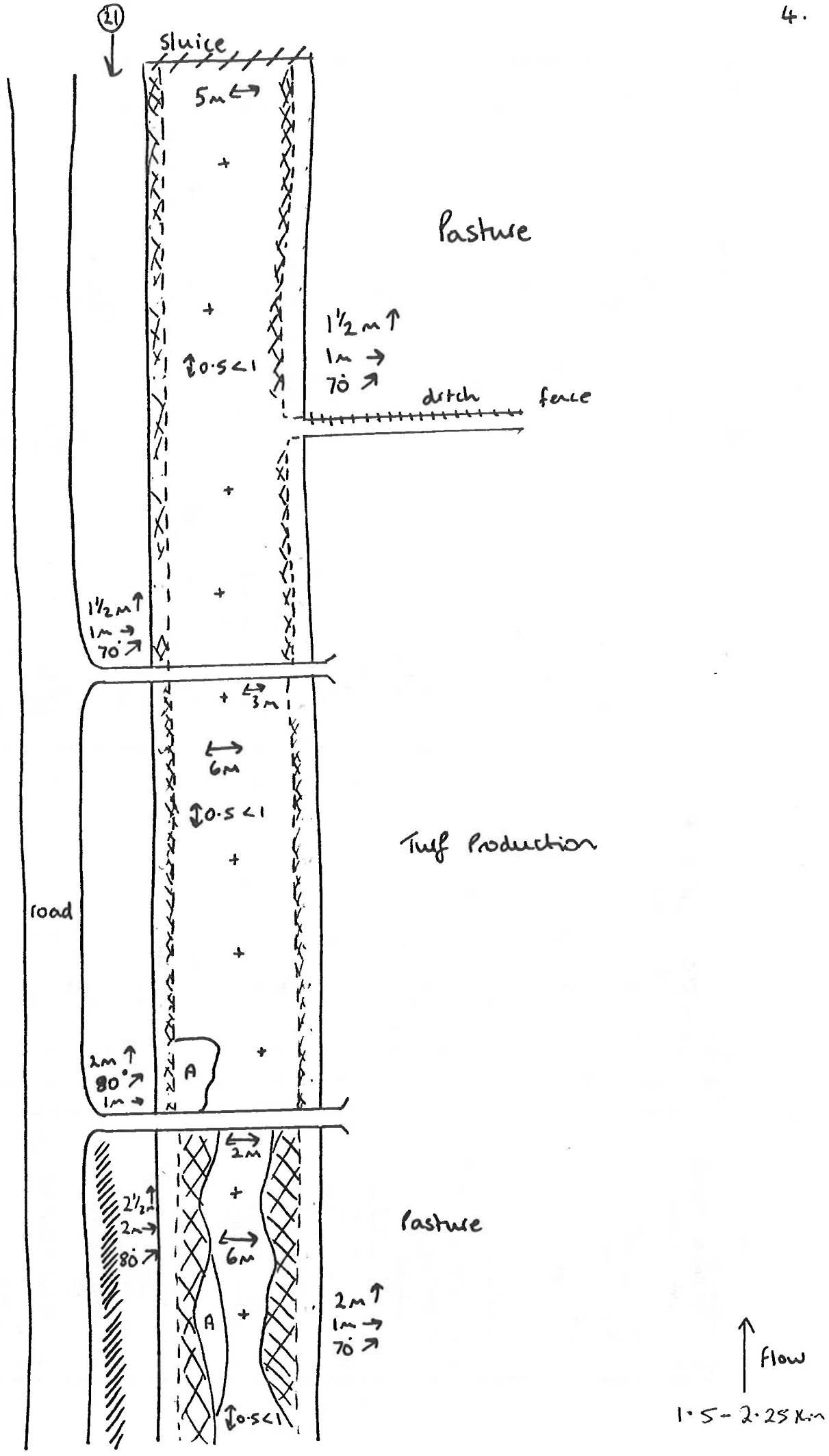
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		
ditch	1	4
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		2
wall	30	
building		30
caravans		
fish farm		
silage clamp		
sewage works		
garden		20
stick pile		
flood debris		
road	100	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		10
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	60	70
>2m	40	30
Width <1m	60	
1·<2.5m		100
2.5·<5m	40	
>5m		
Slope <30°		
30·<60°	100	20
60·<90°		80
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	90
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		1
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %	20	
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		7
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25·<.5		100
0.5·<1.0		
>1.0m		
Width <1		
1·<5		20
5·<10		80
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		10
emergent 1·2m wide		30
emergent >2m wide		50
total veget area		85
B bryophytes		
E emergents	80	
A submerged	20	
F floating		
algae % of stretch	15	

total to 100%


21
Sluice
5m
Pasture
1½m
1m
70°
ditch
fence
0.5<1
1½m
1m
70°
3m
6m
0.5<1
Turf Production
road
2m
80°
1m
A
2m
2½m
2m
80°
6m
A
2m
1m
70°
0.5<1
Pasture
Flow
1·5 - 2·25 km

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		40
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		60
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REEN

Km No. 1·5 – 2·25

Date 31/3/92

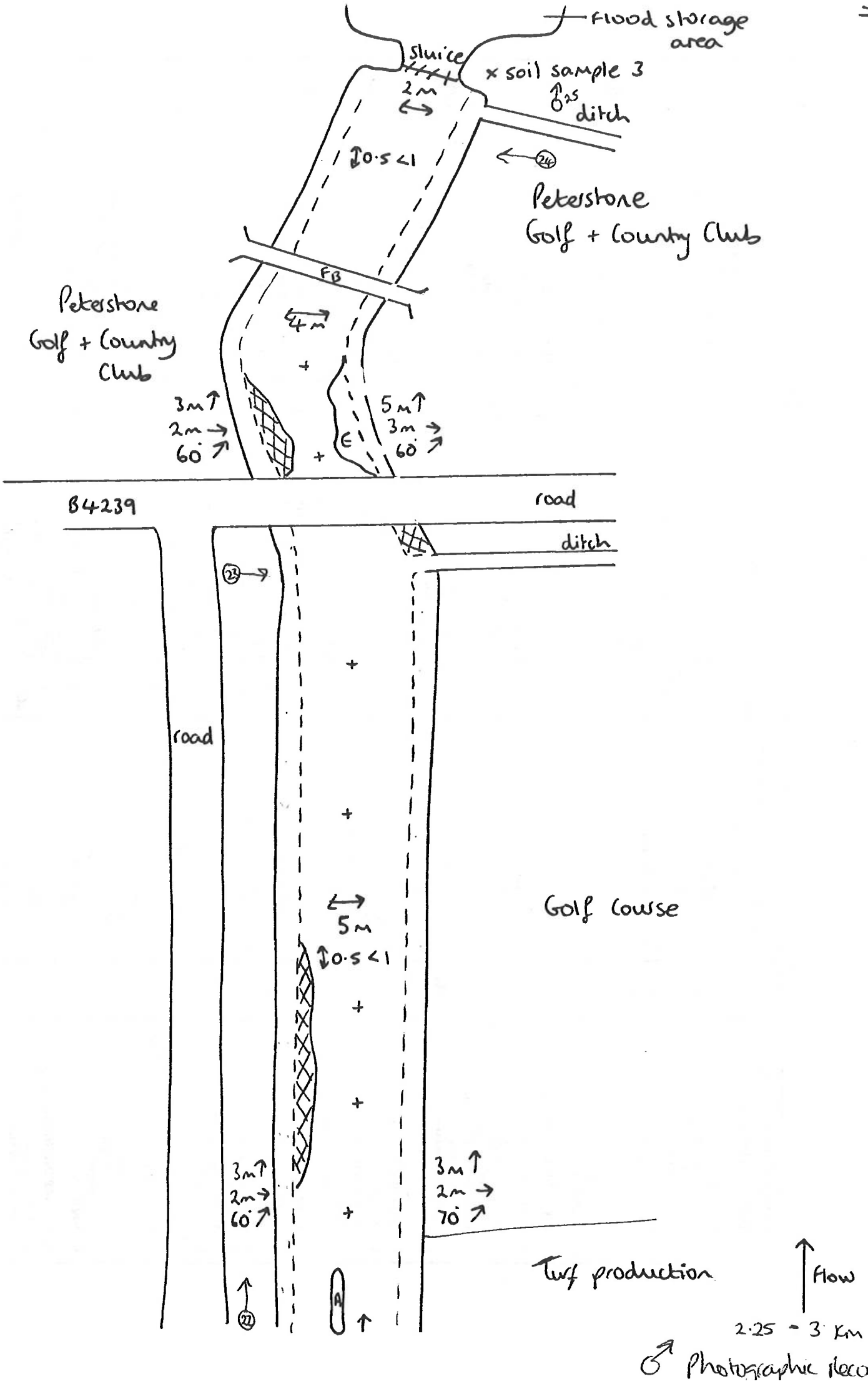
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		1
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	100	
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff (1m ↑)		
soft earth cliff (> 80°)		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	90	100
>2m	10	
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope <30°		
30·<60°	100	100
60·<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %	20	
Sparse Scrub/shrubs %		
Reed/Sedge %	20	
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	1
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	100
0.5·<1.0	
>1.0m	
Width <1	
1·<5	60
5·<10	40
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	80
emergent 1·2m wide	20
emergent >2m wide	
total veget area	20
B bryophytes	
E emergents	90
A submerged	10
F floating	
algae % of stretch	

(total 10 100%)


Flood storage area
sluice
x soil sample 3
2m
ditch
0.5 < 1
Peterstone Golf + Country Club
FB
Peterstone Golf + Country Club
4m
3m
2m
60°
5m
3m
60°
B4239
road
ditch
road
5m
0.5 < 1
Golf Course
3m
2m
60°
3m
2m
70°
Turf production
Flow
2·25 - 3 km
Photographic record

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REEN

Km No. 2·25 – 3

Date 31/3/92

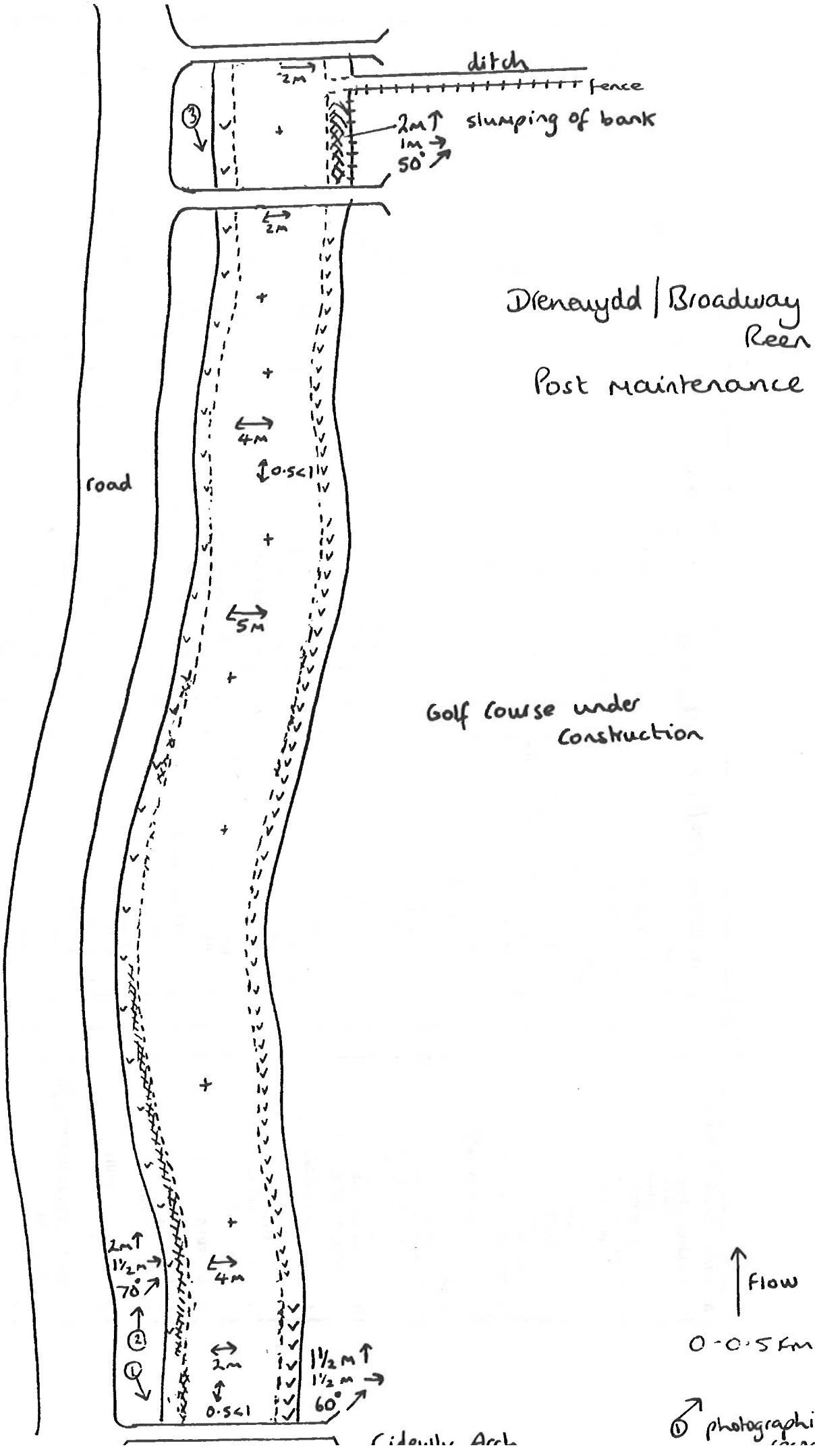
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		2
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland	60	90
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	40	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m		
>2m	100	100
Width <1m		70
1·<2.5m		30
2.5·<5m	100	
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow - recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		2
weirs/500m		1
locks/500m		
inlet/500m		
Depth <.25m	%	
.25·<.5		100
0.5·<1.0		
>1.0m		
Width <1		
1·<5		
5·<10		100
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		98
riffle		
rapids		
run		2
waterfall		
protruding rocks		
Margins		
shingle + bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		90
emergent 1·2m wide		10
emergent >2m wide		
total veget. area		25
B bryophytes		
E emergents	95	
A submerged	5	
F floating		
algae % of stretch		

total to 100%


ditch
fence
2m
slumping of bank
2m ↑
1m →
50°
3
2m
Drenaydd / Broadway
Rees
Post maintenance
road
4m
0.5<1
5m
Golf course under
construction
2m ↑
1½m →
70°
2
1
4m
2m
0.5<1
1½m ↑
1½m →
60°
Flow
0-0.5Km
photographic

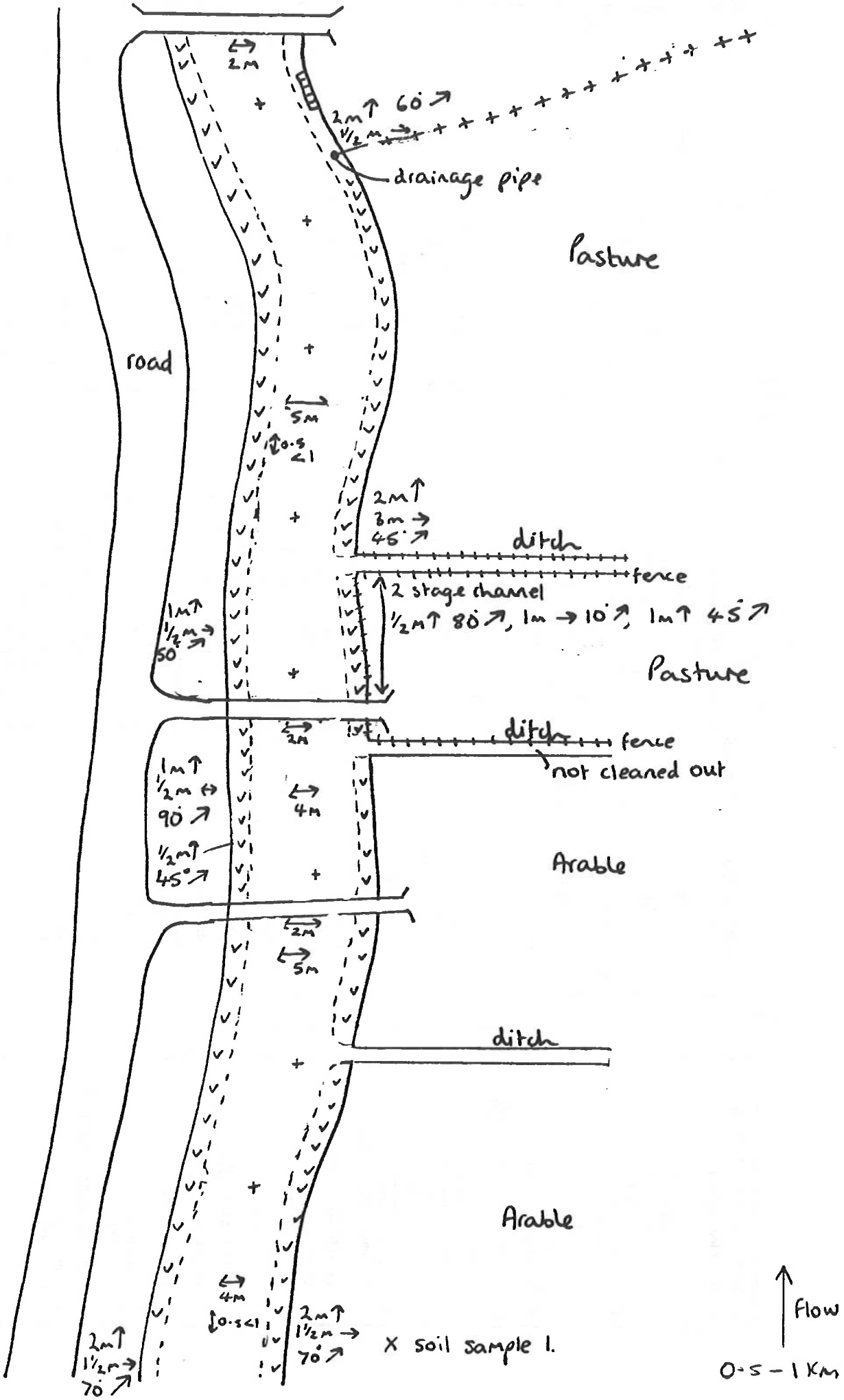
	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWY DD / BROADWAY REEN
Km No. 0-0-5
Date 7/4/93
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj	
canal =	laid in	
ditch	each stretch	
dyke		1
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		9
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	100	
railway disused		
used		
other		100

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m ↑		
soft earth cliff > 80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m		
>2m	100	100
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		10
30-<60°	100	90
60-<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.	40	6
Dense open %.		
Sparse open %.		
Reseeded or mown %.	100	100
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
width at top rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		3
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		
0.5-<1.0		100
>1.0m		
Width <1		100
1-<5		
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1-2m wide		
emergent >2m wide		
total veget area		
B bryophytes		Total
E emergents		1 to 100%
A submerged		
F floating		
algae % of stretch		


2m
2m ↑ 60 ↗
½m →
drainage pipe
Pasture
road
5m
0·5 < 1
2m ↑
3m →
45 ↗
ditch
fence
2 stage channel
½m ↑ 80 ↗, 1m → 10 ↗, 1m ↑ 45 ↗
1m ↑
½m →
50 ↗
Pasture
2m
ditch
fence
not cleaned out
1m ↑
½m ↔
90 ↗
½m ↑
45° ↗
4m
Arable
2m
5m
ditch
4m
0·5<1
2m ↑
1½m →
70 ↗
2m ↑
1½m →
70 ↗
X soil sample 1.
Flow
0·5 – 1 Km

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		50
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REEN

Km No. 0·5 – 1

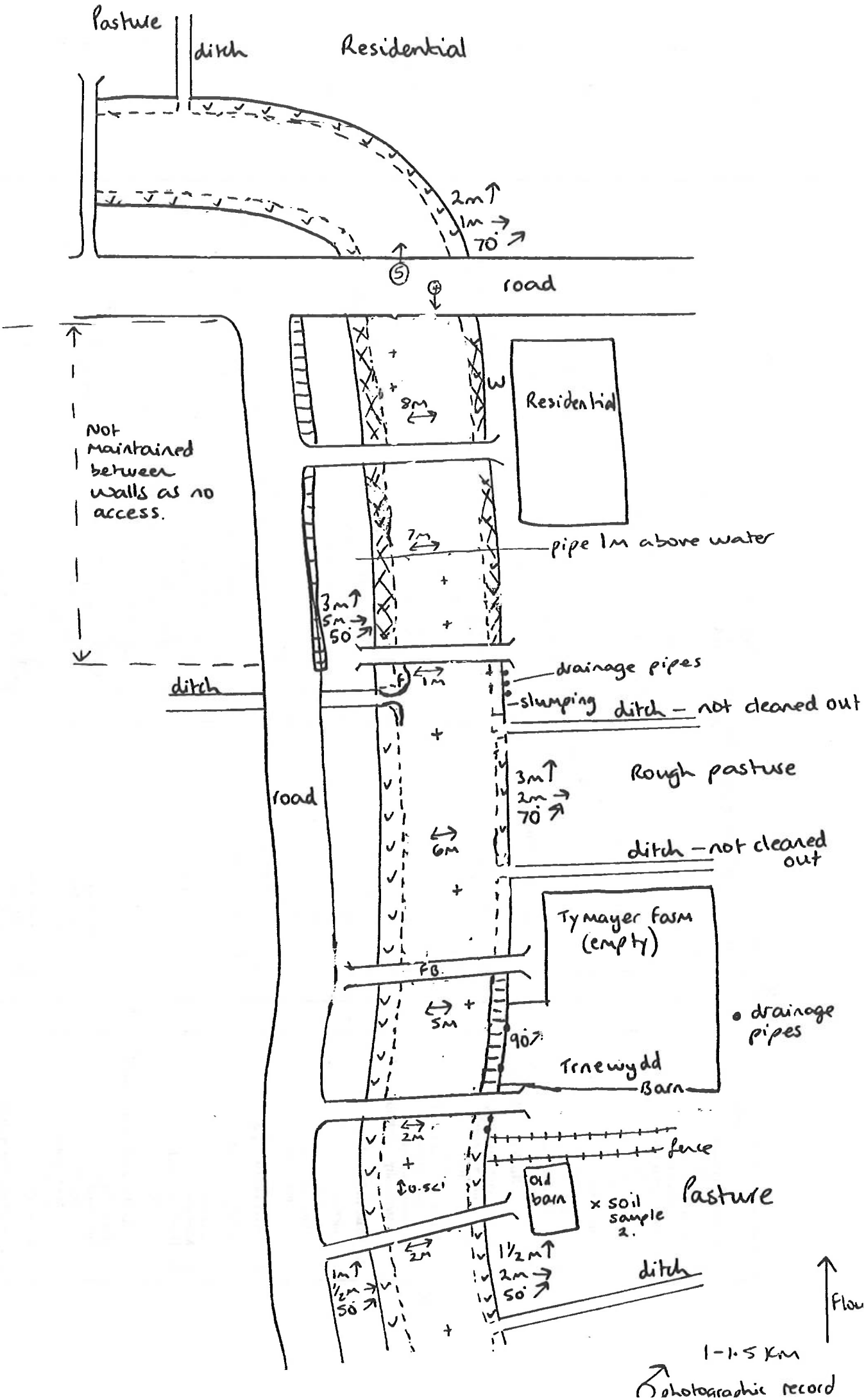
Date 7/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal ↕	% of adj land in each stretch	
canal =		
ditch		3
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		50
amenity grassland		
ephemeral/short herb		
hedge ↕		
hedge =		
fence on bank		10
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		100
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2.5m	100	70
2.5·<5m		30
>5m		
Slope <30°		
30·<60°	60	50
60·<90°	40	50
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %	100	100
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, ↕ bare		
shingle and rock		
shingle, rock ↕ veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		3
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	100
.25·<.5		
0.5·<1.0		
>1.0m		
Width <1		100
1·<5		
5·<10		
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		100
∔ silt/mud		
clay		
peat		
Habitats and Flow		
pool		100
slack		
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ↕ bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1·2m wide		
emergent >2m wide		
total veget area		
B bryophytes		total to 100%
E emergents		
A submerged		
F floating		
algae % of stretch		


Pasture
ditch
Residential
2m↑
1m→
70°↗
⑤
road
Not maintained between walls as no access.
8m
W
Residential
7m
pipe 1m above water
3m↑
5m→
50°↗
drainage pipes
ditch
F
1m
slumping
ditch – not cleaned out
road
3m↑
2m→
70°↗
Rough pasture
6m
ditch – not cleaned out
Tymayer Farm (empty)
FB
5m
90°
drainage pipes
Trnewydd Barn
2m
fence
↕0.5cl
old barn
x soil sample 2.
Pasture
1m↑
½m→
50°↗
2m
1½m↑
2m→
50°↗
ditch
Flow
1-1.5 Km
photographic record

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		50
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

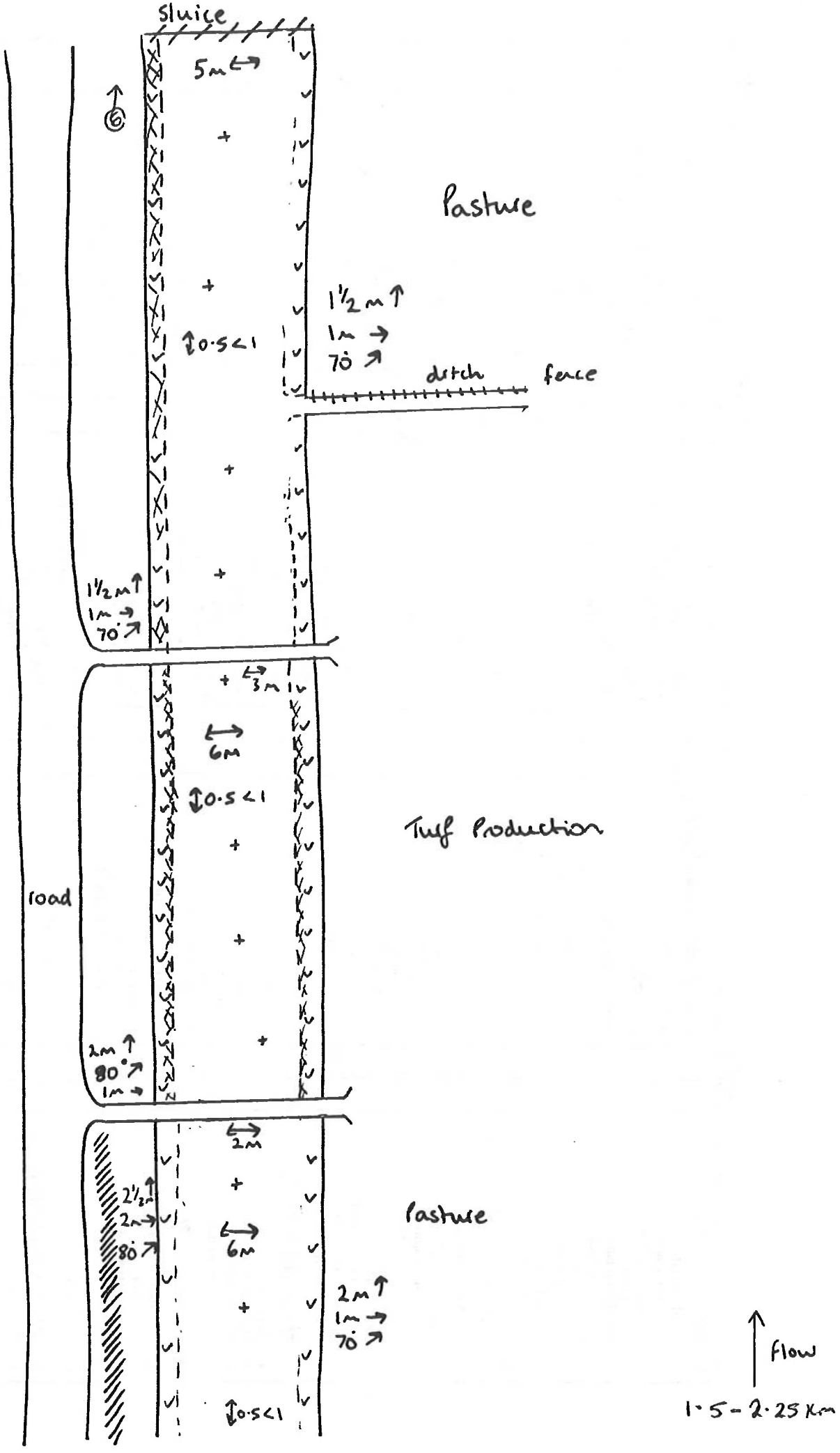
RIVER DRENEWYDD / BROADWAY REEN
Km No. 1 - 1.5
Date 7/4/93
Surveyor JALD.

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj bank in each stretch)		
canal =		
ditch	1	4
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		2
wall	30	
building		30
caravans		
fish farm		
silage clamp		
sewage works		
garden		20
stick pile		
flood debris		
road	100	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	60	70
>2m	40	30
Width <1m	50	
1-<2.5m		100
2.5-<5m	50	
>5m		
Slope <30°		
30-<60°	100	20
60-<90°		80
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	90
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %	100	100
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		7
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	10	
.25-<.5		100
0.5-<1.0		
>1.0m		
Width <1		
1-<5		20
5-<10		80
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
P pool		
slack		100
rr riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1-2m wide		
emergent >2m wide		
total veget. area		
B bryophytes		
E emergents		
A submerged		
F floating		
algae % of stretch		

total = 100%



⑥ photographic record

RIVER DRENEWYDD / BROADWAY REEN

Km No. 1·5 – 2·25

Date 7/4/93

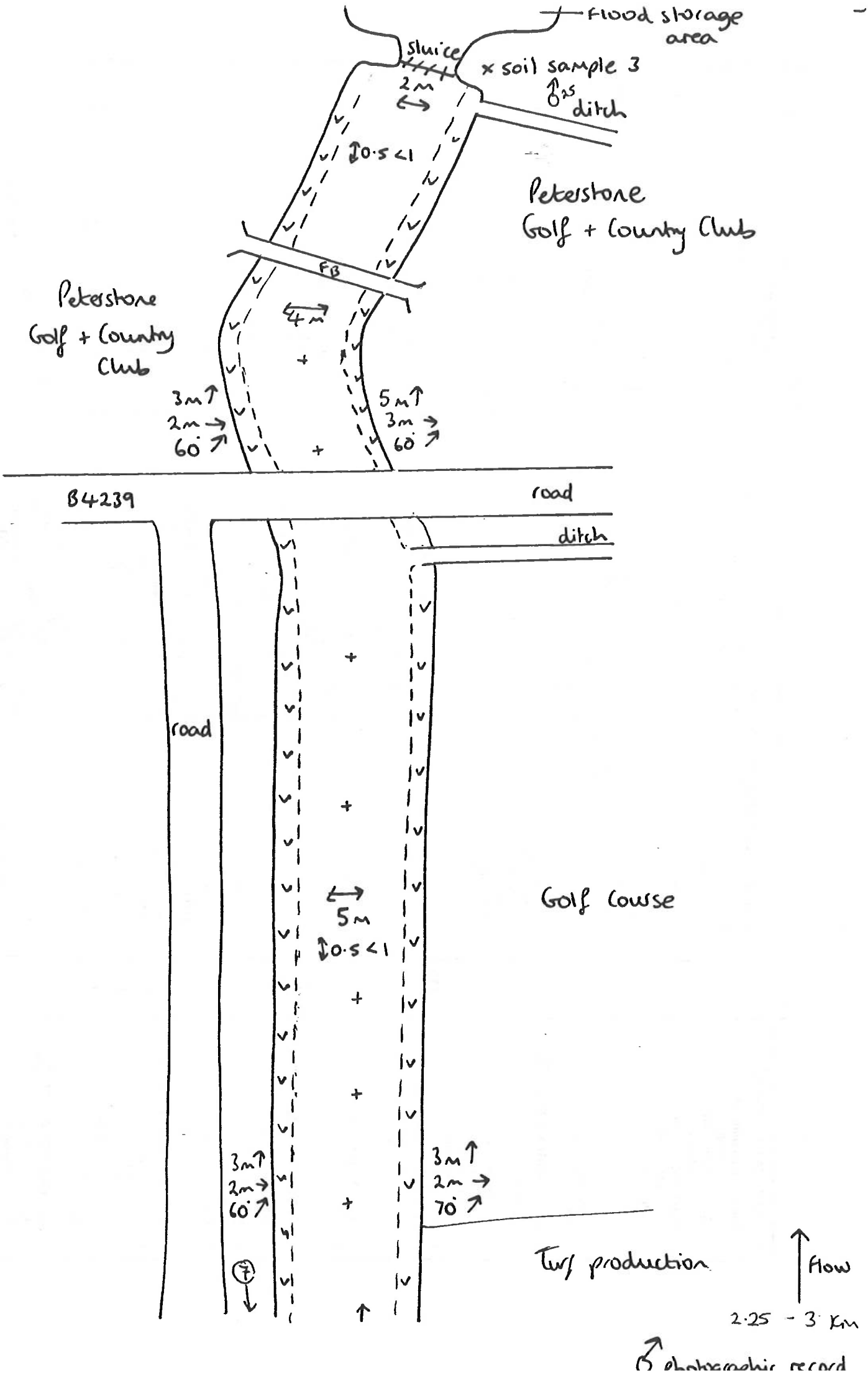
Surveyor JALD.

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		40
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		60
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

	LB	RB
G. OPEN WATER		
1. Standing – canal + (% of adj land in each stretch)		
canal =		1
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		100
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %.		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	90	100
>2m	10	
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.	100	100
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth – maturing		
earth – with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		2
weirs/500m		1
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		100
0.5-<1.0		
>1.0m		
Width <1		
1-<5		60
5-<10		40
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
+ silt/mud		100
clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1-2m wide		
emergent >2m wide		
total veget area		
B bryophytes		total = 100%
E emergents		
A submerged		
F floating		
algae % of stretch		


Flood storage area
Sluice
× soil sample 3
2m
ditch
↕0.5<1
Peterstone Golf + Country Club
FB
Peterstone Golf + Country Club
4m
3m↑ 2m→ 60°↗
5m↑ 3m→ 60°↗
B4239
road
ditch
road
5m
↕0.5<1
Golf course
3m↑ 2m→ 60°↗
3m↑ 2m→ 70°↗
Turf production
Flow
2·25 - 3 km
photographic record

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DRENEWYDD / BROADWAY REGN:
Km No. 2·25 – 3
Date 7/4/93
Surveyor JALD.

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj. bank in each stretch)		2
canal =		
ditch		
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland	60	90
ephemeral/short herb		
hedge +		
hedge =		
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road	40	
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m		
>2m	100	100
Width <1m		
1-<2.5m		70
2.5-<5m	100	30
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %	100	100
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	2
weirs/500m	1
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	100
0.5-<1.0	
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	98
rifle	
rapids	
run	2
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	total to 100%
E emergents	
A submerged	
F floating algae % of stretch	

DYSYNNI LOW LEVEL DRAIN

R&D 317/22/ST

CONTENTS

DYSYNNI LOW LEVEL DRAIN

1. BACKGROUND 1

1.1 PHYSICAL BACKGROUND 1

1.2 STUDY REACH 1

1.3 RIVER CHARACTERISTICS 1

1.4 LAND DRAINAGE 3

1.5 GEOLOGY, SOILS AND LAND CAPABILITY 3

1.6 CAPITAL WORKS 7

1.7 RIVER MAINTENANCE 7

1.7.1 Farmers views on maintenance 7

1.7.2 Alternative maintenance strategies 8

1.8 CLIMATE 8

1.9 AQUATIC VEGETATION 9

1.9.1 Floating vegetation 10

1.9.2 Emergent vegetation 10

1.9.3 Submerged vegetation 10

1.9.4 Algae 11

2. FARM SURVEY 12

2.1 INTRODUCTION 12

2.2 FARM TYPE, SIZE AND TENURE 12

2.3 LIVESTOCK ENTERPRISES 12

2.4 LAND USE IN THE BENEFIT AREA 13

2.5 TURNOUT AND YARDING DATES 13

2.6 GRASS CONSERVATION 16

2.7 NITROGEN APPLICATION 16

2.8 FLOODING 17

2.9 WATERLOGGING 17

2.10 STATISTICAL ANALYSIS 20

3 HYDRAULIC AND HYDROLOGICAL INFORMATION 21

3.1 INTRODUCTION 21

3.2 CROSS-SECTION SURVEYS 21

3.3 FLOOD RETURN PERIOD 27

4. LAND DRAINAGE 29

4.1 FIELD DRAINAGE STATUS 29

5 SCHEME APPRAISAL 32

5.1 BENEFIT ASSESSMENT 32

5.2 MAINTENANCE COSTS 38

5.3 SCHEME APPRAISAL 38

6 ENVIRONMENT 40

6.1 INTRODUCTION 40

6.2 RIVER CORRIDOR SURVEY 40

6.3 PUBLIC CONSULTATION 40

6.4 FARMER ASSESSMENT 40

6.5 WATER QUALITY 41

6.6 CHANNEL AND BANK QUALITY 41

7 CONCLUSIONS 42

7.1 SCHEME APPRAISAL 42

7.2 GUIDELINES FOR RIVER MAINTENANCE 42

7.3 IMPACT OF MAINTENANCE ON CHANNEL VEGETATION 42

7.4 MAINTENANCE BEST PRACTICE 43

Channel *43*

Bank *44*

7.5 RECOMMENDATIONS 44

7.6 EPILOGUE 44

8. REFERENCES 45

APPENDIX I Example of input and output data for the watertable model

APPENDIX II River corridor survey

LIST OF FIGURES

Figure 1 Site location 2

Figure 2 Land drainage and location of land blocks 5

Figure 3 Soil profiles 6

Figure 4 Land use in the benefit area 15

Figure 5 Areas prone to flooding and location of cross-sections 19

Figure 6 Channel information ..... 22 - 26

Figure 7 Flood return period curve 28

LIST OF TABLES

Table 1.1 Rainfall totals 9
Table 1.2 Probability of climatic condition 9
Table 2.1 Turnout dates 13
Table 2.2 Yarding dates 14
Table 2.3 Grass conservation 16
Table 2.4 Nitrogen application rates 16
Table 2.5 Farmer assessment of wetness condition 17
Table 3.1 Bankfull capacity and return periods 21
Table 3.2 Flood return periods and flooded areas 27
Table 4.1 Drainage status for wet, average and dry seasons, with/without maintenance 30
Table 5.1 Financial net returns 34
Table 5.2 Economic net returns 34
Table 5.3 Flood costs 35
Table 5.4 Change in financial net returns 36
Table 5.5 Change in economic net returns 37
Table 5.6 Farmer assessment of maintenance benefits 38
Table 5.7 Maintenance scheme appraisal: Dysynni Low Level Drain 39

WELSH DYSYNNI LOW LEVEL DRAIN

1. BACKGROUND

1.1 Physical Background

The Dysynni Low Level Drain runs parallel to the Afon Dysynni in the Dysynni Valley near Tywyn in Merrioneth, North Wales (Figure 1). From source to mouth it is 8.7 km in length. The flat valley floor ranges from approximately one to 1.3 km in width, bounded by steeply rising mountains to the north, south and east.

The Afon Dysynni is a flood banked carrier which conveys upland water through the valley to the outfall at Aber Dysynni. Two other upland carriers transfer water from the valley sides into the Afon Dysynni at GR. 622 053 and GR. 608 052. The catchment area of the Dysynni Low Level Drain is estimated to be 990 ha.

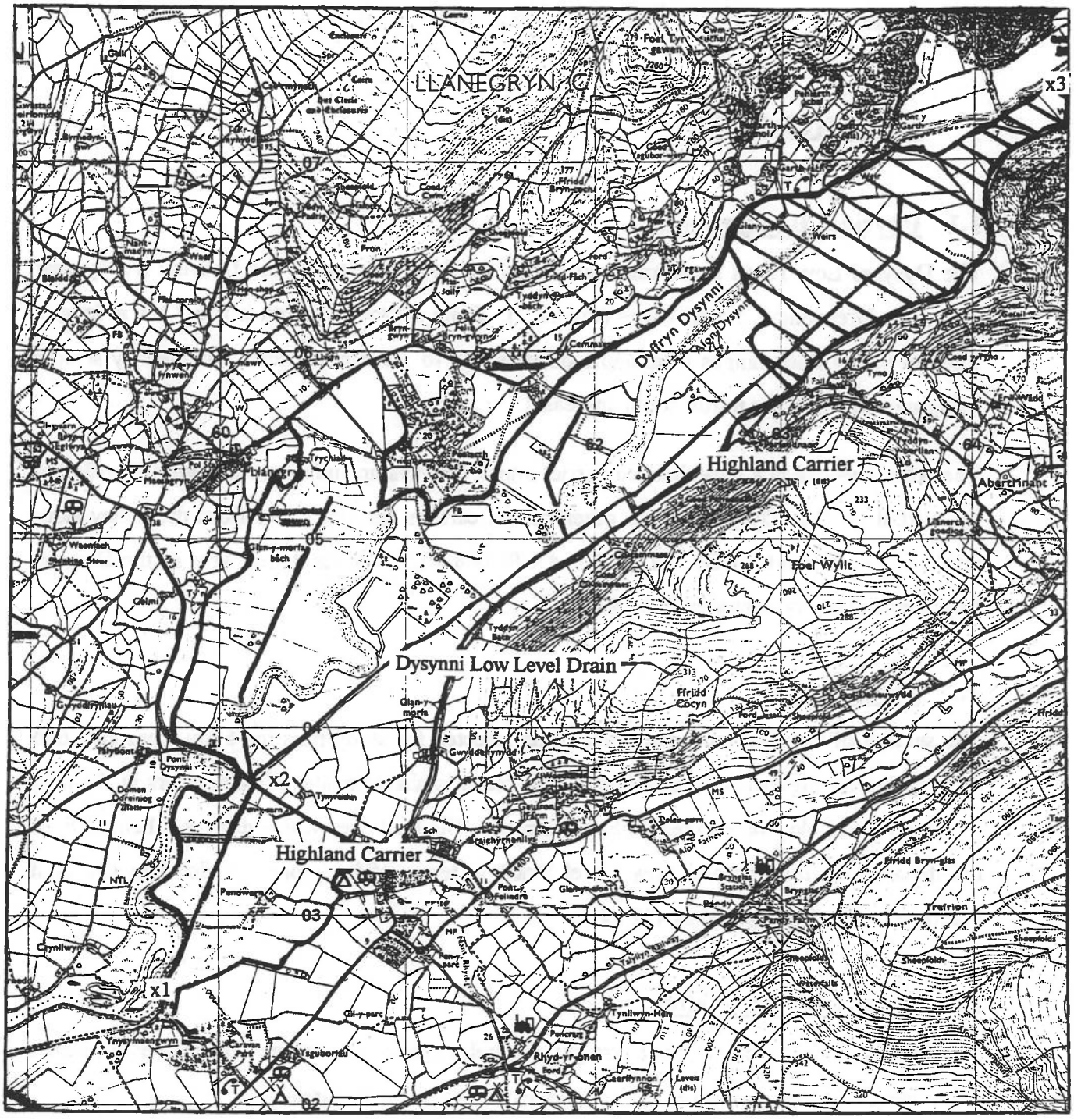
1.2 Study Reach

The section of the Dysynni Low Level Drain selected for study runs for 6 km from GR. 636 065 to Ynsymaengwyn (GR. 602 038). This reach is characteristic of main rivers in the area on which weed clearance is regularly performed. The land area which derives a benefit from maintenance on the Dysynni Low Level Drain in terms of its impact on flooding and land drainage has been estimated as 452 ha.

1.3 River Characteristics

The Dysynni Low Level Drain is a straight channel, trapezoidal in shape. It flows over pasture for its entire length; both grass under the extensive system and marshland.

Channel width varies from 1 m to 8 m, averaging 4 m. Freeboard is consistently high, averaging 1 m in height. Bank angles range from 50 to 90 degrees. Both grassed banks and solid earth cliffs are common. Bog oaks provide a natural revetment along short lengths of the bank. These are remnants of oak trees which were once common in the valley.



Legend :

Scale 1 : 20 000

Benefit area

Location of soil cores

Agricultural land classification Class 4

Agricultural land classification Class 5

Figure 1 Dysynni Low Level Drain

The flow of water is slow due to the shallow gradient and low lying nature of the land. Slack water predominates with the occasional small pool. Silt and mud are the dominant bed substrates.

1.4 Land Drainage

The basic pattern of upland and lowland carriers within the valley is the result of a capital scheme which saw the creation of the system as it stands today, and high levels of maintenance. The Dysynni Low Level Drain passes under the highland water carriers in two culverts at GR. 622 052 and GR. 601 035 near Pen-y-sarn. It provides an outfall for field ditches and under-drains for all the valley south of the Afon Dysynni. The 'main' river extends from the outfall upstream to GR. 623 053. Upstream of this location, the Dysynni Low Level Drain is an adopted ditch. Similarly, the main drainage channels to the north of the Afon Dysynni are adopted ditches and not 'main' river (Figure 1). Maintenance on these adopted ditches is controlled by the Internal Drainage District (IDD) but is carried out by the NRA.

The valley floor to the north of the Afon Dysynni is drained by two lowland carriers which pass under the Afon Dysynni at GR. 618 051 and GR. 601 041.

Figure 2 indicates the areas of land within the benefit area which have field drainage pipes installed. Of the land surveyed, 32 % is under-drained. The remaining area drains naturally by gravity.

1.5 Geology, Soils and Land Capability

The geology of the Dysynni Valley is characterised by rocks of the Palaeozoic era; hard, thinly bedded Silurian shales and mudstones.

Amorphous semi-fibrous peats of the Adventurers' Association dominate the soils within the valley. The Adventurers' series is typical of an earthy peat with a humified subsoil and well decomposed top soil. The fine silty alluvial gley soils of the Conway Series (Conway Association), are characterised by a grey brown colour and yellow/brown mottling. Soil profiles which were taken at three locations within the study reach are shown in Figure 3.

Both soil series are waterlogged throughout the winter and the risk of poaching (surface damage by livestock) is high. Groundwater levels are high and infiltration slow in soil of the

Conway series. The soil profile is 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 soils with these water regimes as having a Wetness Class of IV or V (Rudeforth et al, 1984). The average annual rainfall value is high being approximately 987 mm.

The Agricultural Land Classification system of the Ministry of Agriculture, Fisheries and Food (MAFF) classifies the majority of the land area served by the Dysynni Low Level Drain as Grade 5 agricultural land (Figure 1). This is land of very poor quality with land use restricted to permanent pasture and rough grazing. Land at the upstream limit of the study area is classed as Grade 4. This land is of poor quality on which the range of crops grown and yields are restricted. It is mainly suited to grass.



Legend :

Scale 1 : 20 000

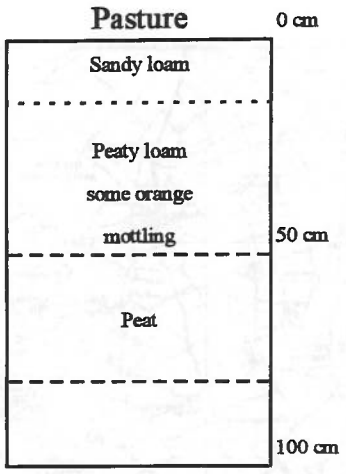
☐ Piped drainage

[101] Block code

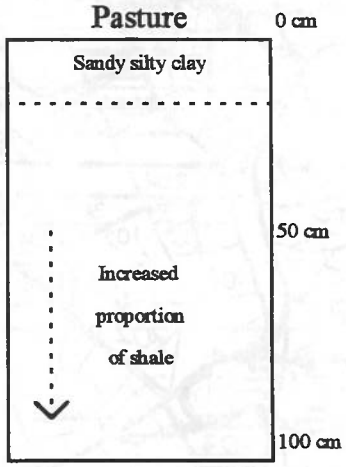
☰ Natural drainage

Figure 2 Land drainage and land use blocks

Grid Reference	597 026
Soil Core Number	1
Soil Colour	Dark brown
Comments	Increasingly peaty with depth



Grid Reference	602 038
Soil Core Number	2
Soil Colour	Grey
Comments	Increased shale with depth



Grid Reference	646 074
Soil Core Number	3
Soil Colour	Brown
Comments	No mottling or gleying

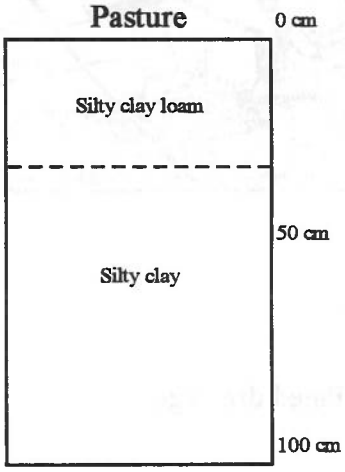


Figure 3 Soil profiles

1.6 Capital Works

No capital works have been carried out on the Dysynni Low Level Drain in the recent past. Since 1977 a new flapped outfall has been built at the drain outfall. The culvert under the A493 was replaced with a lower one when the road bridge was reconstructed.

1.7 River Maintenance

The Dysynni Low Level Drain is subject to a regular programme of weed maintenance for the benefit of land drainage. Weeds are cleared on a regular basis in July/August. If weed growth is excessive, a second cut takes place in November. Due to the narrow width of the channel a Bradshaw bucket is used to remove the channel vegetation and to cut the bank vegetation in a single operation. One hundred percent of the channel vegetation is removed.

Tree and bush clearance of branches overhanging the channel and fallen debris takes place annually during the autumn and winter and desilting is performed every five to 10 years. The last desilting operation was completed in 1987.

The main reason for undertaking river maintenance on this watercourse is that it is scheduled into the regular programme of work as a result of site inspections which highlight the need for maintenance. The criteria used in establishing the level of service to be provided by maintenance is determined through a survey completed by an NRA Engineer. Methods of maintenance selected are determined through knowledge of proven suitability and cost effectiveness. Prior to maintenance, landowners and tenants are notified via the telephone or a personal visit by the NRA.

1.7.1 Farmers views on maintenance

During the interviews with farmers in the benefit area, most of the farmers expressed satisfaction with the maintenance regime along the Dysynni Low Level Drain. However, there is a general feeling among some farmers that two cuts every year would be more beneficial. The channel is cleared of weeds twice a year only if growth is considered excessive by the NRA following a site inspection. However, in practice two cuts per year are common.

1.7.2 Alternative maintenance strategies

The Afon Dysynni is thought by two farmers to contribute to poor drainage in some parts of the benefit area. They stated that if weeds were cleared from the Afon Dysynni thus allowing un-restricted flow, land drainage would improve and river water would not seep back through the ground to the lower land around the Dysynni Low Level Drain.

One other view was raised by a farmer - if water was pumped out from the adopted ditches to the north of the Afon Dysynni into the Dysynni Low Level Drain 'main' river, field drainage would be improved.

1.8 Climate

The impact of river maintenance on the watertable and river levels depends on the particular weather conditions, especially rainfall, which varies from season to season and year to year. The seasonal and yearly rainfall totals for the period of the study on the Dysynni Low Level Drain are shown in Table 1.1. Monthly rainfall records, from the nearest meteorological station to the study reach (Glaspwll, station ref. 523 417) spanning a period of 23 years have been used to determine the probability of wet, average and dry seasons and years occurring. This classification of seasons and years is based on that of the Food and Agricultural Organisation (FAO). Dry and wet seasons/years are classified as those with less than 75 % of the mean and more than 125 % of the mean respectively. Further details of this classification system are presented in the R&D Note 456, Section 3.5.4.

During the study period, the spring of 1992, 1993 and 1995 were relatively dry when compared with the average spring rainfall. The summer of 1993 was exceptionally wet with nearly twice the average summer amount of rainfall falling in this period. This fact is confirmed by the farmers who reported wet conditions underfoot during the summer months.

Table 1.2 shows the probability of each type of season and year occurring in the proximity of the Dysynni Low Level Drain. The probabilities have been based on monthly rainfall records over a 23 year period from 1970 to 1993 (Glaspwll, station ref. 523 417).

Table 1.1 Rainfall totals

Period		Actual Rainfall (mm)	Average Rainfall (mm) *	% of Average Rainfall
1992	Spring	216.0	375.5	57.5
	Summer	286.0	215.5	132.7
	Autumn	499.2	312.0	160.0
1993	Spring	317.0	375.5	84.4
	Summer	424.8	215.5	197.2
	Autumn	287.7	312.0	92.2
1994	Spring	533.3	375.5	142.0
	Summer	270.5	215.5	125.5
	Autumn	548.7	312.0	175.9
1995	Spring	259.5	375.5	69.1
Total	1992	1310.1	1012.2	129.4
	1993	1602.1	1012.2	158.3
	1994	1994.8	1012.2	197.1

(Source : Glaspwll met. station, ref. 523 417)

Table 1.2 Probability of climatic conditions

Season	Dry *	Average *	Wet *
Spring	0.13	0.7	0.17
Summer	0.13	0.78	0.09
Autumn	0.26	0.65	0.09
Year	0.39	0.57	0.04

* (Based on records since 1970, station ref. 523 417)

The process by which financial benefits of maintenance are calculated according to the probability of wet, average and dry seasons and years occurring is described in R&D Note 456, Section 3.5.4.

1.9 Aquatic Vegetation

Aquatic vegetation within the channel was identified prior to maintenance (Section 1.9.1 to 1.9.4). This vegetation has both hydraulic and environmental implications for the channel.

1.9.1 Floating plants

Potamogeton (Pondweed) is a floating plant which has roots in the hydrosoil and thrives in sluggish water. The Pondweed is a broad-leaved plant with oval leaves which are often submerged. *Glyceria* (Sweet-grass) is a narrow leafed emergent plant which grows at the water margins. Floating stems with flat leaves creep out into the body of the water. The Duckweed (*Lemna*) is a small free-floating plant with rootlets on the underside of the leaves. It often forms extensive dense mats.

Lemna spreads through vegetative reproduction by budding from pouches on the side of the leaves. This rapid growth often results in a dense cover of *Lemna* 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 methods may need to be considered if the growth of *Lemna* reaches excessive rates. However, as *Lemna* is a purely floating plant, it poses little resistance to flow and does not restrict channel capacity. Water quality may however, be affected as a dense mat of *Lemna* will restrict the penetration of light into the water thus restricting activity of invertebrates and fish. As plant growth will also be restricted beneath the *Lemna* mat, the presence of this plant may actually reduce flow resistance through inhibiting growth of submerged plants.

The pondweed and sweet-grass grow more slowly than the free floating *Lemna*. As they regenerate through rhizomes they are more difficult to control. Desilting may be necessary every few years in order to reduce the 'rhizome bank' in the hydrosoil. Mechanical control through weed cutting serves to remove leaf matter and to reduce the resistance of the vegetation to flow. Regrowth may actually be enhanced and increased through a regular cutting programme.

1.9.2 Emergent plants

Glyceria is classed as an emergent plant although it does have some floating stems. As discussed in Section 1.9.1, it can pose a significant restriction to flow.

1.9.3 Submerged plants

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.

1.9.4 Algae

Filamentous algae is common within the Dysynni Low Level Drain. It spreads rapidly through cell division (simple fission) and is difficult to remove completely. It grows up from the hydrosoil and often invades areas in which other aquatic plants have been removed.

2. FARM SURVEY

2.1 Introduction

Structured interviews and informal discussions with farmers indicate a benefit area of 452 ha. The benefit area (BA) is described as the area which will derive some benefit from river maintenance in terms of reduced frequency of flooding and improved land drainage. Detailed interviews and discussions have been held with eight farmers who farm within the benefit area. The benefit area is divided into different blocks (Figure 2) according to land management practices and land use type (LUT) and drainage.

2.2 Farm Type, Size and Tenure

All eight farms surveyed within the benefit area are classed as lowland and livestock farms according to the European Union (EU) system of classification. Farm sizes range from 117 ha to 758 ha, averaging 472 ha. Three farms consist of over 600 ha each. The Standard Man Day (SMD) requirement of the farms ranges from 943 to 2804. The SMD (Man - Work Units) is an approximate method for assessing the labour requirement of regular staff. It is assumed that 300 SMD are provided annually per man.

The management status of farms within the benefit area cover a variety of systems. Five farms are under sole proprietorship, two are run in partnerships and one is a managed farm.

The majority of farms within the surveyed area are single holdings. However, one farmer has three holdings which are run as two separate units and another has seven holdings which are farmed independently under different holding numbers.

2.3 Livestock Enterprises

All the farms surveyed within the benefit area have beef herds, mostly Welsh Blacks with some crossed with Charolais and Limousin cattle. Spring calving suckler herd sizes range from 30 to 150 cows. Steers are sold as stores at one year old and heifers are sold at two years of age. One herd is following an 18 month grass/silage system under which beasts are sold off at 580 - 600 kg live weight.

Sheep are all kept under the fat lamb system and are predominantly Welsh ewes with some Hardy and Speckled sheep. Lambing rates range from 0.9 to 1.3 lambs/ewe tupped.

Stocking rates depend upon the weather and condition of the land. On average, stocking rates for cattle are 3.5 beasts / ha and 7 ewes / ha for sheep.

2.4 Land Use In The Benefit Area

All the agricultural land within the benefit area is under a grassland system (Figure 4). Extensive grassland covers 79 % of the area (357 ha). This is classed as that which receives little or low levels of nitrogen (typically < 50 kg N/ha). The grass is grazed by beef and sheep. Nine hectares are under very extensive grass, consisting of marshy land covered in trees and scrub.

The remaining area is under intensive grassland. This is high quality grazing and forage conservation land. Usually well drained, moderate to high levels (> 50 kg/N/ha) of nitrogen are applied and multiple cuts of silage are often taken.

2.5 Turnout and Yarding Dates

The majority of the valley floor is grazed all year round by beef or sheep. Cattle graze from April/May to October/November. They are not overwintered out at grass due to poaching problems (surface damage by livestock). Some sheep are overwintered out at grass over the period November/December to April.

Tables 2.1 and 2.2 provide information as to the areas of land within the benefit area which are grazed at different times.

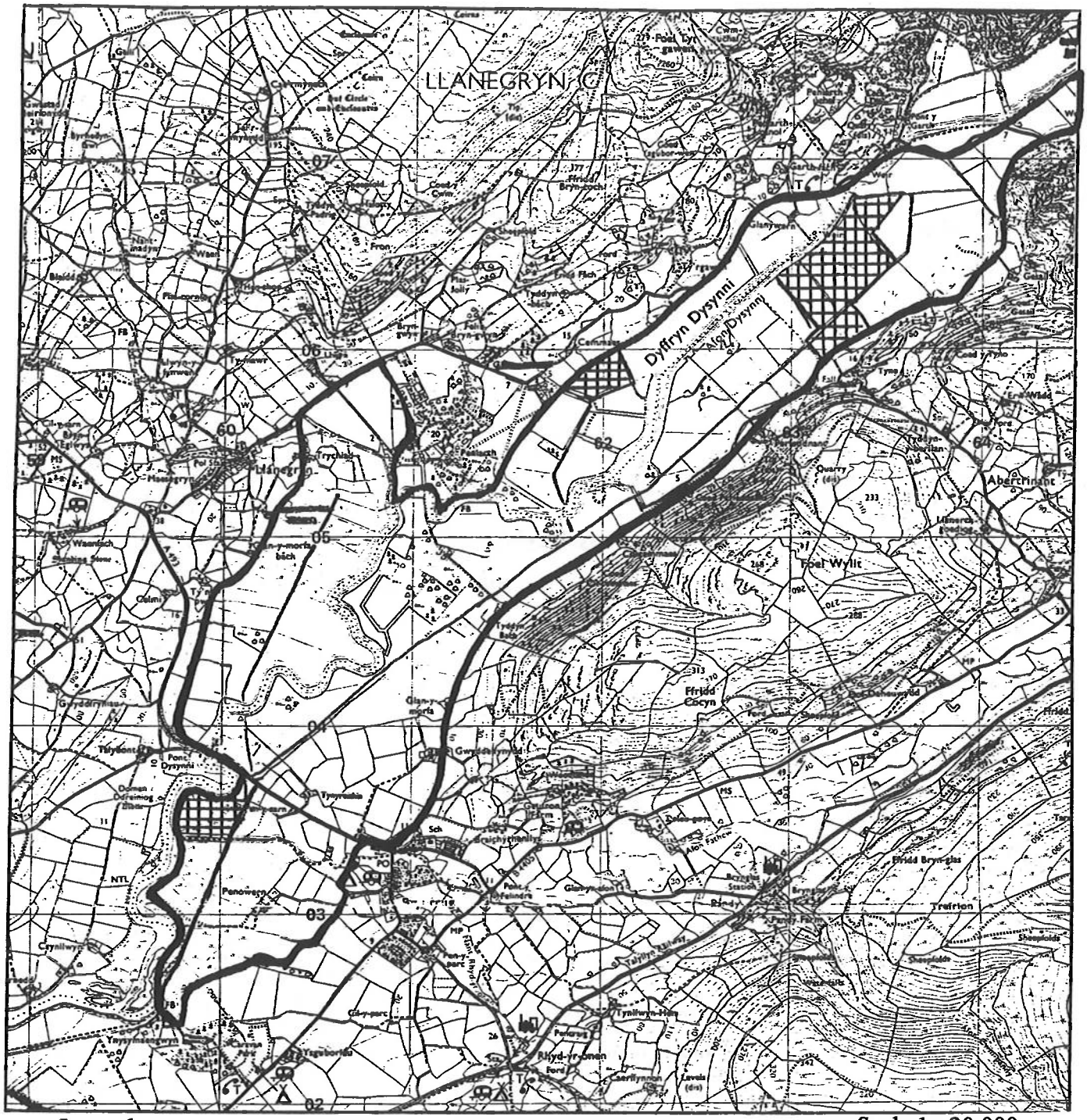
Table 2.1 Turnout dates

Turnout Date	% Benefit Area
Mid/late March	4.2
Early/mid May	12.3
Mid/late May	16.7
After 1st silage cut	12.5
After 1st hay cut	29.2
Overwintered	20.9
Not grazed	4.2

Table 2.2 Autumn yarding dates

Yarding Date	% Benefit Area
Mid / late October	25.0
Early / mid November	20.8
Mid / late November	12.5
Early/mid December	16.6
Overwintered	20.9
Not grazed	4.2

Stock are turned out to grass after hay and silage have been cut on 42 % of the benefit area. Ninety five hectares (21 % of BA) are grazed for a short period over the winter months by sheep.



Legend :

Scale 1 : 20 000

Intensive grass

Extensive grass

Figure 4 Land use in the benefit area

2.6 Grass Conservation

Table 2.3 shows the areas over which various conservation practices take place. No grazing or conservation is practised on 4 % of the benefit area (18 ha). The majority of land within the benefit area (52 %) is grazed only and not cut for hay or silage. One cut of hay and silage is taken off 17 % and 22 % respectively. Two cuts, one each of silage and hay are taken off 20 ha (5 %).

Table 2.3 Grass conservation

Conservation System	% Grassland Area
Grazed only	52.2
1 cut hay	17.4
1 cut silage	21.7
hay and silage	4.5
Not applicable	4.2

2.7 Nitrogen Application

Nitrogen is applied to 65 % of the grassland area (Table 2.4). The compound NPK fertiliser in the proportions 20:10:10 is the most common fertiliser applied.

Table 2.4 Nitrogen rates

Rate (kg/ha)	% Grassland Area
0	34.7
15 - 30	52.1
31 - 40	8.9
41 - 65	4.3

Thirty five percent of the grassland area receives no input of nitrogen. The most common rate applied is 15 to 30 Kg N/ha which is applied to 52 % of the grassland area. The higher rates of nitrogen application correspond to land areas which are cut for silage and hay and are under intensive grassland systems.

2.8 Flooding

Ten percent of the benefit area (47 ha) is reported by the farmers to flood regularly once or twice a year (Figure 5). All the flooding occurs in the winter months.

The duration of flooding ranges from two to 28 days. Up to 22 cm of water is said to cover the land. The main factors reported to be responsible for this flooding are vegetation in the channel retaining water levels and excessive rainfall. Flooding within the benefit area is said to cause no damage.

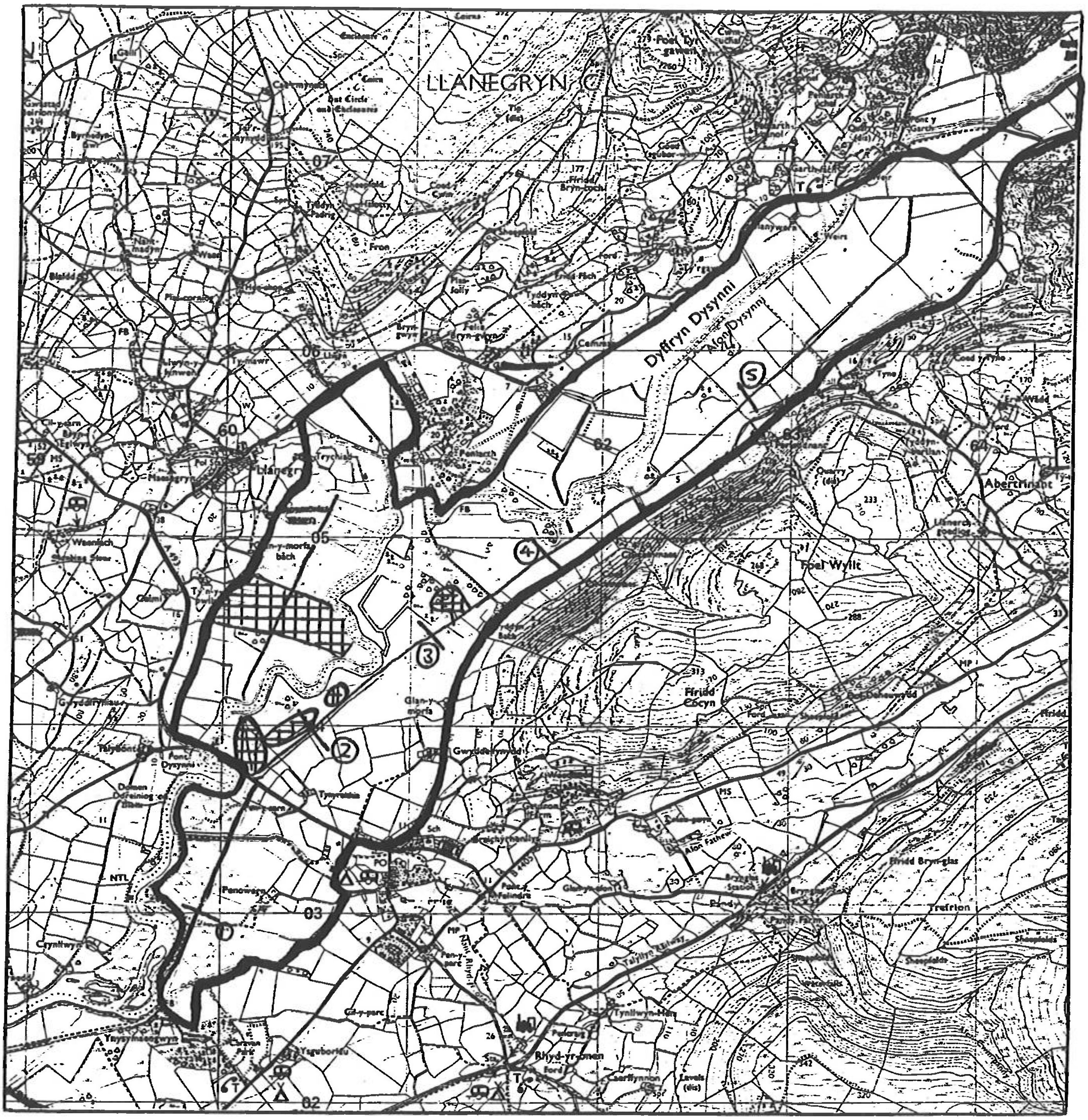
2.9 Waterlogging

Table 2.5 provides a breakdown of the wetness condition of the benefit area during the various seasons according to farmer assessment. The wetness condition of the land follows a similar pattern throughout the benefit area, becoming increasingly wetter in autumn. Under the present maintenance regime, only 25 % of the benefit area experiences wetness problems (often and permanently wet) in spring whereas in autumn this rises to 63 %. In both spring and autumn over 62 % and 33 % of the benefit area can be occasionally wet, showing sensitivity to weather conditions. Over 33 % of the benefit area is 'often wet' in summer but this can be beneficial for grass growth.

Table 2.5 Farmer assessment of field wetness condition

Season	Condition	Area (ha)	% Benefit Area
Spring	Rarely wet	56.5	12.5
	Occasionally wet	282.5	62.5
	Often wet	74.5	16.7
	Permanently wet	38.5	8.3
Summer	Rarely wet	208.0	45.8
	Occasionally wet	74.5	16.7
	Often wet	150.5	33.3
	Permanently wet	19.0	4.2
Autumn	Rarely wet	19.0	4.2
	Occasionally wet	150.5	33.3
	Often wet	169.5	37.5
	Permanently wet	113.0	25.0

The wet conditions have been attributed to a variety of factors such as the soil type, condition of field drains and blockages in the channel causing a localised rise in watertable level. The main factor reported by farmers to be responsible for wet conditions is the high water level in the Dysynni Low Level Drain. This is usually due to excessive rainfall and weeds in the channel causing the water level to rise in the channel and back up field ditches and field drainage pipes, especially in autumn. Poor drainage conditions are also attributed to seepage from the Afon Dysynni.



Legend :

Scale 1 : 20 000

Flooded areas

Location of cross-sections

Figure 5   Areas prone to flooding

2.10 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 Dysynni Low Level Drain maintenance programme:

- A strong relationship exists between the dominant farming system and land use within the benefit area. The dominant farm type is lowland and livestock which is characterised by beef and sheep enterprises. The 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.

- Turnout dates for livestock in the spring are associated with the field wetness condition. Turnout dates are earlier on land (April) which is well drained in the spring (rarely or occasionally wet) compared to on land which is often wet (after silage cut). (Statistically there is a 90 % chance of correctly predicting turnout dates on the basis of field wetness condition in the spring).

- Land use and flood risk are strongly associated. Flood risk is higher on extensive grassland. Most intensive grassland is flood free. (Statistically there is a 60 % chance of correctly predicting flood risk on the basis of land use).

- Fields which are drained by pipes are subject to longer grazing seasons than those which are naturally draining. Livestock tend to be overwintered on those fields which are underdrained.

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 study reach at an average interval of 1200 m (Figure 5). Channel capacity and freeboard were determined from these cross-sections. As the channel dimensions were not altered during the process of river maintenance, a post-maintenance cross-sectional survey of the channel was not necessary.

Before maintenance was carried out, the channel roughness was expressed in the form of Manning's n coefficient, using the methodology developed by Cowan (1956). This coefficient is composed of six parameters which include the predominant bed material, variations in channel cross-section and degree of vegetation growth. Further details of the methodology followed 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. The channel cross-section information including stage discharge curves and Manning's 'n' values are presented in Figure 6. Table 3.1 shows the bankfull channel capacities and associated flood return periods without and with maintenance at the five cross-section locations.

Table 3.1 Bankfull capacity and flood return periods

	Without Maintenance		With Maintenance	
Cross-Section	Bankfull Capacity (cumecs)	Return Period (years)	Bankfull Capacity (cumecs)	Return Period (years)
1	1.5	1.4	2.0	3.5
2	4.2	45.0	6.4	125.0
3	1.3	0.9	2.1	2.1
4	0.9	0.5	1.4	1.0
5	2.0	4.0	3.3	9.0

(Source: modelled estimates)

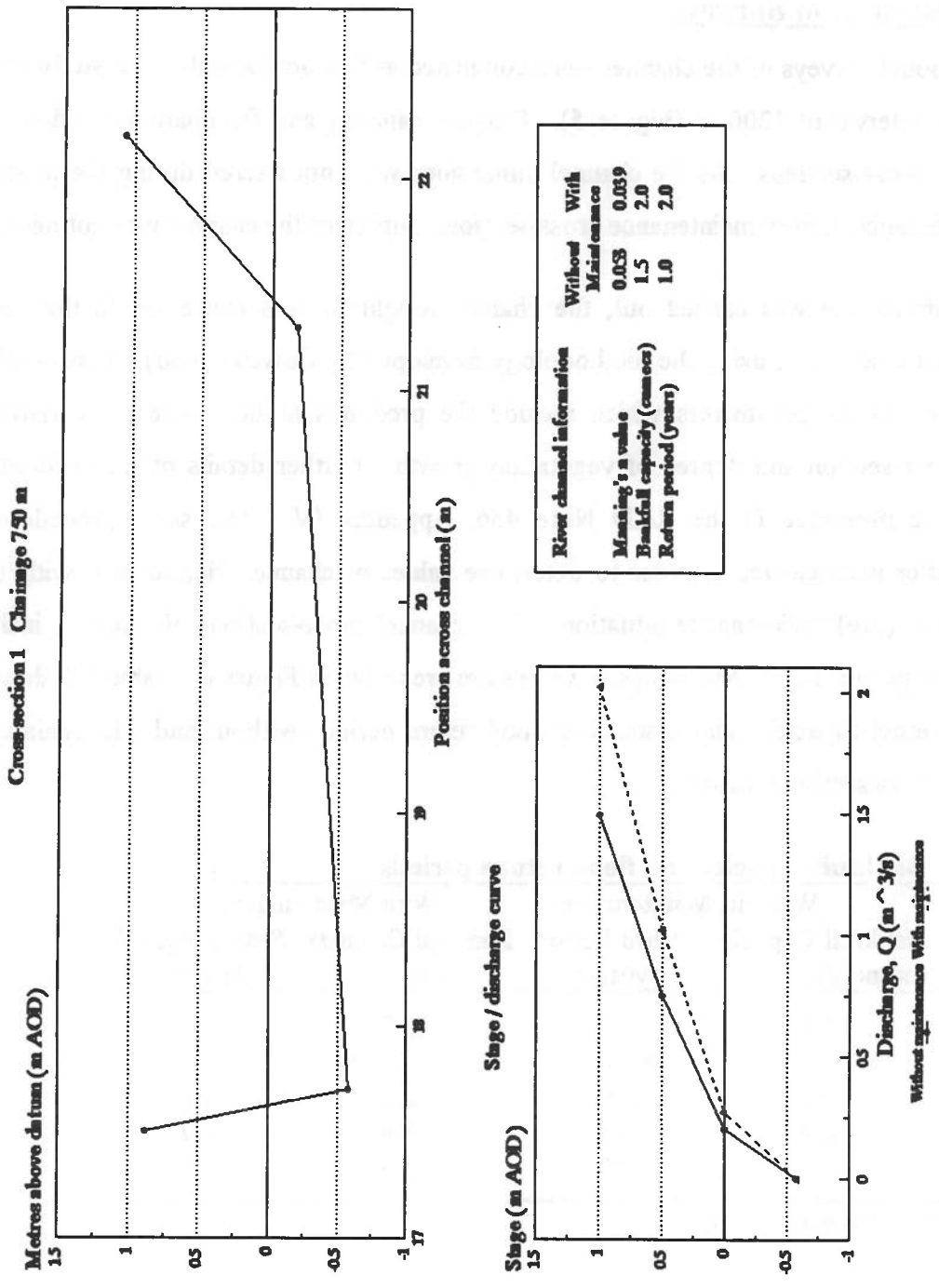
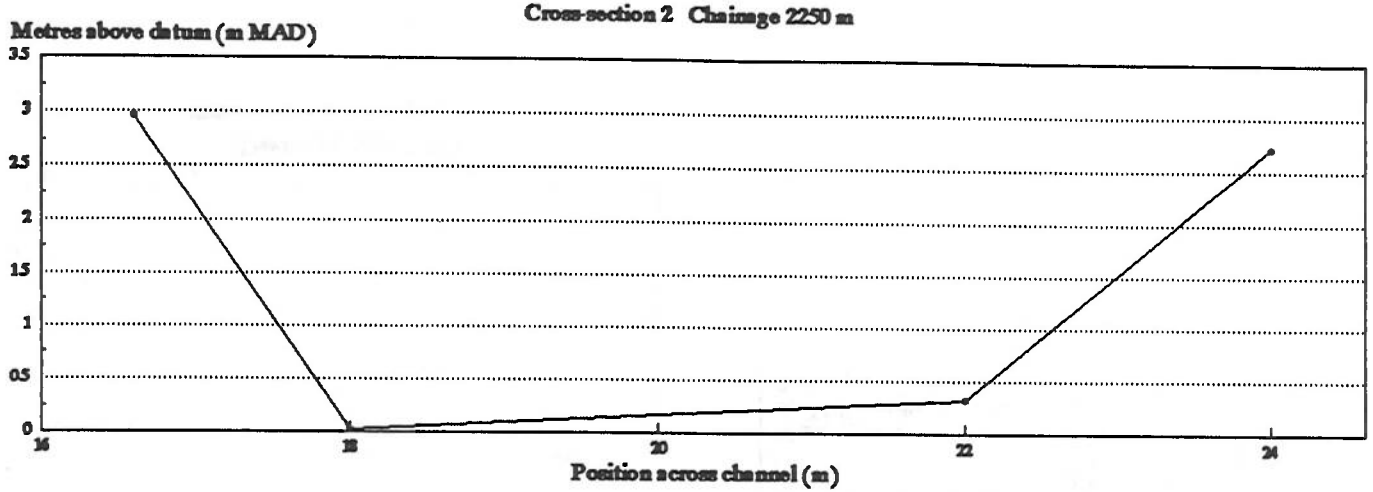
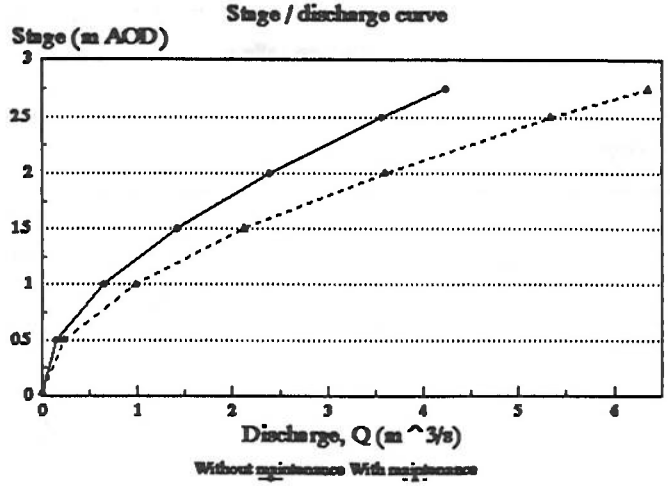
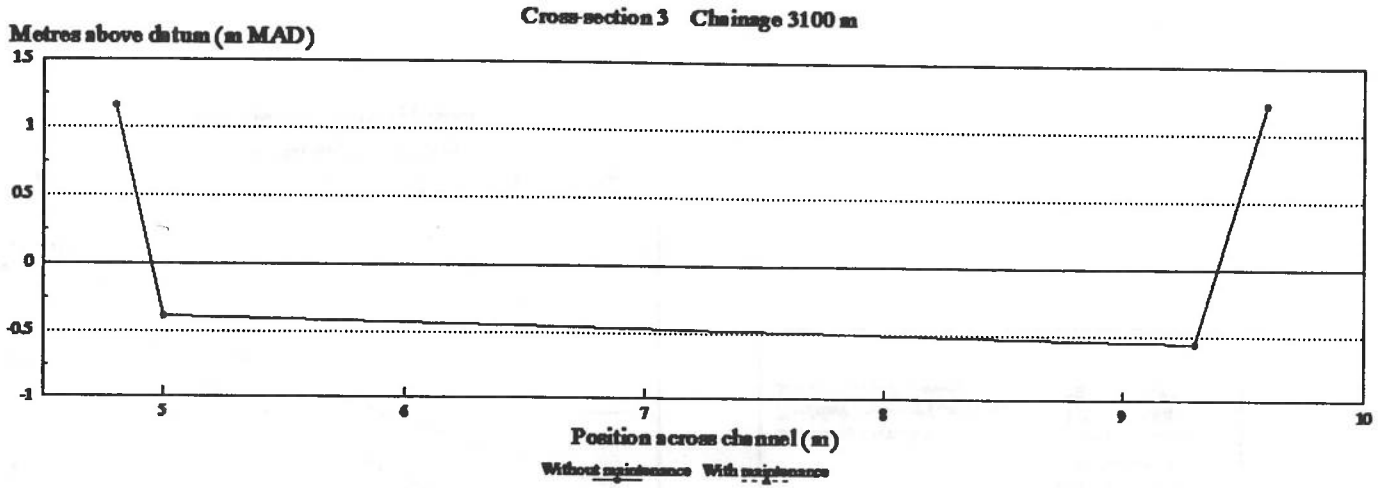


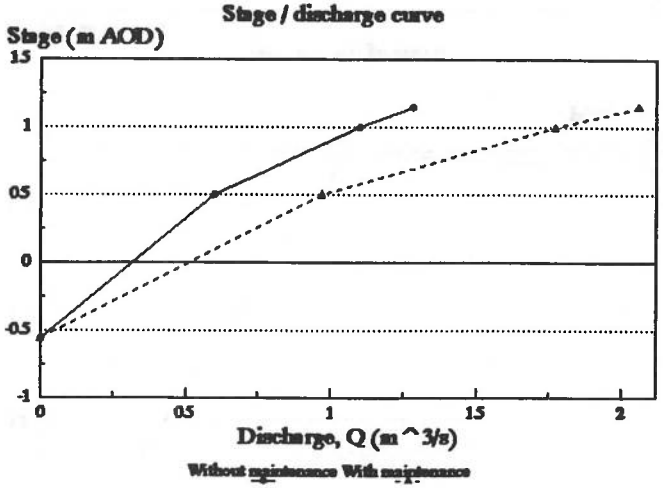
Figure 6 Dysynni Low Level Drain channel information



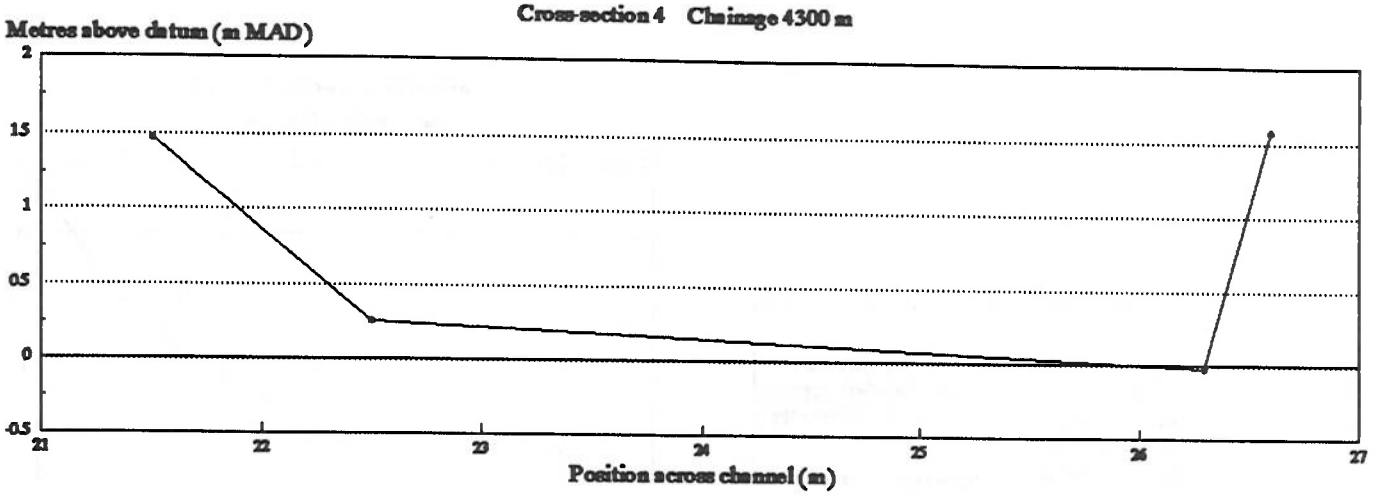


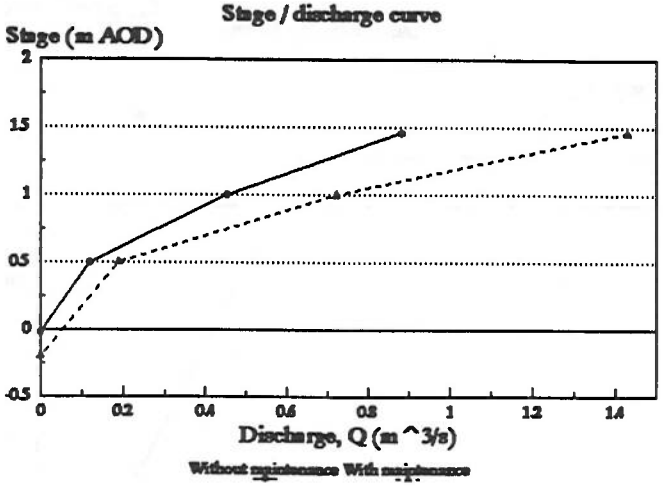
River channel information	Without Maintenance	With
Manning's n value	0.048	0.032
Bankfull capacity (cumecs)	4.2	6.4
Return period (years)	20	145



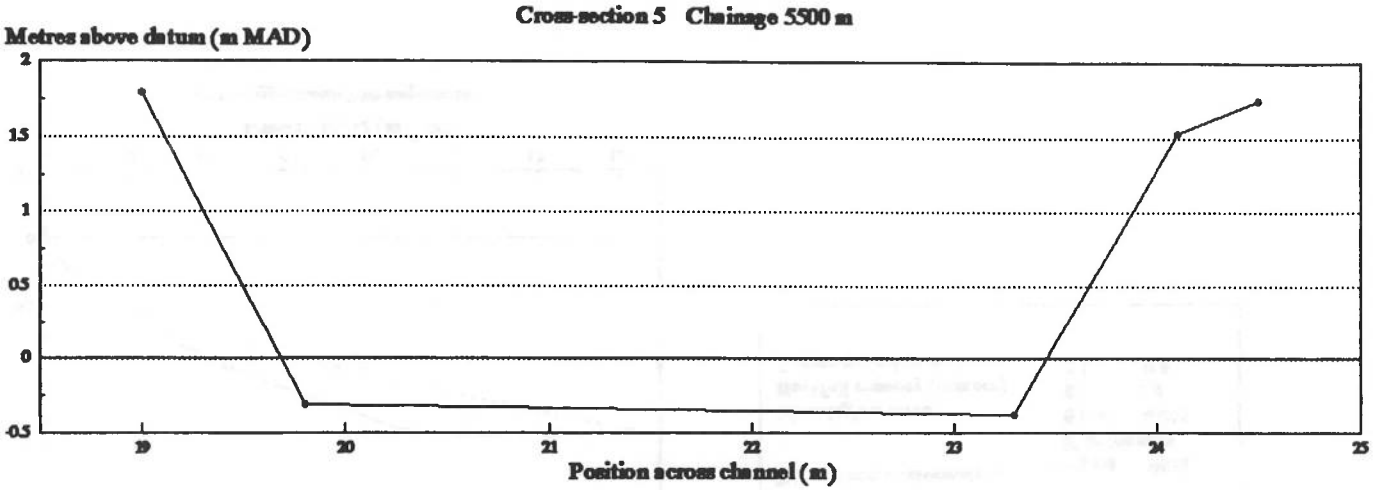


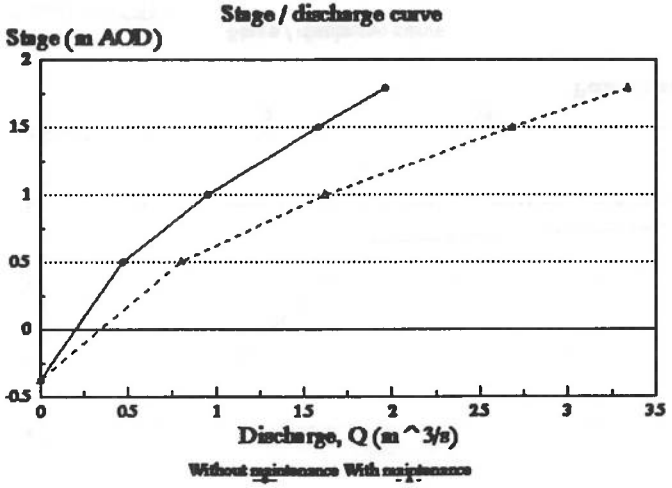
River channel information	Without Maintenance	With
Manning's n value	0.058	0.036
Bankfull capacity (cumecs)	1.3	2.1
Return period (years)	0.7	2.2





River channel information	Without Maintenance	With
Manning's n value	0.058	0.056
Bankfull capacity (cumecs)	0.9	1.4
Return period (years)	0.3	0.9





River channel information	Without Maintenance	With
Manning's n value	0.063	0.037
Bankfull capacity (cumecs)	1.9	3.3
Return period (years)	1.9	10

The bankfull capacity figures obtained from the cross-sections indicate an average increase in capacity attributable to maintenance of 63 % (from 1.4 to 2.2 m^3/s) and an average decrease in flood return period of 44 % from 1.7 years to 3.9 years (excluding cross-section 2). The area affected by flooding has not changed.

3.3 Flood Return Period

Throughout the period of the study, river water level information was collected on a regular basis by reading off channel water levels from gauge boards which were installed within the study 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 the Dysynni Low Level Drain using the methodology contained within the Flood Studies Report (NERC, 1975). The frequency of floods of various magnitudes can be estimated by using this flood return period curve (Figure 7).

The flood return period for each block which floods and 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.	Block Size (ha)	Flooded Area (ha)	Flood Return Period (Years)	
			Without Maintenance	With Maintenance
101	33.7	16.9	0.9	1.5
201	59.8	23.3	0.5	1.0
202	17.9	0.9	1.0	2.0
203	5.7	0.5	1.0	2.0
301	6.0	3.0	1.0	2.0
302	5.2	1.9	0.5	1.0
304	1.1	1.1	0.9	1.5

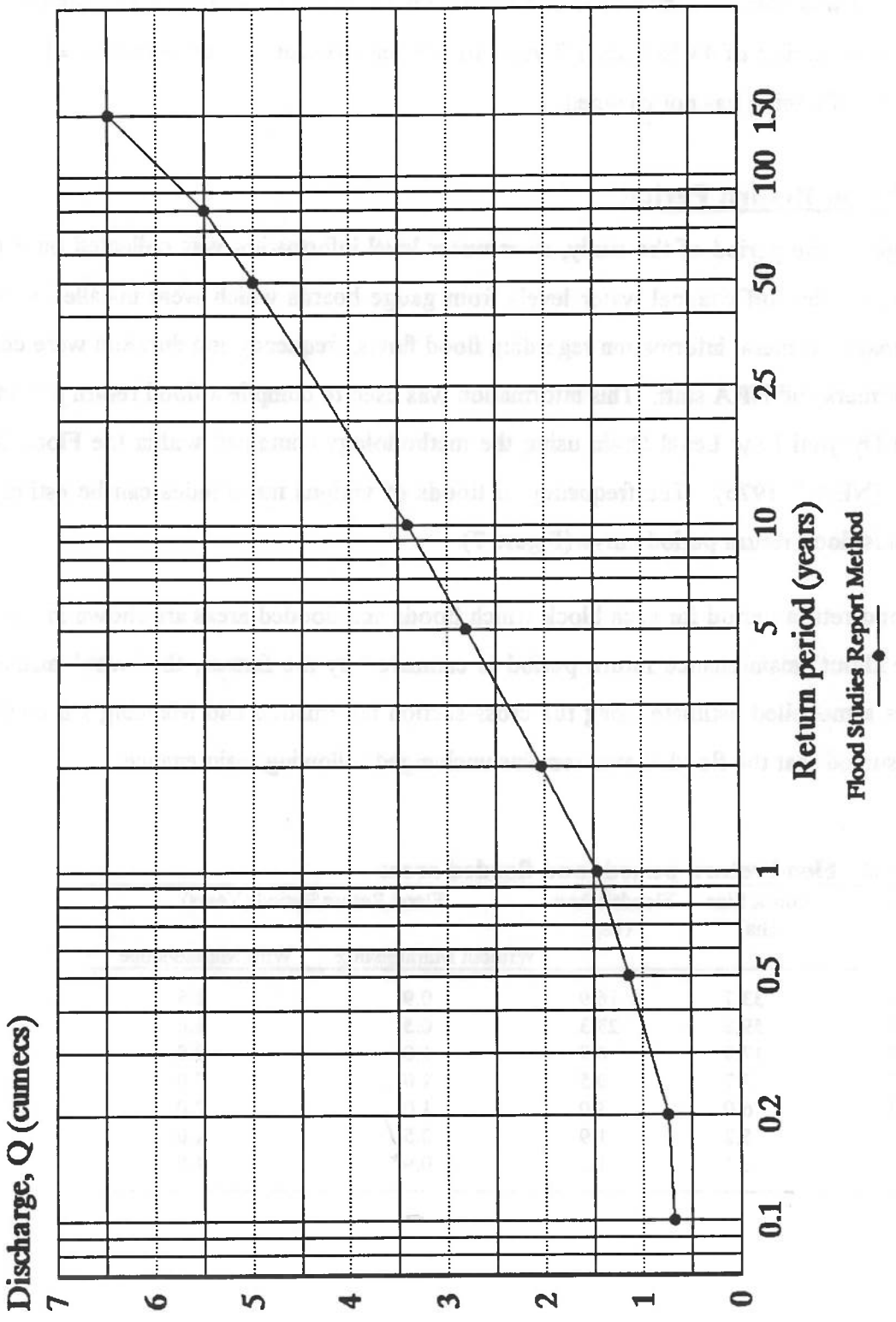


Figure 7 Flood return period curve

4. LAND DRAINAGE

4.1 Field Drainage Status

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 watertable model has been run with 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. Generally, the output from the watertable model is consistent with the farmers assessment of drainage status for the 'with' maintenance situation, under dry and average climatic conditions. Under wet conditions, with maintenance, there is 46 % agreement between farmer and modelled assessment of drainage condition.

With maintenance, drainage status in the benefit area is generally bad in wet climatic conditions and good in average and dry conditions. If maintenance were not performed, drainage conditions would deteriorate to very bad in a wet season and bad under average conditions.

Through an extensive literature and farmer survey, the drainage status of land has been classified into three standards according to the watertable depth. Three watertable bands have been identified as > 0.5 m from the surface, 0.3 to 0.5 m from 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 (no restrictions on agriculture), bad (some limitations to agricultural production) or very bad (severe limitations to agricultural production). Further details are presented in the R&D Note 456, Section 3.5.2. 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 I.

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.

Table 4.1 Drainage status for wet, average and dry seasons, without/with maintenance (Modelled results)

Block No		Wet Season		Average Season		Dry Season		Farmer Assessment With Maintenance			Without
		Without	With	Without	With	Without	With	Wet	Average	Dry	
101	Y	VB	VB	VB	VB	B	B	VB	VB	B	VB
102	Y	**VB**	**B**	B	B	B	B	B	B	*G*	B
201	N	**B**	**G**	**B**	**G**	G	G	*B*	G	G	G
202	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
203	N	G	G	G	G	G	G	G	G	G	G
301	N	**VB**	**B**	B	B	**B**	**G**	B	B	*B*	B
302	Y	**VB**	**B**	B	B	**B**	**G**	B	B	*B*	B
303	Y	**VB**	**B**	B	B	**B**	**G**	B	B	*B*	B
304	N	**VB**	**B**	B	B	**B**	**G**	*VB*	B	*B*	B
401	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
402	Y	**VB**	**G**	G	G	G	G	*B*	G	G	G
403	Y	**VB**	**G**	G	G	G	G	*B*	G	G	B
501	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
502	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
503	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
504	Y	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
505	Y	**VB**	**G**	**B**	**G**	G	G	*B*	G	G	B
601	N	G	G	G	G	G	G	G	G	G	G
602	Y	**B**	**G**	**B**	**G**	G	G	*B*	G	G	B
701	Y	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
702	Y	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
703	Y	**VB**	**B**	**B**	**G**	G	G	B	G	G	B
801	N	**B**	**G**	**B**	**G**	G	G	*B*	G	G	B
802	N	**B**	**G**	**B**	**G**	G	G	*B*	G	G	B

NB : Y or N refers to the presence or absence of field drainage
Bold type indicates a change in drainage classification due to maintenance
Italics indicate a difference in farmer and modelled assessment of drainage condition with maintenance

River maintenance results in the prevention of a deterioration of drainage status on 21 blocks of land in a wet season, on 14 blocks in an average season and on 4 blocks in a dry season.

The percentage change of area by drainage status as a result of maintenance activities are estimated to be:-

- in a wet season, maintenance prevents the deterioration of:

  84 ha from B to VB (19 % of BA)

  219 ha from G to B (48 % of BA)

  99 ha from G to VB (22 % of BA)

- in an average season, maintenance prevents the deterioration of:

  332 ha from G to B (73 % of BA)

- in a dry season, maintenance prevents a deterioration of:

  20 ha changes G to B (4 % of BA).

Farmer perception of drainage deterioration due to lack of maintenance (under average conditions) was from good to bad on 64 % of the benefit area.

5 SCHEME APPRAISAL

5.1 Benefit Assessment

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. Estimates have been derived of the monetary value of changes in field management and productivity associated with these standards of drainage service.

Two perspectives have been used to value the 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 value-added 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 type of 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 £ 17011 in 1995 financial prices, equivalent to about £ 38/ha per year. The majority of this benefit is associated with the maintenance of drainage status (rather than flood alleviation) on grassland for sheep and beef production. 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 £ 6300 in economic prices for the benefit area, equivalent to £ 14/ha. On this basis, the benefit to the national economy is 39 % 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 financial and economic benefit estimates show the limits which farmers and the nation respectively should justifiably spend on maintenance. These estimates require cautious interpretation as explained in the R&D Note 456 Section 2.7.2.

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.

Table 5.1 Financial net returns, 1995/96 prices

Block	Block Size (ha)	Financial Prices Net Return (£/ha) Good	Bad	Very Bad	Change in Total Returns (£/ha) Good to Bad	Bad to Very Bad	Good to Very Bad
101	33.70	258	221	174	37	47	83
102	18.20	392	350	307	41	44	85
201	59.80	463	396	332	67	64	131
202	17.90	350	349	313	1	36	36
203	5.70	547	470	338	77	132	209
301	6.00	315	249	194	65	56	121
302	5.20	432	361	295	71	65	137
303	7.40	217	183	151	33	32	66
304	1.10	528	447	375	82	72	153
401	15.20	299	327	291	-28	36	8
402	15.60	471	422	370	50	52	102
403	16.30	471	422	370	50	52	102
501	2.70	318	264	183	53	82	135
502	12.70	463	396	332	67	64	131
503	4.90	291	247	174	44	73	117
504	4.70	558	470	399	88	71	160
505	13.40	265	236	176	29	60	89
601	11.20	558	470	411	88	59	147
602	11.42	220	219	193	1	26	27
701	18.60	317	256	205	61	51	112
702	14.50	541	453	379	88	74	162
703	7.80	698	565	372	133	194	326
801	70.00	488	406	338	82	69	150
802	78.00	464	415	364	49	51	100

Table 5.2 Economic net returns, 1995/96 prices

Block	Block Size (ha)	Economic Prices Net Return (£/ha) Good	Bad	Very Bad	Change in Total Returns (£/ha) Good to Bad	Bad to Very Bad	Good to Very Bad
101	33.7	50	49	31	1	18	18
102	18.2	141	122	103	19	19	38
201	59.8	160	132	106	28	26	53
202	17.9	52	57	50	-5	8	2
203	5.7	107	88	58	19	30	49
301	6	153	110	74	42	37	79
302	5.2	153	97	69	56	28	83
303	7.4	61	48	33	13	15	27
304	1.1	77	62	44	15	17	32
401	15.2	55	62	54	-7	8	1
402	15.6	174	151	127	23	23	46
403	16.3	174	151	127	23	23	46
501	2.7	121	93	57	27	36	63
502	12.7	160	132	106	28	26	53
503	4.9	94	76	49	18	27	45
504	4.7	196	159	130	36	29	66
505	13.4	102	87	62	15	25	40
601	11.2	196	159	133	36	26	63
602	11.42	63	69	59	-6	10	4
701	18.6	163	122	88	41	34	75
702	14.5	153	117	86	37	31	67
703	7.8	102	79	33	23	47	70
801	70	81	65	50	17	14	31
802	78	166	144	121	22	22	45

Table 5.3 Flood costs

	GOOD DRAINAGE		BAD DRAINAGE		VERY BAD DRAINAGE		CHANGE IN FLOOD COSTS						
Block No.	Without maintenance FRP	With maintenance FRP	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	Without maintenance flood cost	With maintenance flood cost	GOOD Without -with	BAD Without -with	VERY BAD Without -with	GOOD TO BAD Without -with	BAD TO VERY BAD Without -with	GOOD TO VERY BAD Without -with
101	0.90	1.50	24.42	14.65	21.67	13.00	18.00	10.80	9.77	8.67	7.20	7.02	5.00	3.35
201	0.50	1.00	4.98	2.49	4.40	2.20	4.20	2.10	2.49	2.20	2.10	1.91	2.00	1.71
202	1.00	2.00	1.04	0.52	0.70	0.35	0.18	0.09	0.52	0.35	0.09	0.18	-0.17	-0.34
301	1.00	2.00	9.24	4.62	7.88	3.94	6.92	3.46	4.62	3.94	3.46	3.26	2.98	2.30
302	0.50	1.00	2.58	1.29	2.22	1.11	2.00	1.00	1.29	1.11	1.00	0.93	0.89	0.71
304	0.90	1.50	43.08	25.85	40.03	24.02	39.37	23.62	17.23	16.01	15.75	14.18	15.35	13.52

Table 5.4 Changes in net returns due to maintenance and climate, 1995/96 financial prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	33.70	0	7.20	7	0	7.20	7	0	8.67	9	253
102	18.20	44	0.00	44	0	0.00	0	0	0.00	0	79
201	59.80	67	1.91	69	67	1.91	69	0	2.49	2	3339
202	17.90	36	-0.34	36	0	0.18	0	0	0.52	1	72
203	5.70	0	0.00	0	0	0.00	0	0	0.00	0	0
301	6.00	56	2.98	59	0	3.94	4	65	3.26	69	134
302	5.20	65	0.89	66	0	1.11	1	71	0.93	72	114
303	7.40	32	0.00	32	0	0.00	0	33	0.00	33	73
304	1.10	71	15.35	86	0	16.01	16	82	14.18	96	43
401	15.20	36	0.00	36	28	0.00	28	0	0.00	0	351
402	15.60	102	0.00	102	0	0.00	0	0	0.00	0	159
403	16.30	102	0.00	102	0	0.00	0	0	0.00	0	166
501	2.70	135	0.00	135	53	0.00	53	0	0.00	0	137
502	12.70	131	0.00	131	67	0.00	67	0	0.00	0	764
503	4.90	117	0.00	117	44	0.00	44	0	0.00	0	209
504	4.70	71	0.00	71	88	0.00	88	0	0.00	0	324
505	13.40	89	0.00	89	29	0.00	29	0	0.00	0	396
601	11.20	0	0.00	0	0	0.00	0	0	0.00	0	0
602	11.40	1	0.00	1	1	0.00	1	0	0.00	0	13
701	18.60	51	0.00	51	61	0.00	61	0	0.00	0	893
702	14.50	74	0.00	74	88	0.00	88	0	0.00	0	1001
703	7.80	194	0.00	194	133	0.00	133	0	0.00	0	876
801	70.00	82	0.00	82	82	0.00	82	0	0.00	0	4566
802	78.00	49	0.00	49	49	0.00	49	0	0.00	0	3051
Total	452									Total	17011
Probability of :		Wet season		0.10						Benefit (£/ha)	**38**
		Average season		0.70							
		Dry season		0.20							

Table 5.5 Changes in net returns due to maintenance and climate, 1995/96 economic prices

Block	Area (ha)	Wet Season			Average Season			Dry Season			Total Change (£/yr)
		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	
101	33.70	0	7.20	7	0	7.20	7	0	8.67	9	253
102	18.20	19	0.00	19	0	0.00	0	0	0.00	0	35
201	59.80	28	1.91	30	28	1.91	30	0	2.49	2	1442
202	17.90	2	-0.34	2	-5	0.18	-5	0	0.52	1	-59
203	5.70	0	0.00	0	0	0.00	0	0	0.00	0	0
301	6.00	37	2.98	40	0	3.94	4	42	3.26	45	95
302	5.20	28	0.89	29	0	1.11	1	56	0.93	57	78
303	7.40	15	0.00	15	0	0.00	0	13	0.00	13	30
304	1.10	17	15.35	33	0	16.01	16	15	14.18	29	22
401	15.20	1	0.00	1	-7	0.00	-7	0	0.00	0	-68
402	15.60	46	0.00	46	0	0.00	0	0	0.00	0	72
403	16.30	46	0.00	46	0	0.00	0	0	0.00	0	75
501	2.70	63	0.00	63	27	0.00	27	0	0.00	0	69
502	12.70	53	0.00	53	28	0.00	28	0	0.00	0	313
503	4.90	45	0.00	45	18	0.00	18	0	0.00	0	85
504	4.70	66	0.00	66	36	0.00	36	0	0.00	0	150
505	13.40	40	0.00	40	15	0.00	15	0	0.00	0	193
601	11.20	0	0.00	0	0	0.00	0	0	0.00	0	0
602	11.40	-6	0.00	-6	-6	0.00	-6	0	0.00	0	-54
603	3.20	0	0.00	0	0	0.00	0	0	0.00	0	0
701	18.60	34	0.00	34	41	0.00	41	0	0.00	0	595
702	14.50	31	0.00	31	37	0.00	37	0	0.00	0	419
703	7.80	47	0.00	47	23	0.00	23	0	0.00	0	163
801	70.00	17	0.00	17	17	0.00	17	0	0.00	0	926
802	78.00	22	0.00	22	22	0.00	22	0	0.00	0	1399
Total	455									Total	6232
Probability of :		Wet season		0.10						Benefit (£/ha)	**14**
		Average season		0.70							
		Dry season		0.20							

Table 5.6 Farmer asessment of maintenance benefits

Block	Area (ha)	Average Season Financial prices: Benefit due to drainage (£/ha/yr)	Average Season Financial prices: Benefits of flood alleviation (£/ha)	Average Season Financial prices: Change in net return due to maintenance	Average Season Economic Prices: Benefit due to drainage (£/ha/yr)	Average Season Economic Prices: Benefits of flood alleviation (£/ha)	Average Season Economic Prices: Change in net return due to maintenance
101	33.70	0	7.20	243	0	7.20	243
102	18.20	0	0.00	0	0	0.00	0
201	59.80	0	1.91	114	0	1.91	114
202	17.90	1	-0.34	12	-5	0.18	-86
203	5.70	0	0.00	0	0	0.00	0
301	6.00	0	2.98	18	0	3.94	24
302	5.20	0	0.89	5	0	1.11	6
303	7.40	0	0.00	0	0	0.00	0
304	1.10	0	15.35	17	0	16.01	18
401	15.20	-28	0.00	-426	-7	0.00	-106
402	15.60	0	0.00	0	0	0.00	0
403	16.30	50	0.00	815	23	0.00	375
501	2.70	53	0.00	143	27	0.00	73
502	12.70	67	0.00	851	28	0.00	356
503	4.90	44	0.00	216	18	0.00	88
504	4.70	88	0.00	414	36	0.00	169
505	13.40	29	0.00	389	15	0.00	201
601	11.20	0	0.00	0	0	0.00	0
602	11.40	1	0.00	11	-6	0.00	-68
701	18.60	61	0.00	1135	41	0.00	763
702	14.50	88	0.00	1276	37	0.00	537
703	7.80	133	0.00	1037	23	0.00	179
801	70.00	82	0.00	5740	17	0.00	1190
802	78.00	49	0.00	3822	22	0.00	1716
Total	452	Total financial benefit (£)		15831	Total economic benefit (£)		5789
		Benefit (£/ha)		35	Benefit (£/ha)		13

5.2 Maintenance Costs

Maintenance activities on the Dysynni Low Level Drain involve the flailing of banks twice each year, weed removal from the channel and selected tree and bush work. Estimates provided by NRA were £ 3000, £ 7200 and £ 400 per year respectively for the whole reach, in 1995 prices; a total of £ 10600. In addition, about £ 6200 is spent every 10 years on desilting the main channel, equivalent to an average annual cost at 6 % interest of £ 998. Total average maintenance costs are therefore approximately £ 11600 in 1995 prices.

5.3 Scheme Appraisal

The estimated benefits attributable to maintenance can be compared with estimated costs to determine the justification for expenditure. Because the main maintenance activity is performed annually, the appraisal involves a simple comparison of annual benefits and costs.

Table 5.7 Maintenance scheme appraisal: Dysynni Low Level Drain

Average Annual Benefit (£)	Average Annual Benefits (£)	Average Annual Costs (£)	Benefit: Cost Ratio
Modelled Estimates			
Financial Prices	17000	11600	1.46
Economic Prices	6200	11600	0.53
Farmer Estimates in an Average Season			
Financial Prices	15831	11600	1.36
Economic Prices	5789	11600	0.50

Table 5.7 shows that the existing maintenance scheme is viable in financial terms. Benefits to farmers exceed the costs of the scheme. In economic terms, however, the benefits to the economy do not appear to fully recover the costs of maintenance.

Farmer assessment gave an average annual financial benefit of £ 15831 (£ 35/ha) and an economic benefit of £ 5789 (£ 13/ha). The scheme generates an annual benefit : cost ratio of 1.36 and 0.5 in financial and economic terms respectively.

The application of MAFF Guidance Notes on economic analysis suggests that the maintenance programme is not justified. 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 Dysynni Low Level Drain is outlined in this chapter. Reference is made to river corridor surveys, public consultation and farmer assessment.

6.2 River Corridor Survey

Before maintenance was carried out in 1992, a river corridor survey was completed for the selected reach using the survey methodology developed by the Nature Conservancy Council (NCC) now English Nature (EN). Sketch maps and record cards (Appendix II) were completed for each 500 m reach within the study area.

Following maintenance, a second survey was completed in order to ascertain the impact of maintenance on the channel environment. As weed clearance was carried out on the channel and the channel characteristics were not altered, the post-maintenance survey took the form of a vegetational survey. This concentrated on the location and extent of channel coverage of different types of aquatic vegetation. The post-maintenance survey is presented in Appendix II.

6.3 Public Consultation

Since 1979, prior to the introduction of the Wildlife and Countryside Act of 1981, the NRA has liaised with conservationists regarding river maintenance activities. In the spring of each year a work programme detailing each maintenance activity and other works to be completed is distributed to various organisations such as the Countryside Commission for Wales and the Royal Society for the Protection of Birds (RSPB). Representatives from these organisations are invited to attend a meeting where the work programme is discussed and issues can be raised. If necessary the programme of works may be modified. If requested, a site meeting is held at a later date to discuss the finer points of the exact work to be completed.

6.4 Farmer Assessment

Each farmer interviewed in the benefit area was asked to identify any environmental features within the selected reach thought to be affected by river maintenance. Only one farmer

thought the river maintenance would have an adverse impact in the form of damaging the habitat for birds and flora living within the river and its banks.

The area of the Afon Dysynni and its banks to the north of the benefit area is reported by one farmer to support one of the largest communities of Welsh Mudwort in Europe.

6.5 Water Quality

The quality of water in the Dysynni Low Level Drain is good (class 1b) according to the former National Water Council (NWC) classification system. There is no visible evidence of pollution and the water is of high quality. However, it cannot be placed in class 1a because of the effect of physical factors such as the low gradient.

6.6 Channel and Bank Quality

The environmental quality of the Dysynni Low Level Drain has been determined by following the procedure outlined in the 'Guidelines for the Justification of River Maintenance' (R&D Note 511).

The channel and banks are both of medium quality. Extensive beds of well developed emergent and submerged vegetation are frequent within the channel. Substrates are commonly sand/silt but areas of coarser sediment can be found.

The channel banks are uniform in structure consisting of predominantly one vegetation type and lack trees and scrub. Typically the banks are less than 2 m in width. Submerged and exposed roots and ancient trunks of the 'bog oaks' provide varied habitats for wildlife. These roots also stabilise banks. Flowering herbs in the spring and summer improve the botanical quality of the banks.

7 CONCLUSIONS

7.1 Scheme Appraisal

The existing maintenance scheme of annual weed clearance, tree and bush maintenance and desilting every five to 10 years is viable in financial terms. The average annual benefit of maintenance in terms of its prevention in a deterioration in drainage status and increase in flooding is £ 17 000. Average annual maintenance costs are £ 11 600. The benefit : cost ratio is therefore 1.46.

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 the Dysynni Low Level Drain.

According to this method, the financial benefit : cost ratio is 1.4. This value approximates to that derived from the detailed analysis ; the results of which are summarised in Section 7.1.

7.3 Impact of Maintenance on Channel Vegetation

The types of vegetation found within the Dysynni Low Level Drain are discussed in Section 1.9. The impact of the floating, submerged and emergent vegetation on channel capacity is also discussed. Different vegetation types respond to maintenance in different ways.

The pondweed and sweet-grass reproduce 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 from the channel bed.

The floating vegetation *Lemna* reproduces vegetatively and unless every fragment of this vegetation is removed from the channel, reproduction will occur and the weed will rapidly regrow. Chemical control is the most effective method of control in this case. However, *Lemna* does not affect channel capacity as it is a free-floating plant and offers no resistance to flow. It can however, reduce water quality.

The current maintenance regime therefore is appropriate in controlling the channel vegetation. The vegetation is cut and removed from the channel, the majority of the *Lemna* is removed and the channel is desilted every five to 10 years which reduces the rhizome bank in the channel sediments.

7.4 Maintenance Best Practice

The 'best practice' vegetation maintenance methods for the Dysynni Low Level Drain were determined using 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 :

- 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 :

- Biennial cutting, 10 - 30 %;
- Biennial cutting - selective;
- Cutting on a 3 to 5 year rotation, 10 - 30 %; and,
- Cutting 3 to 5 year rotation - selective.

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

Since the beginning of this study, annual weed maintenance in the late summer has taken place. All the vegetation is removed.

According to these Guidelines, the current maintenance regime is too severe in environmental terms. If the cutting frequency could be reduced to every other year, the environmental quality of the channel would be improved. If a margin of vegetation were left un-cut down one or both banks, this would greatly increase the channel quality.

Bank

Best practice maintenance operations for bank vegetation are identified as :

- Light grazing.

Light grazing is suggested as the best method of bank maintenance in order to increase bank environmental quality. At present, the majority of the banks are fenced and so the banks are not grazed by livestock. In order to increase bank environmental quality, these fences would need to be removed. This could be an expensive operation as capital has already been spent in fencing the channel and the risk of livestock loss may increase due to the absence of fencing - particularly during the lambing season. Bank erosion due to poaching (surface damage by livestock), structural damage and possible over-grazing may actually result in the deterioration of bank environmental quality.

7.5 Recommendations

It is recommended that further research examines :-

- the impact of a reduced maintenance frequency on land drainage and flooding within the benefit area;
- the impact of reduced channel maintenance on channel environmental quality; and,
- the impact of cutting the vegetation on one bank only on channel hydraulics, flooding, land drainage and 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.

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APPENDIX I

Example of input and output data for the watertable model

Dysynni Low Level Drain
Block Number 501
Cross-section 5

	Input Data	Output Data
	River height (m AOD)	Watertable height (m AOD)
Week 1994		
1	1.52	1.10
2	1.73	1.11
3	1.68	1.38
4	1.87	1.38
5	1.63	1.45
6	1.41	1.11
7	1.25	1.04
8	1.20	0.94
9	1.10	1.05
10	1.03	0.93
11	1.09	1.04
12	1.14	0.95
13	1.00	0.87
14	1.15	1.04
15	1.18	1.15
16	1.54	1.17
17	1.36	1.10
18	1.14	1.19
19	1.10	1.23
20	1.46	1.41
21	1.63	1.44
22	1.48	1.28
23	1.40	1.79
24	1.87	1.79
25	1.79	1.79
26	1.73	1.58
27	1.79	1.17
28	1.59	1.29
29	1.63	1.29

Example of drainage status classification, Dysynni Low Level Drain

With maintenance

Block 501

	Watertable depth (m)	No. of weeks 1993	Spring 1993	No. of weeks	Summer 1993	No. of weeks	Autumn 1993	No. of weeks
>0.5	1.369	35	1.369	13	1.369	9	1.369	8
0.3><0.5m	1.569	8	1.569	0	1.569	3	1.569	3
<0.3m	1.869	9	1.869	0	1.869	1	1.869	2

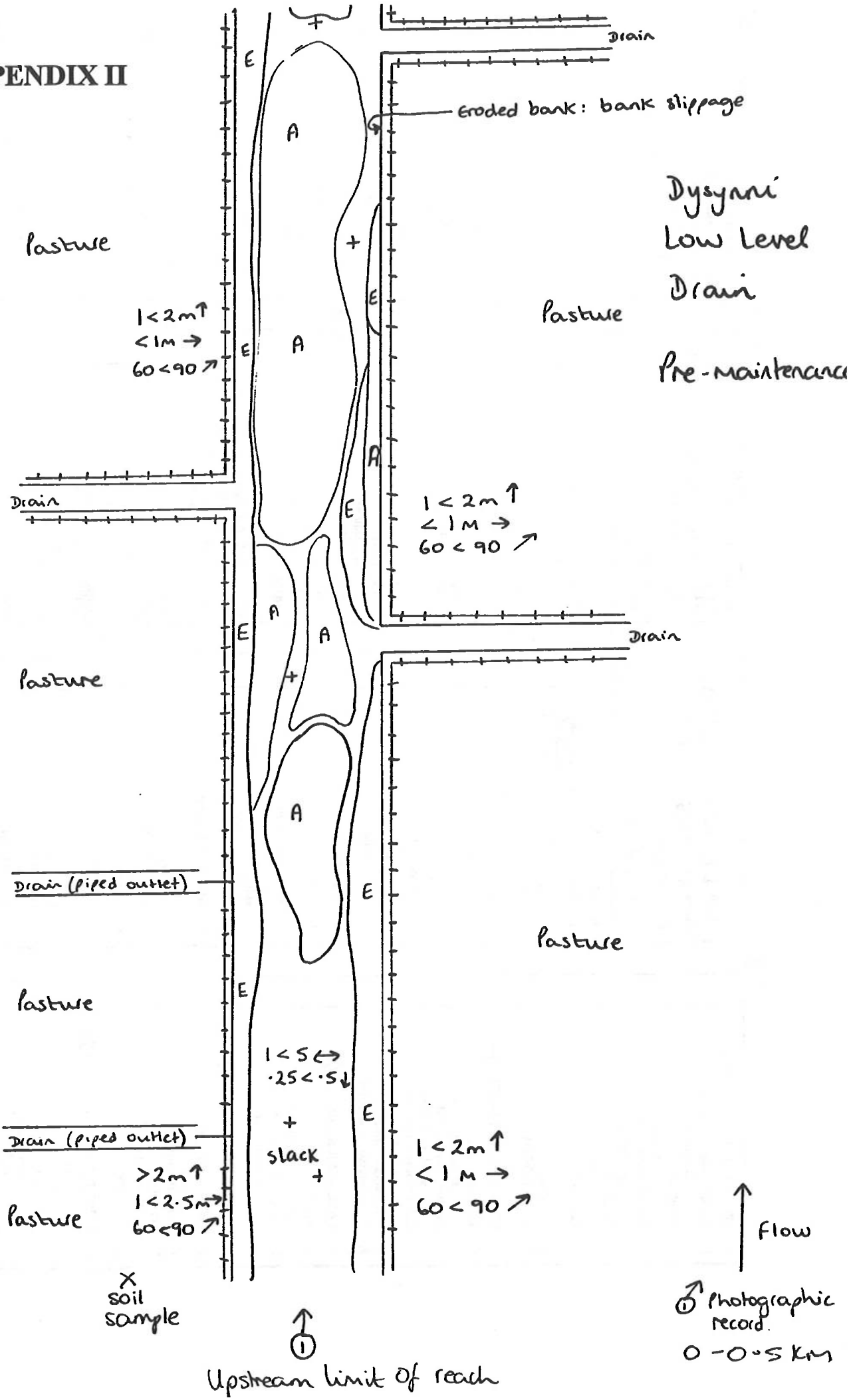
Drainage status classification, according to time watertable is within the G, B, VB drainage bands	Good	Bad	Bad

Without maintenance

	Watertable depth (m)	No. of weeks 1993	Spring 1993	No. of weeks	Summer 1993	No. of weeks	Autumn 1993	No. of weeks
>0.5	1.369	14	1.369	10	1.369	0	1.369	2
0.3><0.5m	1.569	12	1.569	2	1.569	4	1.569	4
<0.3m	1.869	26	1.869	1	1.869	9	1.869	7

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

APPENDIX II


Drain
Eroded bank: bank slippage
Dysynni
Low Level
Drain
Pre-maintenance
Pasture
Pasture
1<2m↑
<1m→
60<90↗
Drain
1<2m↑
<1m→
60<90↗
Drain
Pasture
Pasture
Drain (piped outlet)
Pasture
Pasture
1<5↔
·25<·5↓
+
slack
+
Drain (piped outlet)
>2m↑
1<2·5m→
60<90↗
Pasture
1<2m↑
<1m→
60<90↗
E
A
+
soil sample
1
Upstream limit of reach
Flow
1
Photographic record
0-0·5 km

River DYSYNNI LOWER LEVEL DRAIN
Km No. 0-0.5
Date 10/6/92
Surveyor JALD

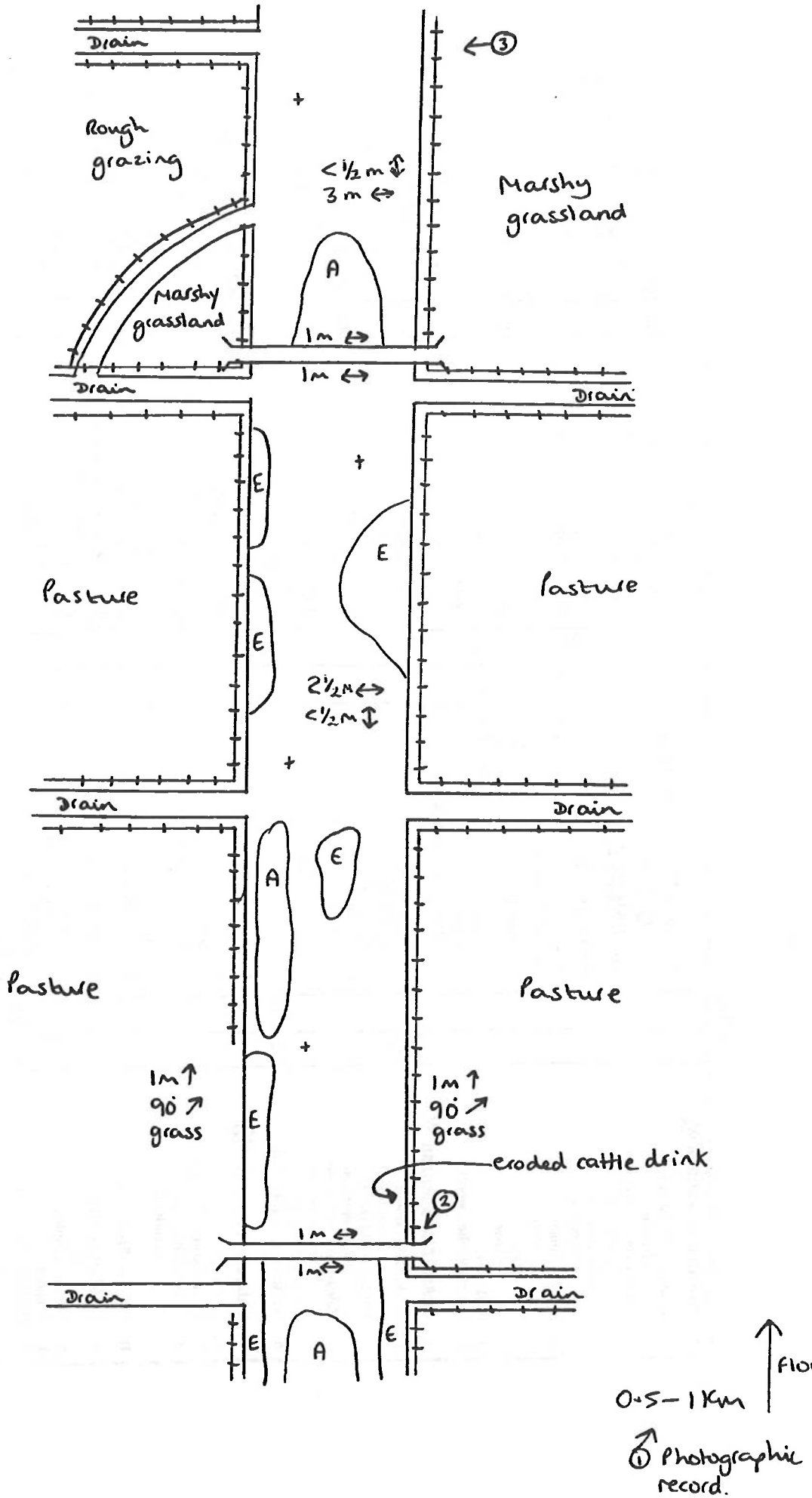
	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry	100	100
6. wet		
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		

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	3	2
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff 1M↑	100	90
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	90	100
>2m	10	
Width <1m		
1-<2.5m	30	
2.5-<5m	70	100
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle	100	95
earth		5
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	100
.25-<.5	
0.5-<1.0	
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	30
emergent 1-2m wide	50
emergent >2m wide	
total veget area	80
B bryophytes	
E emergents	40
A submerged	60
F floating	
algae % of stretch	

total to 100%


Drain
Rough grazing
<½m ↕
3m ↔
Marshy grassland
A
Marshy grassland
1m ↔
1m ↔
Drain
Drain
E
E
Pasture
E
Pasture
2½m ↔
<½m ↕
Drain
Drain
A
E
Pasture
Pasture
1m ↑
90° ↗
grass
E
1m ↑
90° ↗
grass
eroded cattle drink
1m ↔
1m ↔
Drain
Drain
E
A
E
Flow
0·5–1Km
Photographic record.

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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	10	
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	10	20
C. TALL HERB & 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. Heath/grassland – dry	80	80
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 0·5 – 1

Date 10/6/92

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =	5	3
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream <1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	90	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	100	100
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope <30°		
30·<60°	100	100
60·<90°		
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		

BANK VEGETATION

- Conifer
- Oak, Ash, Sycamore
- P Willow recent pollard
- W Willow old, not pollard
- S Standard willows
- A Alder
- Other trees
- Young trees
- Thick Scrub/shrubs %
- Sparse Scrub/shrubs %
- Reed/Sedge %
- Dense open %
- Sparse open %
- Reseeded or mown %
- Exposed tree roots

ISLANDS

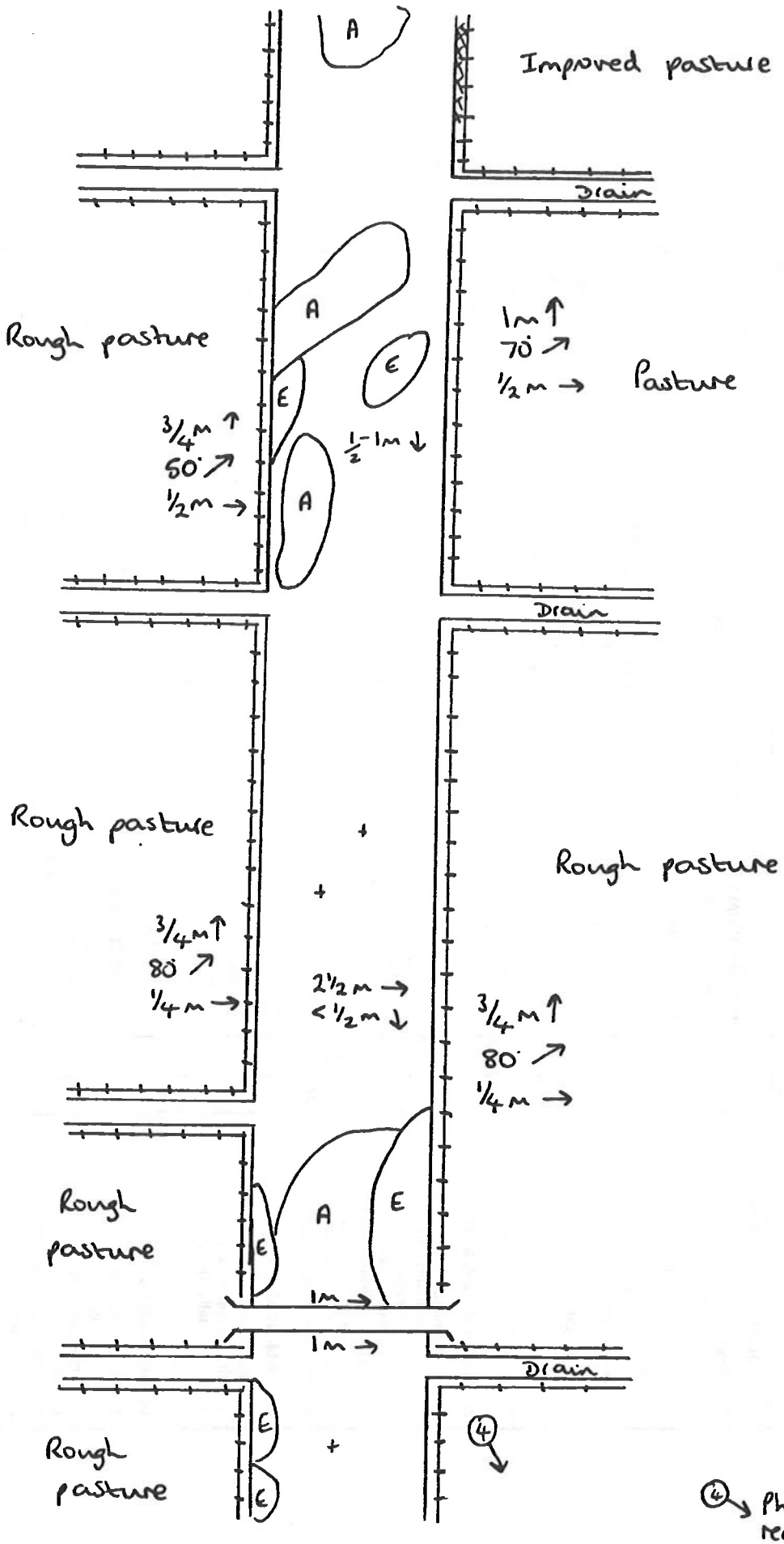
- Rocky, vegetated
- with <½ tree: rocky, + bare
- shingle and rock
- shingle, rock + veg
- x earth - maturing
- NCA earth - with trees
- % developed

RIVER HABITATS		RIVER
bridges/500m		2
weirs/500m		
locks/500m		
inlet/500m	1	
Depth <.25m	%	
.25·<.5		100
0.5·<1.0		
>1.0m		
Width <1		
1·<5		100
5·<10		
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
+ silt/mud		100
clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		

FLORA %

emergent veg <1m wide		60
emergent 1·2m wide		40
emergent >2m wide		
total veget area		30
B bryophytes		
E emergents	60	
A submerged	40	
F floating		
algae % of stretch		

total to 100%


A
Improved pasture
Drain
Rough pasture
A
E
E
A
3/4m ↑
50° ↗
1/2m →
1/2-1m ↓
1m ↑
70° ↗
1/2m → Pasture
Drain
Rough pasture
Rough pasture
3/4m ↑
80° ↗
1/4m →
2 1/2m →
< 1/2m ↓
3/4m ↑
80° ↗
1/4m →
Rough pasture
E
A
E
1m →
1m →
Drain
Rough pasture
E
E
4
Flow
4 Photographic record.
1-1.5 km

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland	100	90
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER JYSYNNI LOW LEVEL DRAIN

Km No. 1 – 1·5 Km

Date 10/6/92

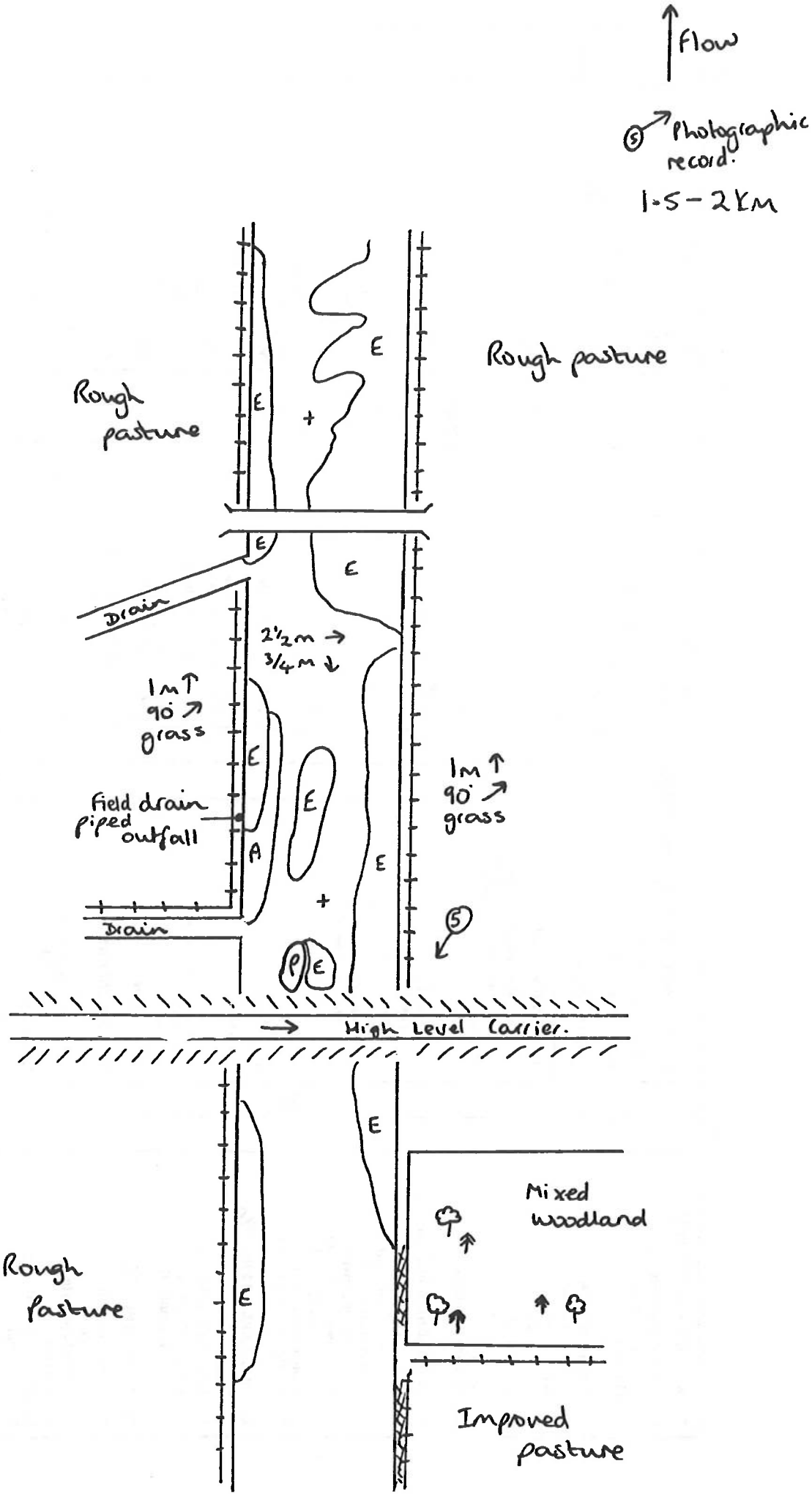
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj canal = laid in each stretch)		
ditch	4	3
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff 1m↑		
soft earth cliff > 80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m	100	60
1·<2m		40
>2m		
Width <1m		
1·<2.5m		
2.5·<5m	100	100
>5m		
Slope <30°		
30·<60°	40	
60·<90°	60	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %.		10
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	1
Depth <.25m %	
.25·<.5	70
0.5·<1.0	30
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	
clay	100
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle + bare	
shingle, vegetated	
mud	
sss sand	
FLORA %	
emergent veg < 1m wide	80
emergent 1·2m wide	20
emergent >2m wide	
total veget area	30
B bryophytes	
E emergents	45
A submerged	55
F floating	
algae % of stretch	

total to 100%


Flow
Photographic record.
1·5 – 2 KM
Rough pasture
Rough pasture
E
E
E
+
E
E
Drain
2½m →
¾m ↓
1m ↑
90° ↗
grass
E
Field drain
piped
outfall
A
E
E
+
Drain
1m ↑
90° ↗
grass
5
P
E
High Level Carrier.
E
Mixed
woodland
Rough
Pasture
E
Improved
pasture

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		20
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland	100	70
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 1-5-2

Date 10/6/92

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)	2	
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	90	60
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

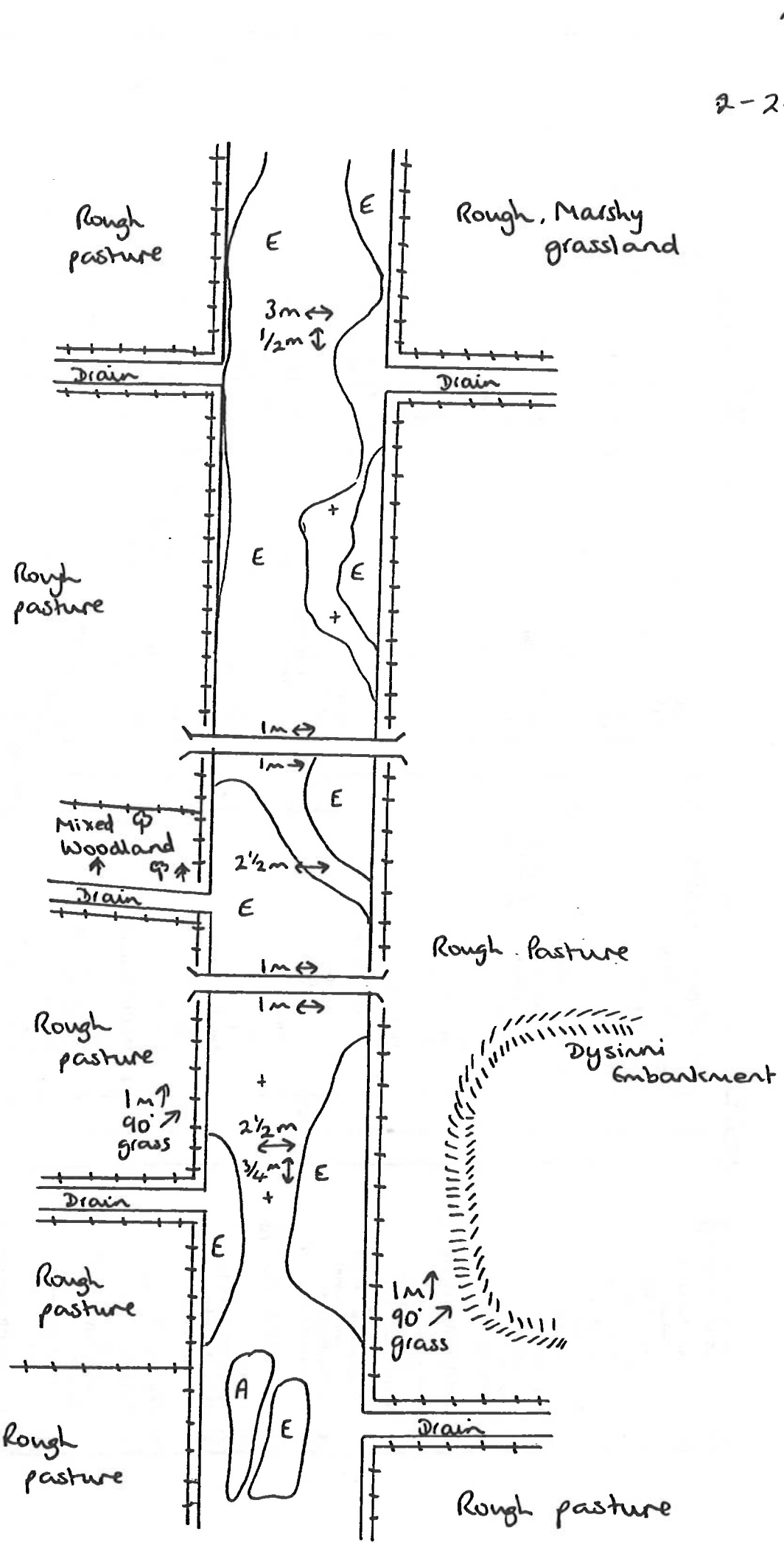
BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand	100	100
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		

BANK VEGETATION	
Conifer	
Oak, Ash, Sycamore	
P Willow recept pollard	
W Willow old, not pollard	
S Standard willows	
A Alder	
Other trees	
Young trees	
Thick Scrub/shrubs %.	
Sparse Scrub/shrubs %.	
Reed/Sedge %.	
Dense open %.	
Sparse open %.	
Reseeded or mown %.	
Exposed tree roots	

ISLANDS	
Rocky, vegetated	
rocky, + bare	
shingle and rock	
shingle, rock + veg	
earth - maturing	
earth - with trees	
developed	

RIVER HABITATS		RIVER
bridges/500m		2
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		100
0.5-<1.0		
>1.0m		
Width <1		
1-<5		100
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
+ silt/mud		100
clay		
peat		
Habitats and Flow		
pool		1
slack		99
rillle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		90
emergent 1-2m wide		10
emergent >2m wide		
total veget area		30
B bryophytes		
E emergents	95	
A submerged	5	
F floating		
algae % of stretch		

total = 100%


Flow
2-2.5km
Rough pasture
E
E
Rough, Marshy grassland
3m ↔
½m ↕
Drain
Drain
Rough pasture
E
E
+
+
1m ↔
1m →
Mixed Woodland
E
2½m ↔
Drain
E
Rough Pasture
1m ↔
1m ↔
Rough pasture
Dysinni Embankment
1m ↑
90° ↗
grass
2½m ↔
¾m ↕
E
+
Drain
E
Rough pasture
1m ↑
90° ↗
grass
A
E
Drain
Rough pasture
Rough pasture

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	100	100
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 2-2-5

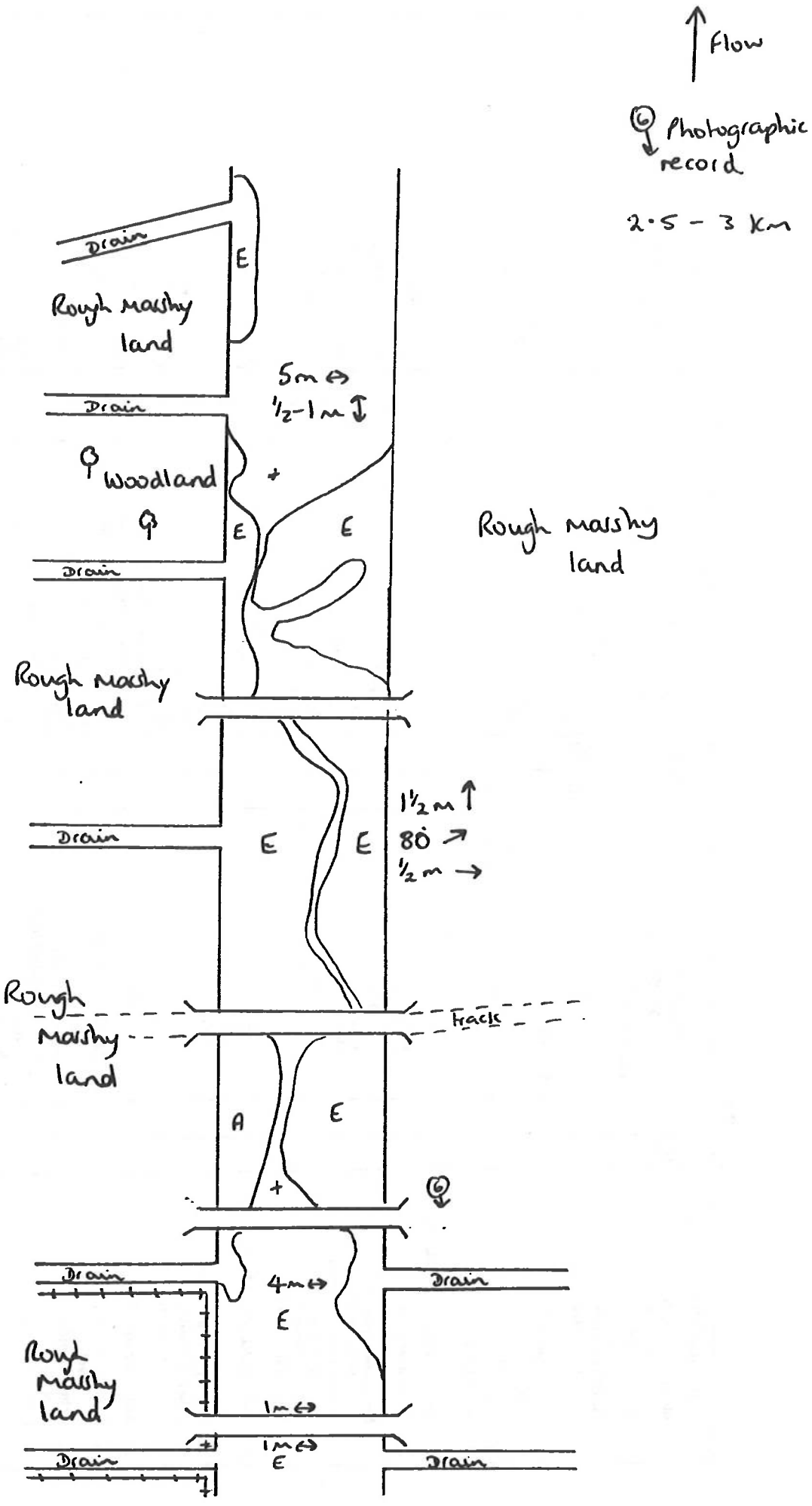
Date 10/6/92

Surveyor

	LB	RB
G. OPEN WATER		
1. Standing - canal + % of adj land in each stretch	3	2
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
sheet %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m	100	100
1-<2.5m		
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	20
.25-<.5	80
0.5-<1.0	
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	100
rille	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	20
emergent 1-2m wide	80
emergent >2m wide	
total veget. area	75
B bryophytes	
E emergents 95	
A submerged 5	total to 100%
F floating	
algae % of stretch	


Flow
Photographic record
2·5 – 3 km
Drain
E
Rough marshy land
5m ↔
½–1m ↕
Drain
Woodland
+
E
E
Rough marshy land
Drain
Rough marshy land
1½m ↑
80° ↗
½m →
Drain
E
E
Rough marshy land
Tracks
A
E
+
Drain
4m ↔
E
Drain
Rough marshy land
1m ↔
+
1m ↔
E
Drain
Drain

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	10	
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	90	90
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
E. MIRE, FLUSH AND SPRING %		
1. Mires – bog		10
Fen – reed		
sedge		
sweet-grass		
mixed		
2. Bog flushes		
F. SWAMP/INUNDATION %		
1. Swamp – single sp. dom.		
Tall mixed assemblage		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 2·5 - 3

Date 10/6/92

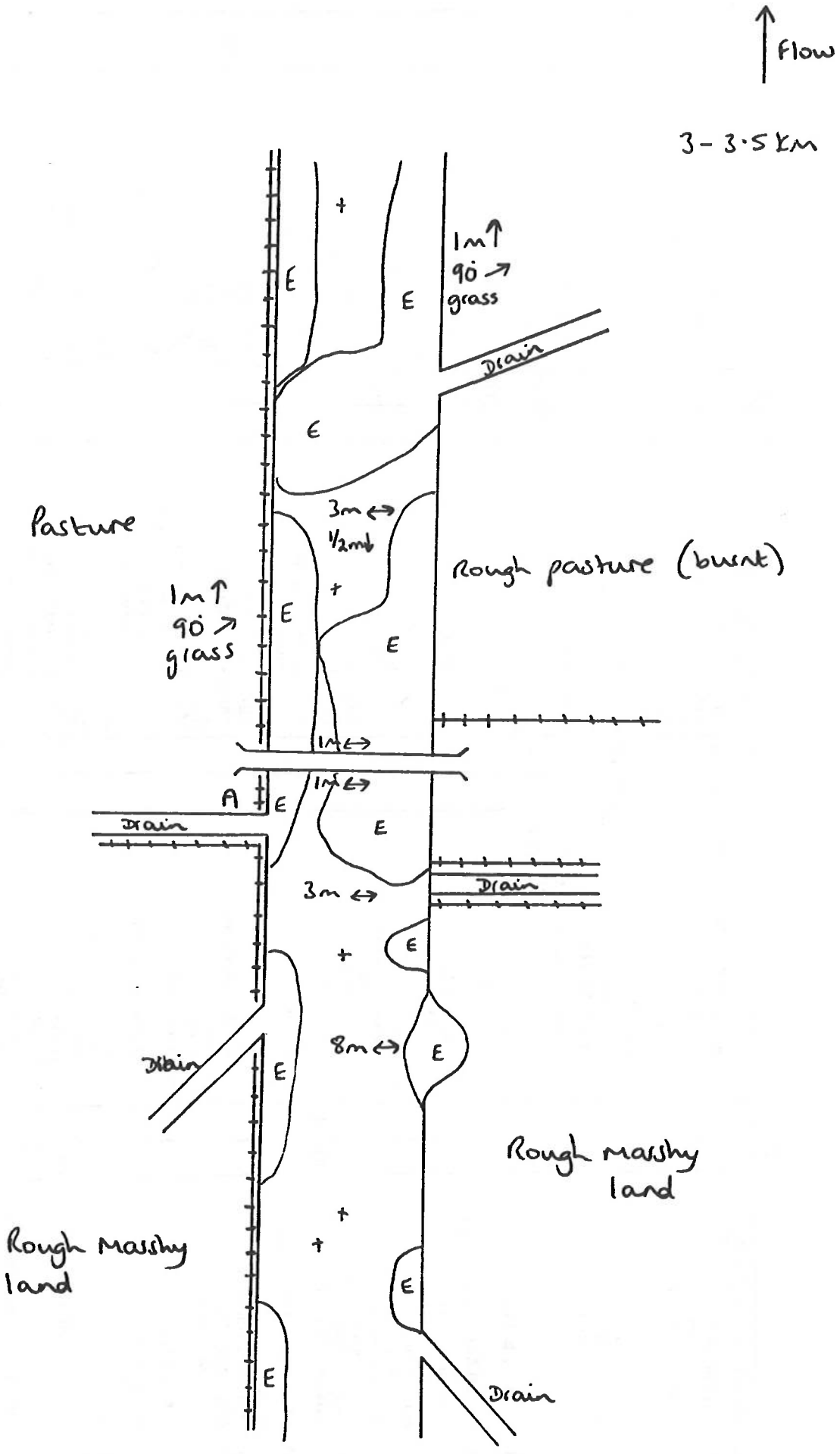
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =	6	2
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream <1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	5	
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
slope %		
solid earth cliff		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m	100	100
1·<2·5m		
2·5·<5m		
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth		
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	4
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	
0·5·<1·0	100
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	
clay	100
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg <1m wide	10
emergent 1·2m wide	90
emergent >2m wide	
total veget area	90
B bryophytes	
E emergents	80
A submerged	20
F floating	
algae % of stretch	

Total to 100%


Flow
3 - 3·5 km
1m ↑
90° ↗
grass
Drain
E
Pasture
3m ↔
½m ↕
Rough pasture (burnt)
1m ↑
90° ↗
grass
1m ↔
A
Drain
3m ↔
Drain
8m ↔
Drain
Rough marshy land
Rough marshy land
Drain

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	90	100
C. TALL HERB & FERN %		
1. Bracken		
2. Upland spp. rich vegel.		
3. Other - tall ruderal		
non ruderal		
D. HEATHLAND %		
1. Dwarf scrub – dry		
wet		
3. Lichen/bryophyte		
4. Montane		
5. Heath/grassland – dry	10	
6. wet		
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		

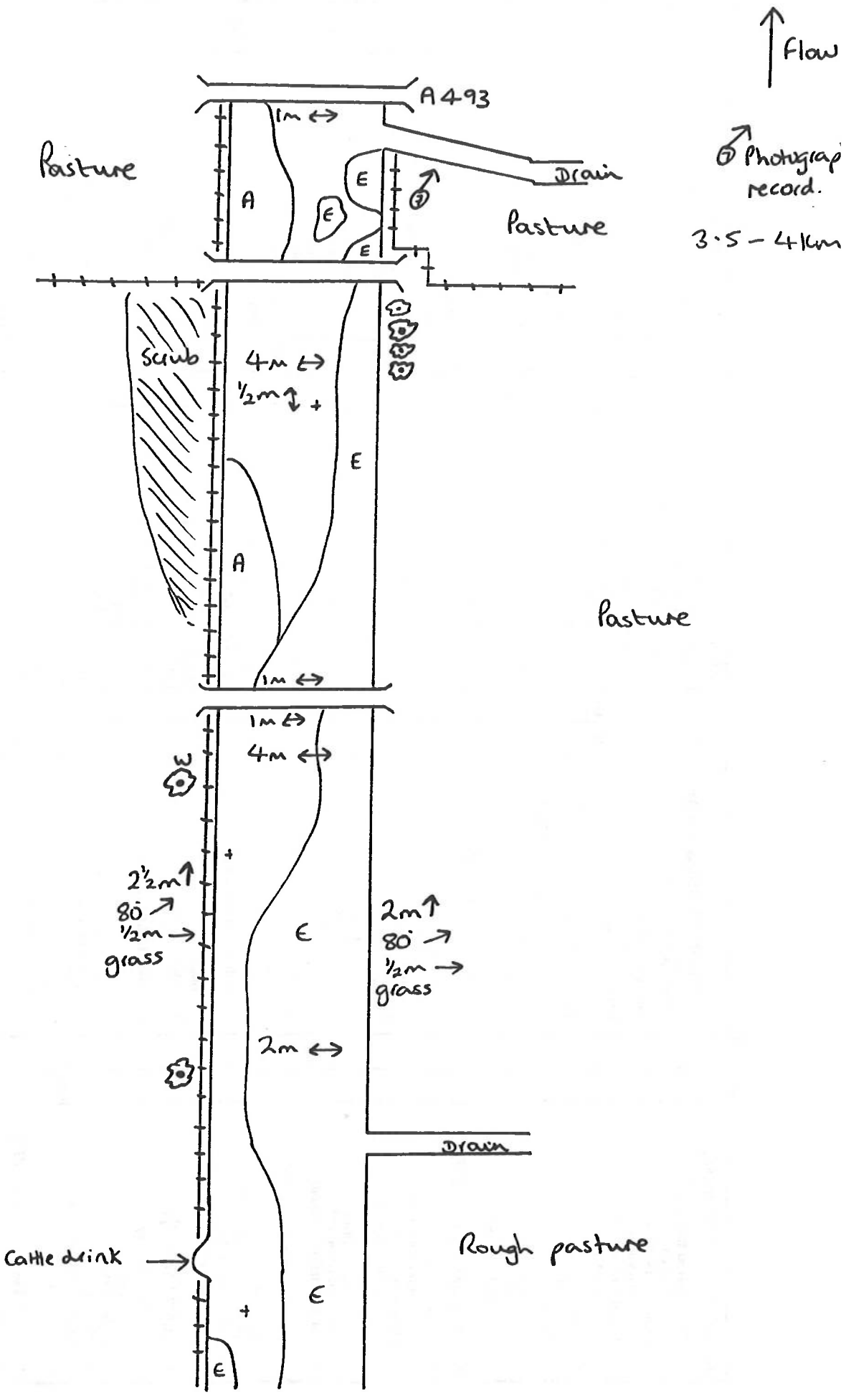
RIVER DYSYNNI LOW LEVEL DRAIN
Km No. 3 – 3·5
Date 11/6/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =	2	3
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff	1m↑	
soft earth cliff	>80°	
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope <30°		
30·<60°		
60·<90°		
>90°	100	100
mud		
sand		
bare shingle		
vegetated shingle		
earth		
natural cobbles	100	100
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		1
weirs/500m		
locks/500m		
inlet/500m	1	
Depth <.25m	%	
.25·<.5		
0.5·<1.0		100
>1.0m		
Width <1		
1·<5		80
5·<10		20
10·<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		20
emergent 1·2m wide		80
emergent >2m wide		
total veget area		40
B bryophytes		
E emergents	100	
A submerged		
F floating		
algae % of stretch		

total to 100%


Flow
A493
1m ↔
Pasture
A
E
E
E
Drain
Pasture
Photograph record.
3·5 – 4 km
Scrub
4m ↔
½m ↕
E
A
Pasture
1m ↔
1m ↔
4m ↔
W
2½m ↑
80° ↗
½m →
grass
E
2m ↑
80° ↗
½m →
grass
2m ↔
Drain
Cattle drink →
Rough pasture
E
E

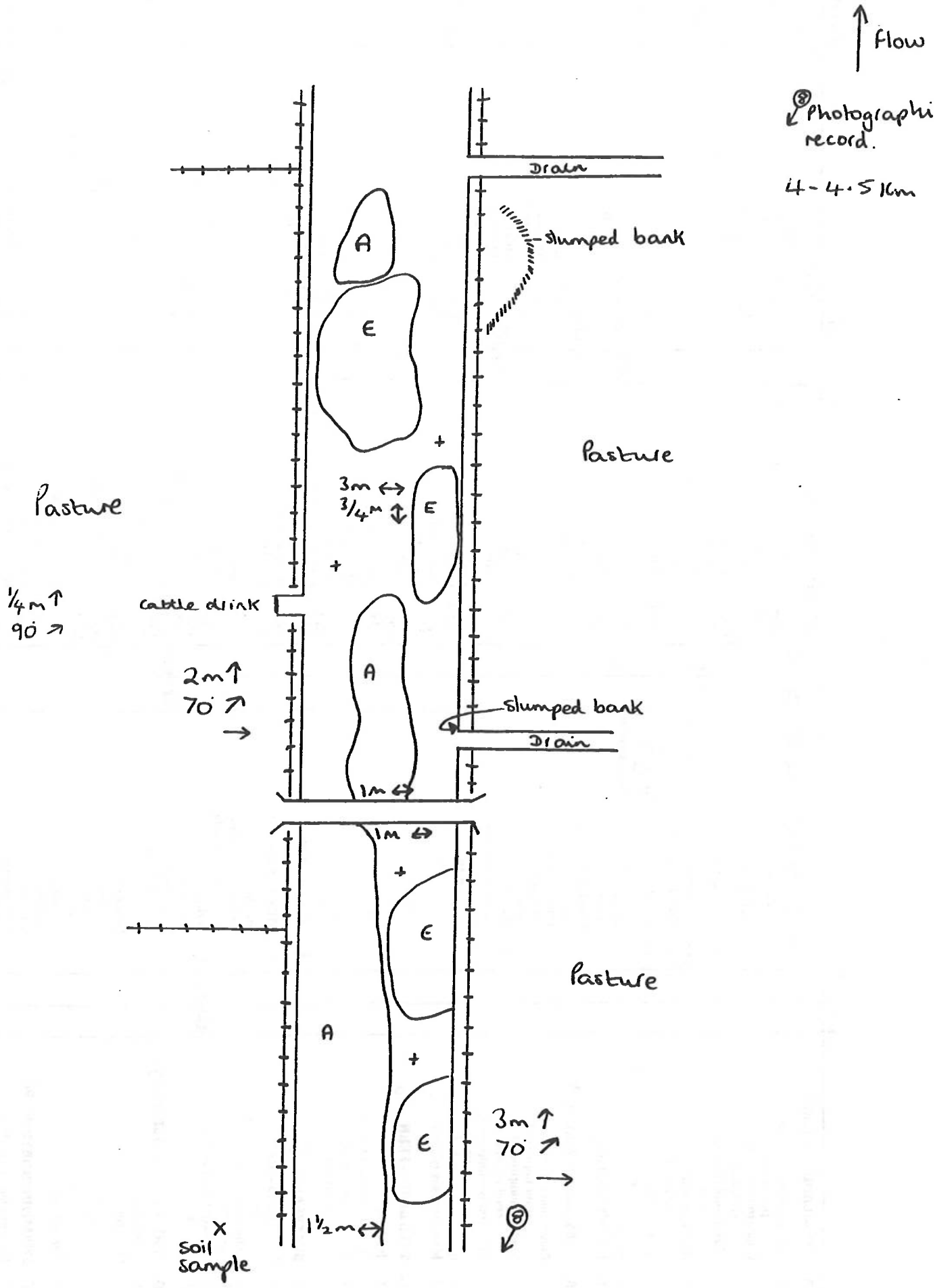
	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		10
C. TALL HERB & 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. Heath/grassland – dry	100	90
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN
Km No. 3 - 5 - 4
Date 11/6/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj. land in each stretch)		
canal =		1
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	5
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff (1m ↑ > 80°)		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m		100
>2m	100	
Width <1m		
1-<2.5m		
2.5-<5m	100	100
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore	2	4
P Willow recent pollard		
W Willow old, not pollard	1	
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %	20	
Sparse Scrub/shrubs %		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		3
weirs/500m		
locks/500m		
inlet/500m	1	
Depth <.25m	%	
.25-<.5		
0.5-<1.0		100
>1.0m		
Width <1		100
1-<5		
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sss sand		
FLORA %		
emergent veg < 1m wide		5
emergent 1-2m wide		95
emergent >2m wide		
total veget. area		80
B bryophytes		
E emergents	80	
A submerged	20	
F floating		
algae % of stretch		
		total to 100%


Flow
Photographic record.
4-4.5 16m
Drain
A
E
slumped bank
Pasture
3m ↔
3/4m ↕
E
Pasture
1/4m ↑
90° ↗
cattle drink
2m ↑
70° ↗
→
A
slumped bank
Drain
1m ↔
1m ↔
+
E
Pasture
A
+
E
3m ↑
70° ↗
→
1½m ↔
X
soil sample

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry	100	100
6. wet		
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		

River DYSYNNI LOW LEVEL DRAIN

Km No. 4 - 4.5

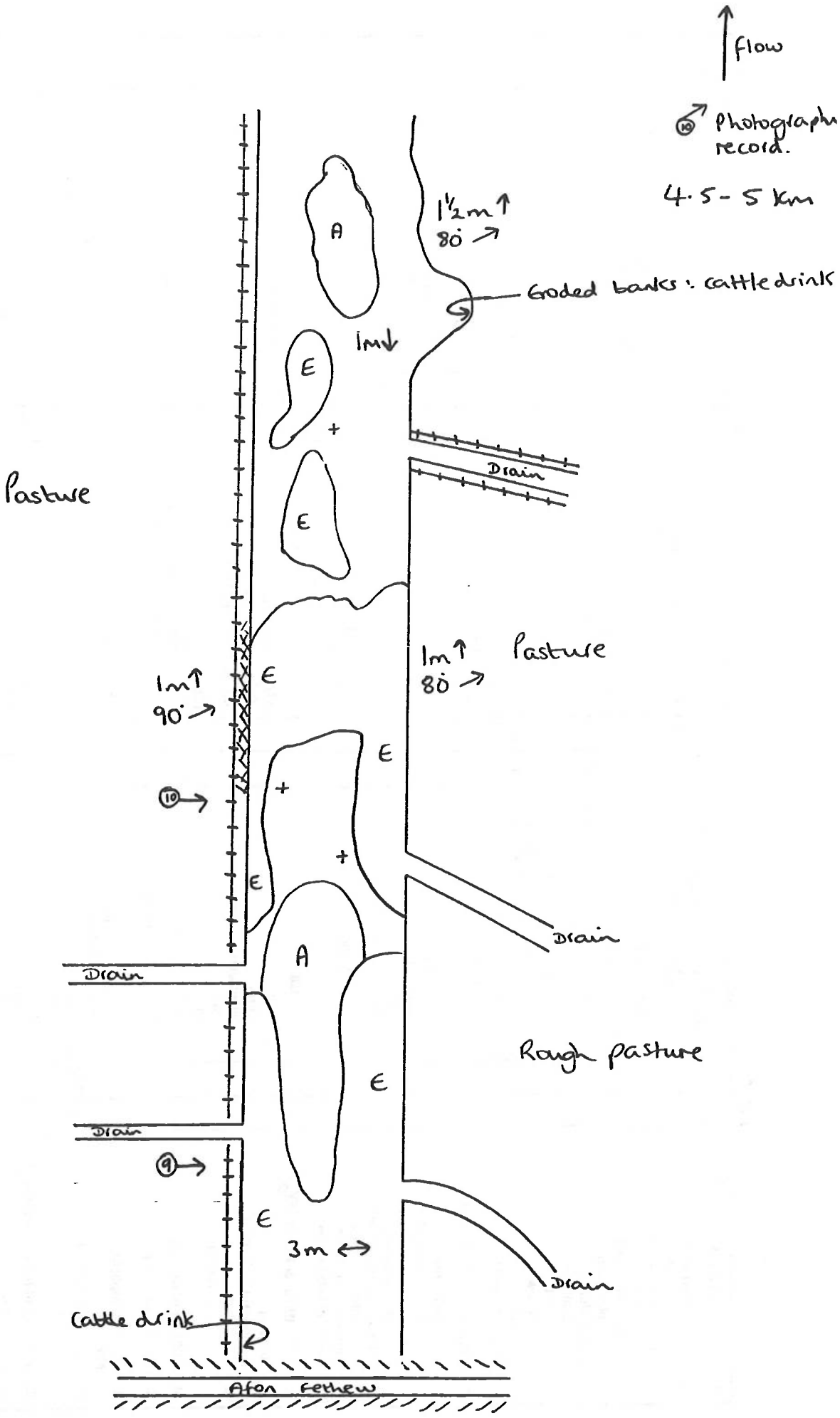
Date 11/6/92

Surveyor JALD.

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj. land in each stretch	
canal =		2
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
sheet %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m		
>2m	100	100
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow - recent pollard		
W Willow old, not pollard		
S Standard willows		
Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	River
RIVER HABITATS	
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	100
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	106
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	20
emergent 1-2m wide	80
emergent >2m wide	
total veget area	50
B bryophytes	
E emergents	
A submerged	88
F floating	
algae % of stretch	total to 100%


Flow
Photograph record.
4·5 - 5 km
1½m ↑
80° ↗
Graded banks : cattle drink
A
1m↓
E
+
Drain
Pasture
E
1m↑
90°↗
E
1m↑
80°↗
Pasture
10
+
E
+
E
Drain
A
Drain
Rough pasture
E
Drain
9
E
3m ↔
Drain
Cattle drink
Afon Fethew

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		10
C. TALL HERB & 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. Heath/grassland – dry	100	90
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN
Km No. 4·5 – 5
Date 11/6/92
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		2 3
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

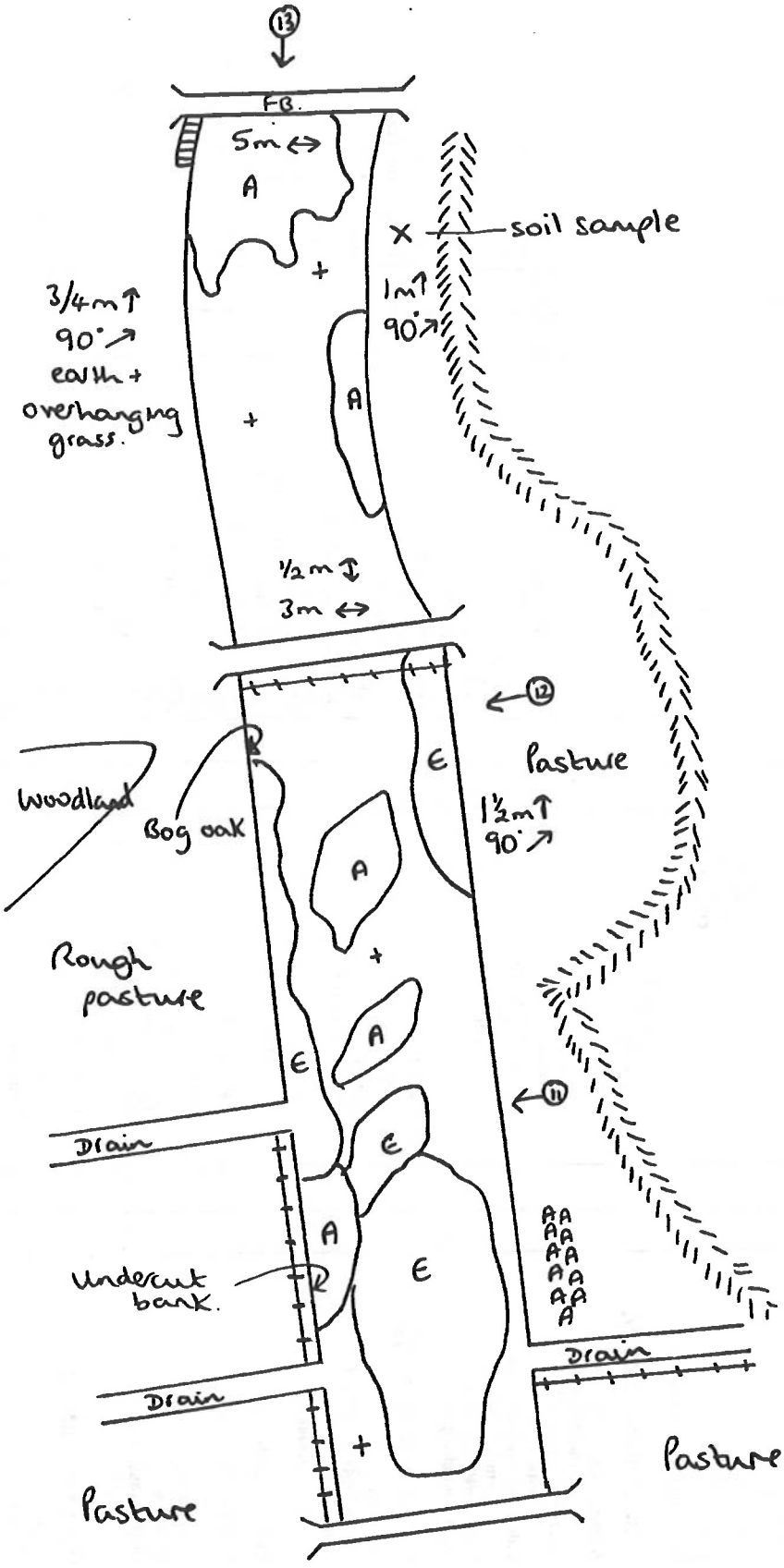
BANK FEATURES %	LB	RB
shell %		
solid earth cliff		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2·5m	100	100
2·5·<5m		
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %	20	
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	
0·5·<1·0	100
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	20
emergent 1·2m wide	
emergent >2m wide	80
total veget area	70
B bryophytes	
E emergents	30
A submerged	30
F floating	
algae % of stretch	total to 100%

Flow

⑪ Photographic record.

5 - 5·85 Km



	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	10	
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	80	
C. TALL HERB & 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. Heath/grassland – dry	10	100
6. wet		
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		

River DYSYNNI LOW LEVEL DRAIN.

Km No. 5 - 5·85

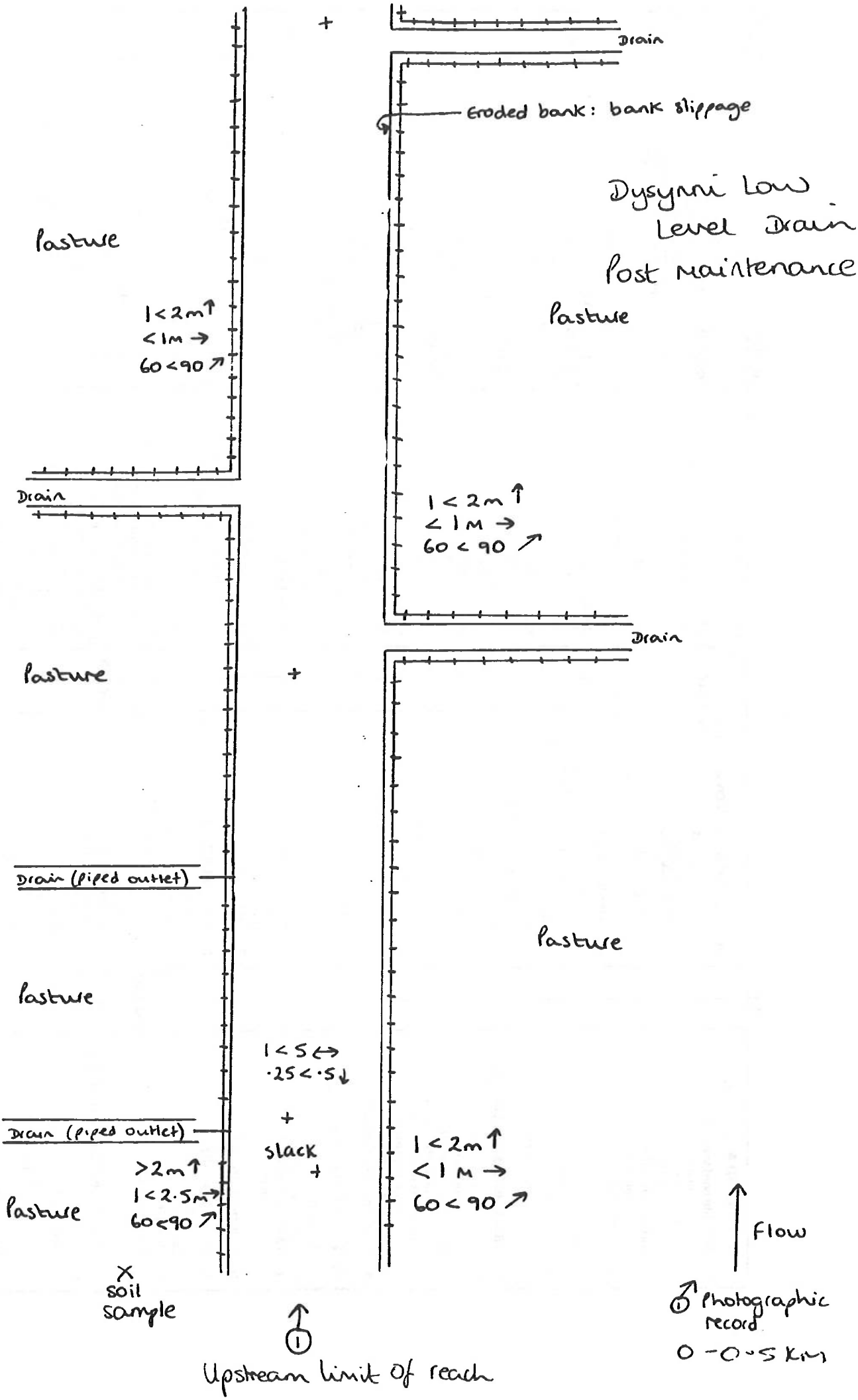
Date 11/6/92

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	2	1
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	25	1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
slip %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial	1	
FB flood bank adj		
FB flood bank set back		
levee		95
Height <1m	100	
1-<2m		100
>2m		
Width <1m	100	100
1-<2.5m		
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		11
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	3
weirs/500m	
locks/500m	
inlet/500m	1
Depth <.25m %	100
.25-<.5	
0.5-<1.0	
>1.0m	
Width <1	100
1-<5	
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
+ silt/mud	100
clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	20
emergent 1-2m wide	80
emergent >2m wide	
total veget area	40
B bryophytes	
E emergents	45
A submerged	55
F floating	
algae % of stretch	(total to 100%)


Drain
Eroded bank: bank slippage
Dysynni Low Level Drain Post Maintenance
Pasture
1<2m↑
<1m→
60<90↗
Pasture
Drain
1<2m↑
<1m→
60<90↗
Drain
Pasture
Drain (piped outlet)
Pasture
Pasture
1<5↔
·25<·5↓
slack
Drain (piped outlet)
>2m↑
1<2.5m→
60<90↗
Pasture
1<2m↑
<1m→
60<90↗
Flow
X soil sample
1
Upstream limit of reach
1 Photographic record
0-0·5 km

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry	100	100
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 0 - 0.5

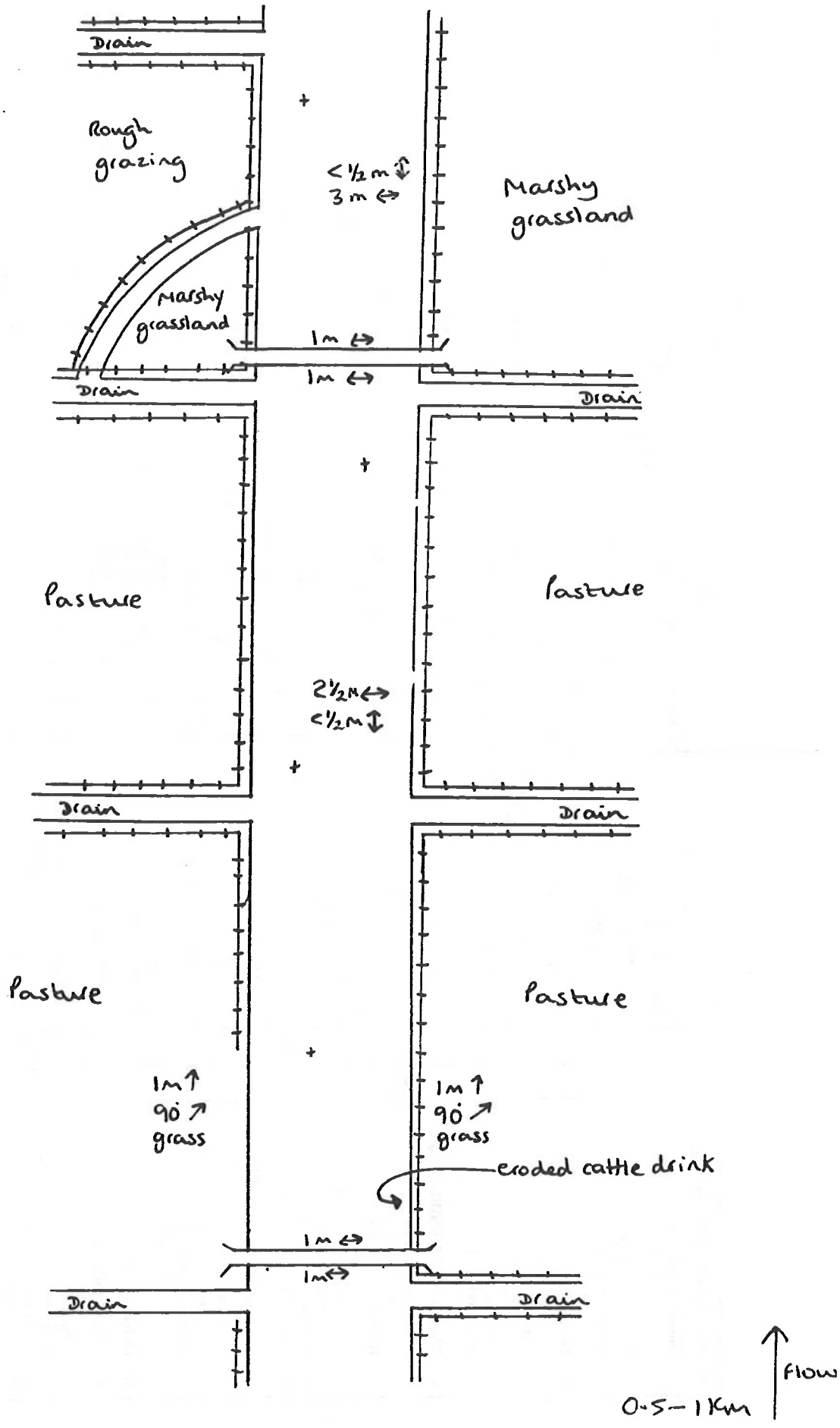
Date 22/8/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =	3	2
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑	100	90
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	90	100
>2m	10	
Width <1m		
1-<2.5m	30	
2.5-<5m	70	100
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle	100	95
earth		5
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	
.25-<.5		100
0.5-<1.0		
>1.0m		
Width <1		
1-<5		100
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si silt/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
rille		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1-2m wide		
emergent >2m wide		
total veget. area		
B bryophytes		
E emergents		
A submerged		total 10 100%
F floating		
algae % of stretch		


Drain
Rough grazing
< ½ m ↕
3 m ↔
Marshy grassland
Marshy grassland
1m ↔
1m ↔
Drain
Drain
Pasture
Pasture
2½M ↔
<½M ↕
Drain
Drain
Pasture
Pasture
1m ↑
90° ↗
grass
1m ↑
90° ↗
grass
eroded cattle drink
1m ↔
1m ↔
Drain
Drain
Flow
0·5–1Km

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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	10	
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	10	20
C. TALL HERB & 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. Heath/grassland – dry	80	80
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 0·5 – 1

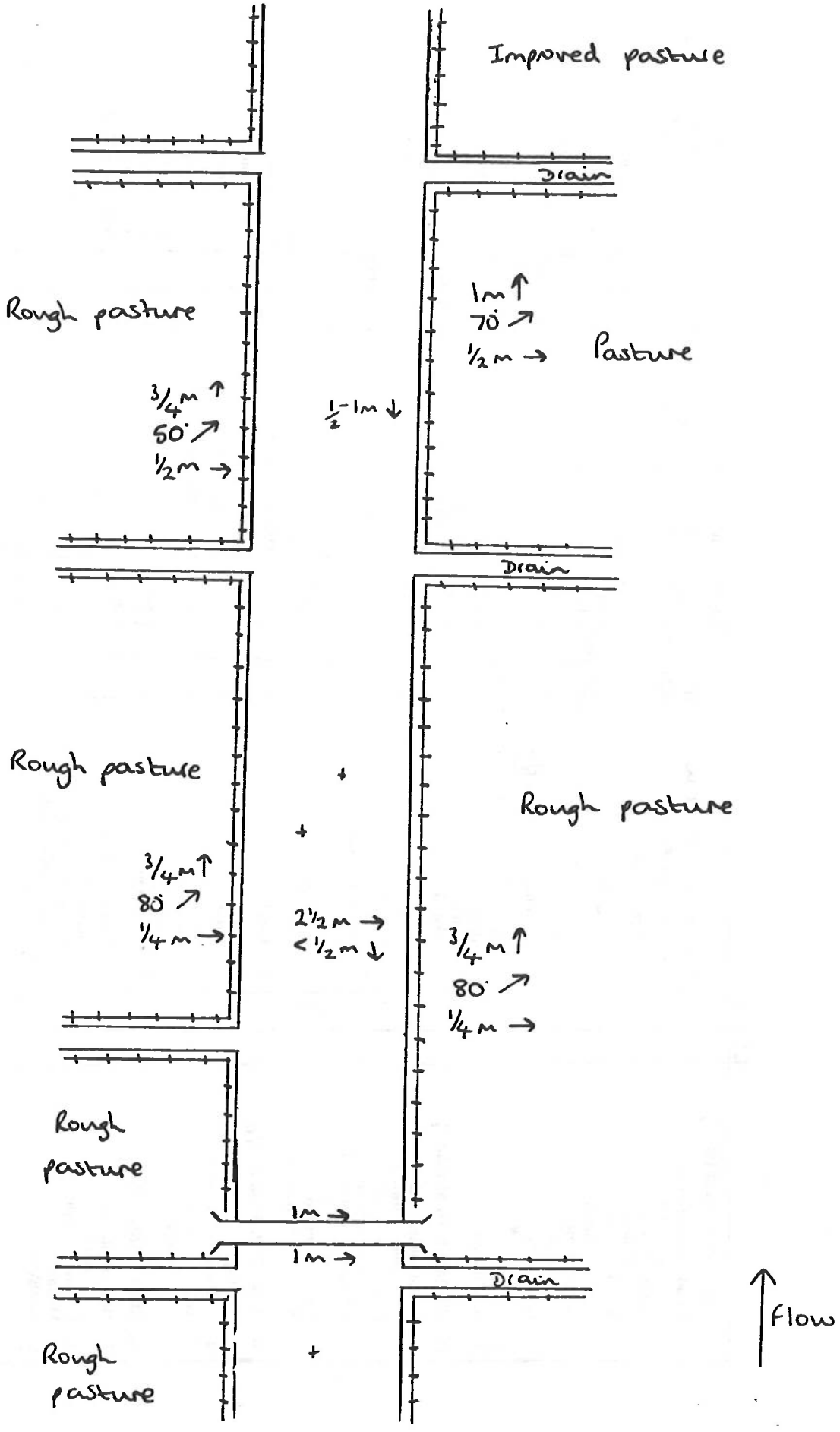
Date 22/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal † % of adj land in each stretch		
canal =		
ditch	5	3
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge †		
hedge =		
fence on bank	90	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff 1M↑	100	100
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2.5m	100	100
2.5·<5m		
>5m		
Slope: <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, † bare		
shingle and rock		
shingle, rock † veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	100
.5·<1.0	
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	
cl clay	100
peat	
Habitats and Flow	
pool	
slack	
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	total
E emergents	to 100%
A submerged	
F floating	
algae % of stretch	


Improved pasture
Drain
Rough pasture
1m ↑
70 ↗
½m →
Pasture
¾m ↑
50 ↗
½m →
½-1m ↓
Drain
Rough pasture
Rough pasture
¾m ↑
80 ↗
¼m →
2½m →
< ½m ↓
¾m ↑
80 ↗
¼m →
Rough pasture
1m →
1m →
Drain
Rough pasture
Flow
1-1.5KM

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland	100	90
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 1 – 1·5

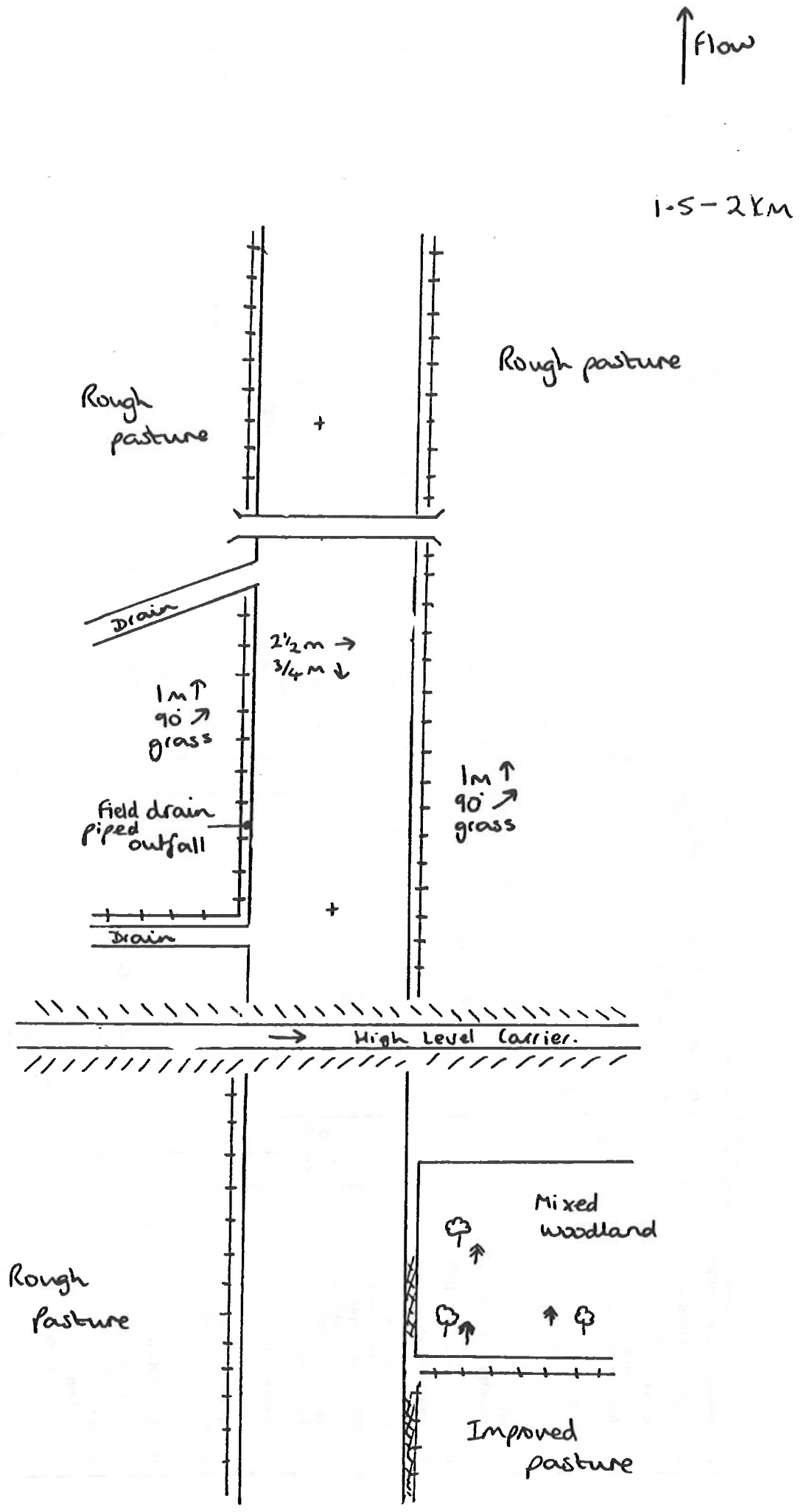
Date 22/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)	4	3
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shelf %		
solid earth cliff (1m ↑)		
soft earth cliff > 80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height < 1m	100	60
1 - <2m		40
>2m		
Width < 1m		
1 - <2.5m		
2.5 - <5m	100	100
>5m		
Slope: <30°		
30 - <60°	40	
60 - <90°	60	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	
weirs/500m	
locks/500m	
inlet/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	
p pebbles	
g gravel	
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	
slack	
rille	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget area	total = 100%
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	


Flow
1·5–2Km
Rough pasture
Rough pasture
Drain
2½m →
¾m ↓
1m ↑
90° ↗
grass
Field drain
piped
outfall
1m ↑
90° ↗
grass
Drain
High Level Carrier.
Mixed woodland
Rough Pasture
Improved pasture

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		20
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		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		10
5. Marsh/marshy grassland	100	70
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 1-5-2

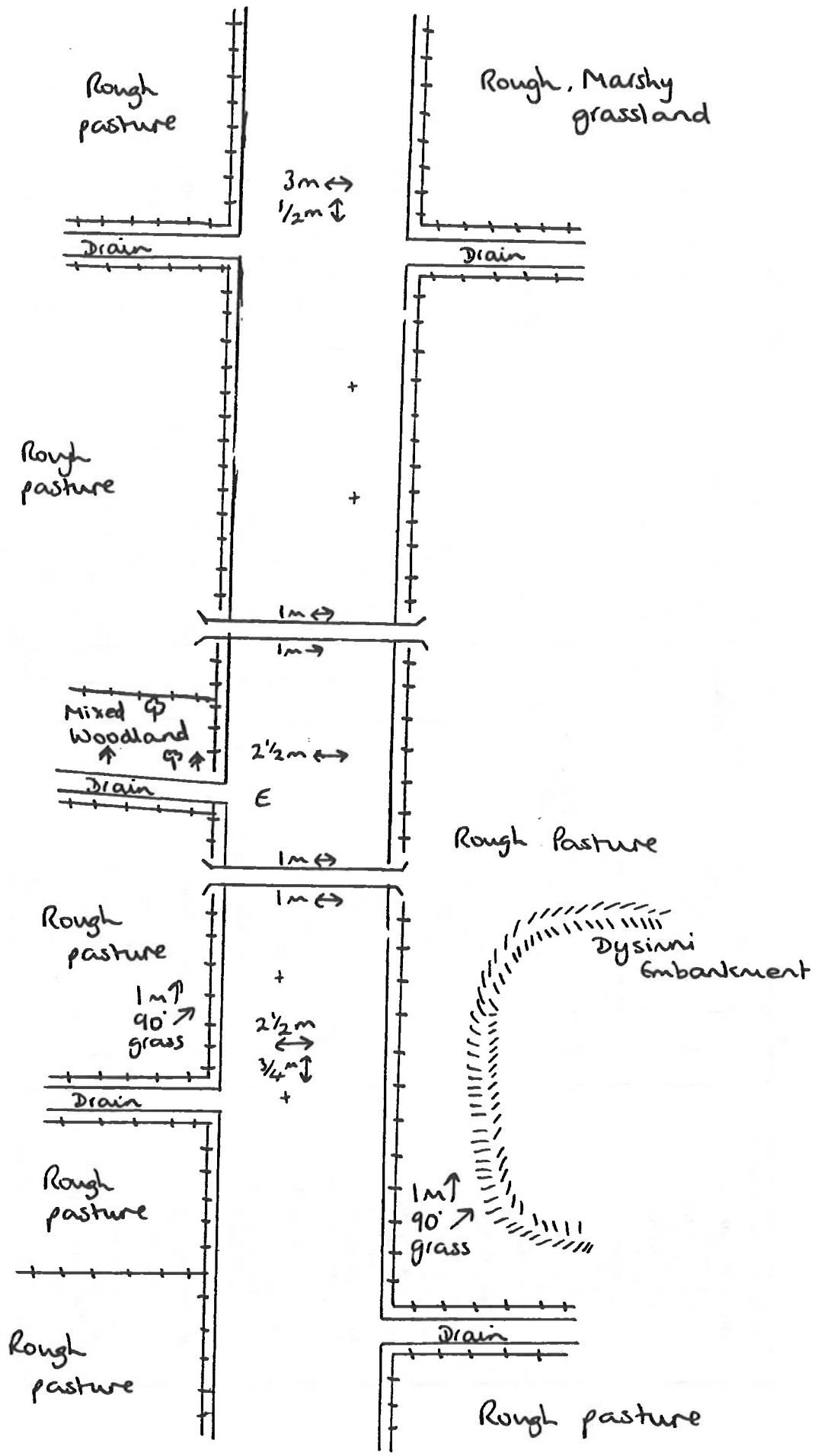
Date 23/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal +	% of adj land in each stretch	
canal =		
ditch	2	
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =	90	60
fence on bank		
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shelf %		
solid earth cliff (1m↑)		
soft earth cliff (>80°)		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m	100	100
1-<2.5m		
2.5-<5m		
>5m		
Slope <30°		
30-<60°	100	100
60-<90°		
>90°		
mud	100	100
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recept pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	1
Depth <.25m %	
.25-<.5	100
0.5-<1.0	
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	1
slack	99
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sss sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	total 10 100%
E emergents	
A submerged	
F floating	
algae % of stretch	


Flow
2 - 2·5 km
Rough pasture
Rough, Marshy grassland
3m ↔
½m ↕
Drain
Drain
Rough pasture
1m ↔
1m →
Mixed Woodland
2½m ↔
Drain
E
Rough Pasture
1m ↔
1m ↔
Rough pasture
Dysinni Embankment
1m ↑
90° ↗
grass
2½m ↔
¾m ↕
Drain
Rough pasture
1m ↑
90° ↗
grass
Drain
Rough pasture
Rough pasture

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 2 – 2·5

Date 22/4/93

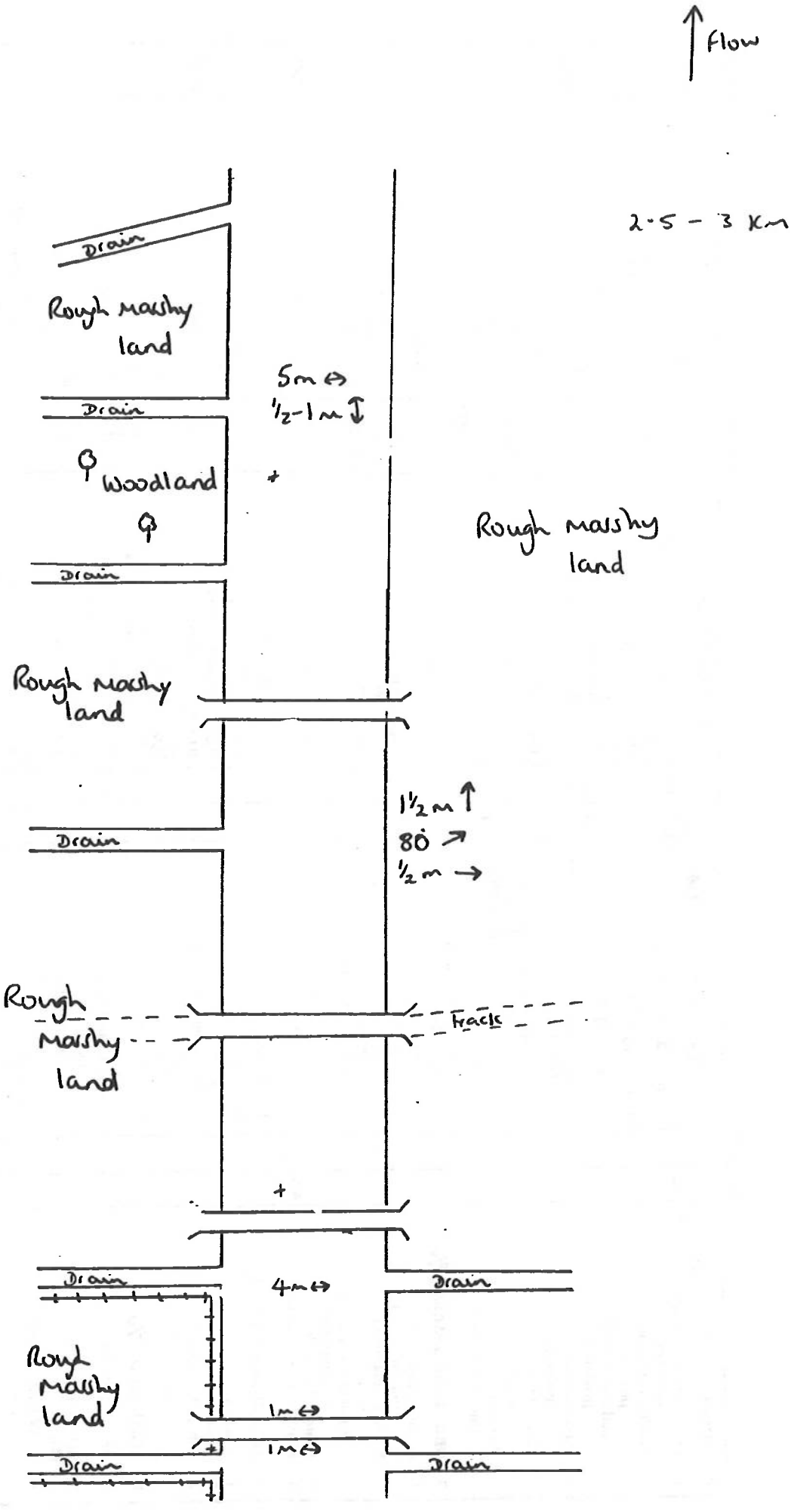
Surveyor JALD

	LB	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	100	100
C. TALL HERB & 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. Heath/grassland – dry		
6. wet		
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		

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =	3	2
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m	100	100
1·<2·5m		
2·5·<5m		
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	2
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	20
.25·<.5	80
0·5·<1·0	
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	total
E emergents	= 100%
A submerged	
F floating	
algae % of stretch	


Flow
2·5 – 3 km
Drain
Rough marshy land
5m ↔
½-1m ↕
Drain
Woodland
Rough marshy land
Drain
Rough marshy land
1½m ↑
80 ↗
½m →
Drain
Rough marshy land
Tracks
4m ↔
Drain
Drain
Rough marshy land
1m ↔
1m ↔
Drain
Drain

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	10	
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	90	90
C. TALL HERB & FERN %		
1. Bracken		
2. Upland spp. rich vegetl.		
3. Other – tall ruderal		
non ruderal		
D. HEATHLAND %		
1. Dwarf scrub – dry		
wet		
3. Lichen/bryophyte		
4. Montane		
5. Heath/grassland – dry		
6. wet		
E. MIRE, FLUSH AND SPRING %		
1. Mires – bog		10
Fen – reed		
sedge		
sweet-grass		
mixed		
2. Bog flushes		
F. SWAMP/INUNDATION %		
1. Swamp – single sp. dom.		
Tall mixed assemblage		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 2·5 – 3

Date 22/4/93

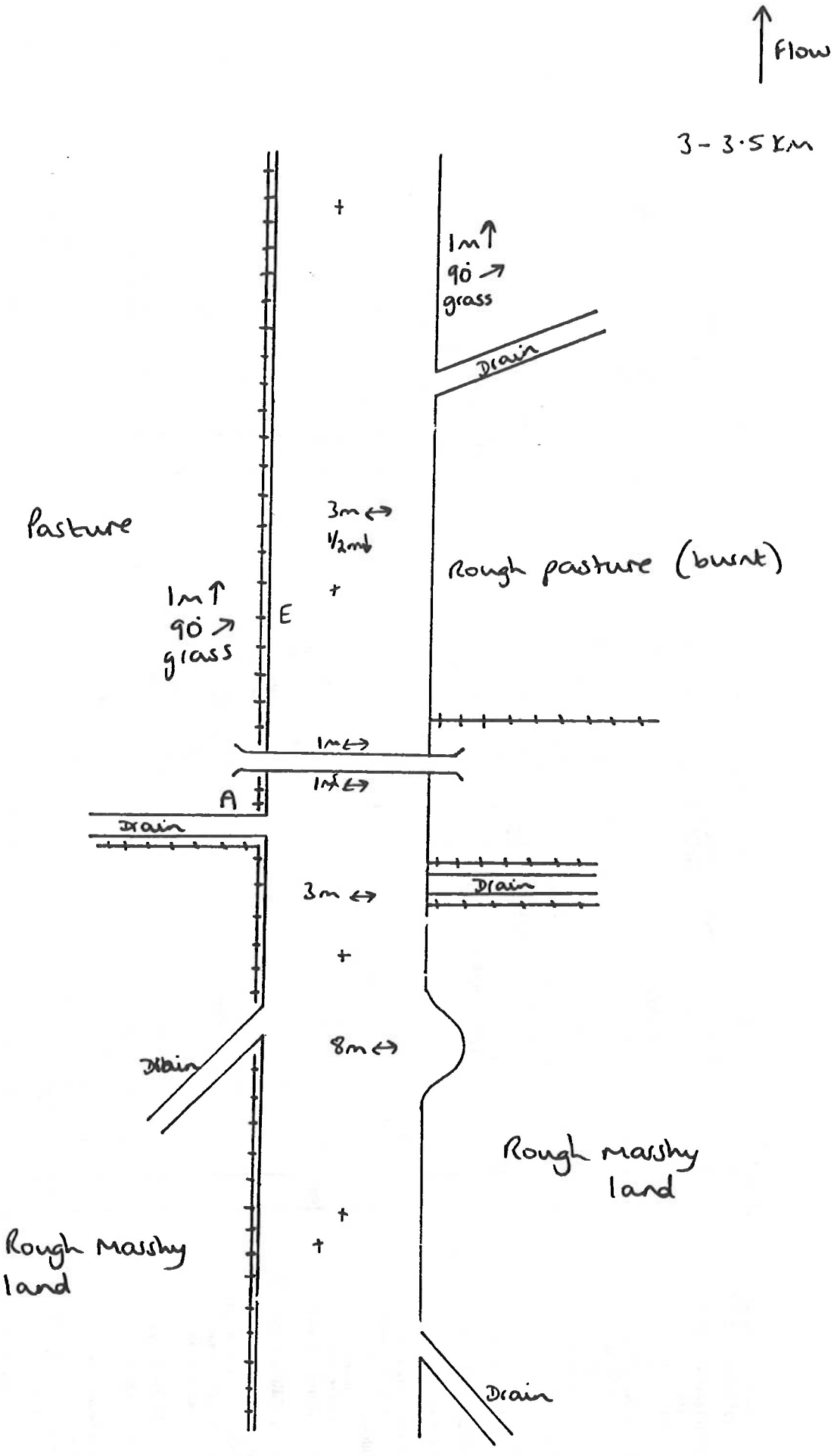
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing – canal +	% of adj land in each stretch	
canal =		
ditch	6	2
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	5	
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

	LB	RB
BANK FEATURES %		
shell %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m	100	100
>2m		
Width <1m		
1·<2·5m	100	100
2·5·<5m		
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth		
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, 1 bare		
shingle and rock		
shingle, rock + veg		
earth – maturing		
earth – with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	4
weirs/500m	
locks/500m	
inlet/500m	
Depth <·25m %	
.25·<.5	
0·5·<1·0	
>1.0m	100
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
rifle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total vegel area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

total to 100%


Flow
3 - 3·5 km
1m ↑
90 ↗
grass
Drain
Pasture
3m ↔
½m ↔
Rough pasture (burnt)
1m ↑
90 ↗
grass
E
1m ↔
1m ↔
A
Drain
Drain
3m ↔
8m ↔
Drain
Rough marshy land
Rough marshy land
Drain

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 3 – 3.5

Date 22/4/93

Surveyor JALJ

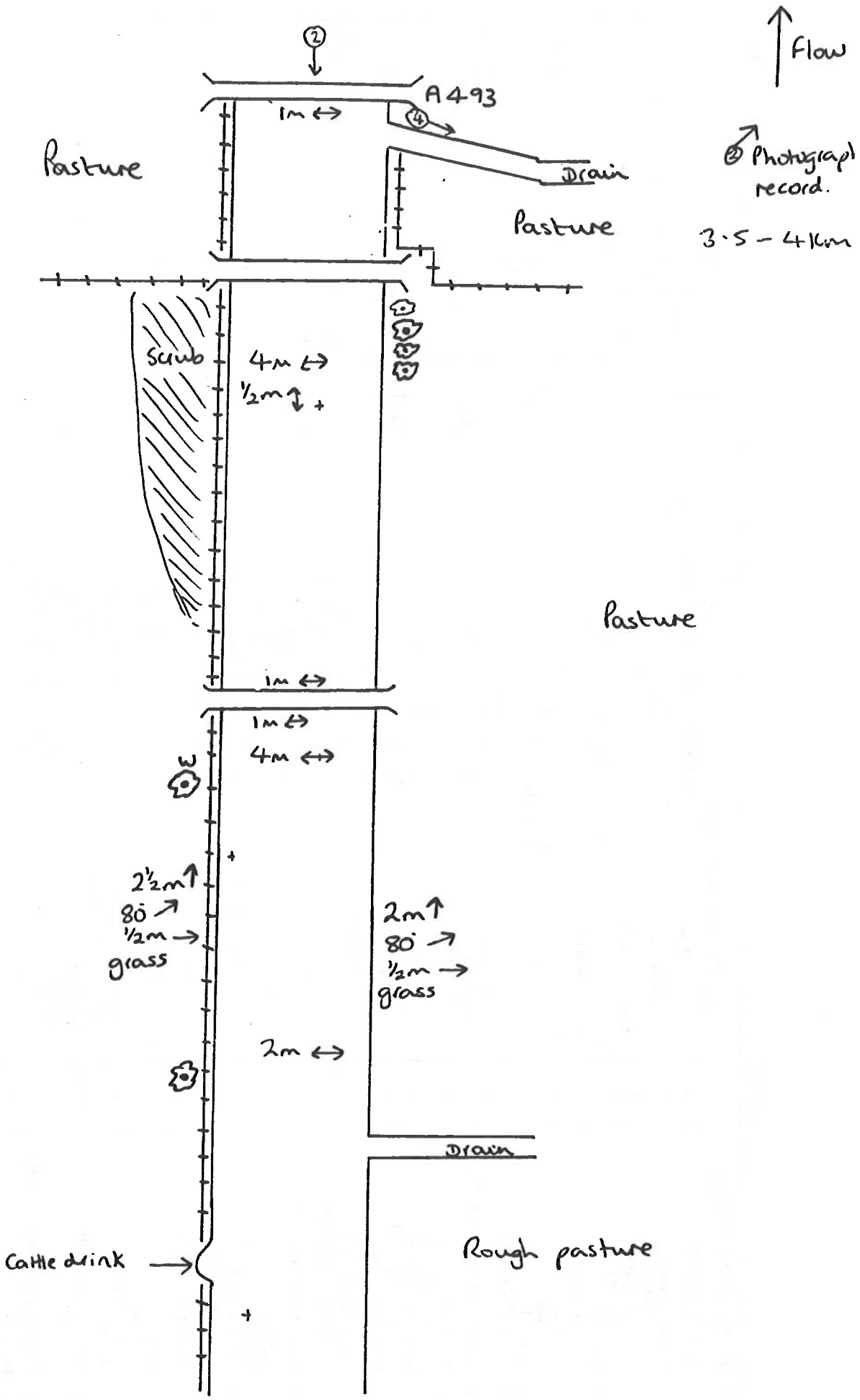
	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic uninproved		
semi-improved		
Neutral uninproved		
semi-improved		
Calcareous uninproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	90	100
C. TALL HERB & 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. Heath/grassland – dry	10	
6. wet		
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		

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)	2	3
canal =		
ditch		
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial		
flood bank adj		
flood bank set back		
levee		
Height <1m		
1-<2m		
>2m	100	100
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°		
>90°	100	100
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %.		
Sparse Scrub/shrubs %.		
Reed/Sedge %.		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	1
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
0.5-<1.0	100
>1.0m	
Width <1	
1-<5	80
5-<10	20
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

total to 100%


Flow
2
A493
1m ↔
4
Pasture
Drain
Pasture
Photograph record.
3·5 – 4 km
Scrub
4m ↔
½m ↕
Pasture
1m ↔
1m ↔
4m ↔
W
2½m ↑
80° ↗
½m →
grass
2m ↑
80° ↗
½m →
grass
2m ↔
Drain
Cattle drink →
Rough pasture

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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 uninproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		10
C. TALL HERB & 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. Heath/grassland – dry	100	90
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 3·5 – 4

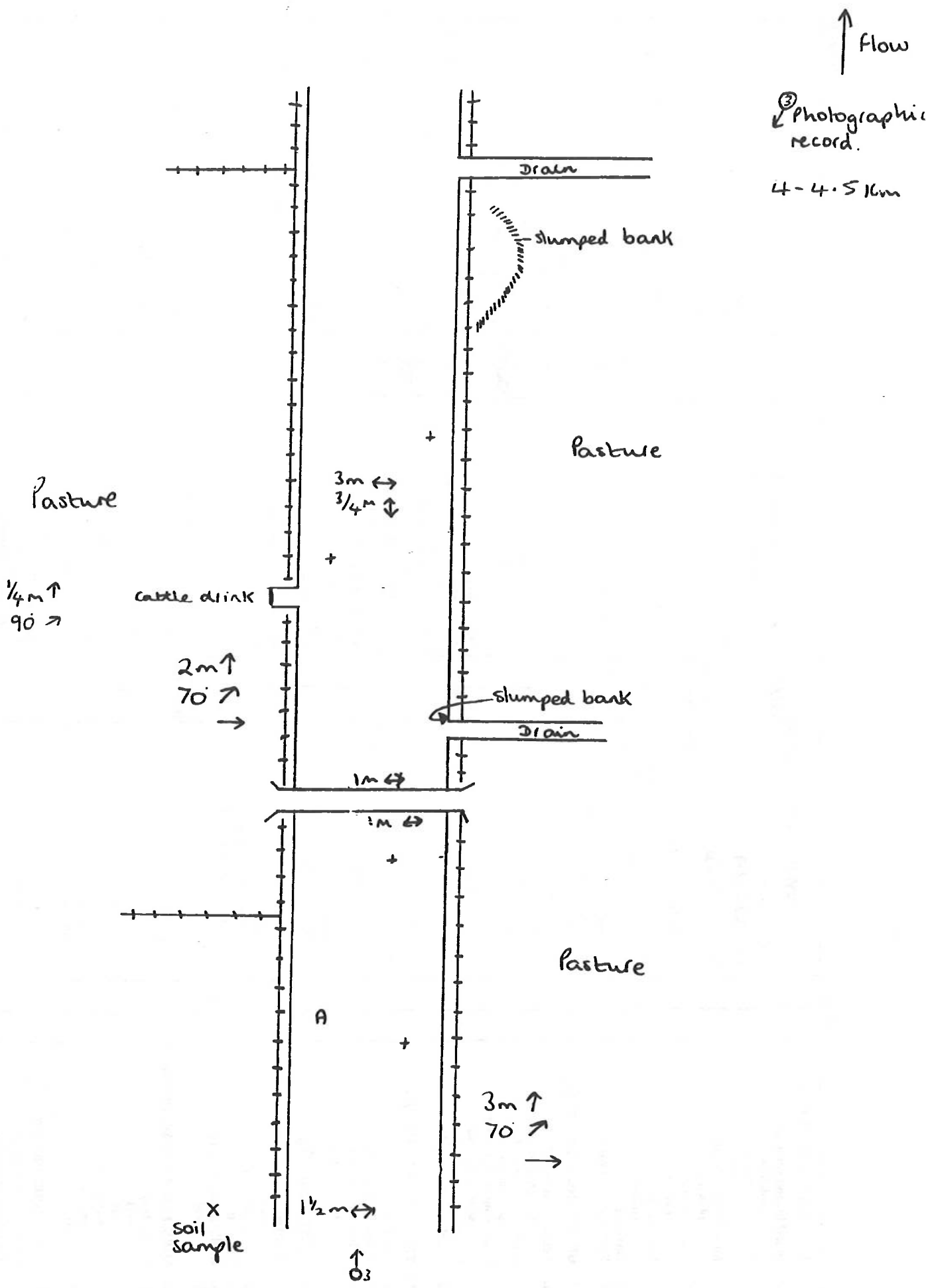
Date 22/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal	% of adj land in each stretch	
canal =		
ditch		2
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1·5m		
5·10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge ↓		
hedge =		
fence on bank	100	5
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shell %		
solid earth cliff	1m↑	
soft earth cliff	>80°	
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1·<2m		100
>2m	100	
Width <1m		
1·<2.5m		
2.5·<5m	100	100
>5m		
Slope <30°		
30·<60°		
60·<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore	2	4
P Willow recept pollard		
W Willow old, not pollard	1	
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %	20	
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, ↓ bare		
shingle and rock		
shingle, rock ↓ veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	3
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25·<.5	
0·5·<1.0	
>1.0m	
Width <1	
1·<5	100
5·<10	
10·<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1·2m wide	
emergent >2m wide	
total vegel area	
B bryophytes	Total 10 100%
E emergents	
A submerged	
F floating	
algae % of stretch	


Flow
③ Photographic record.
4 - 4·5 1Cm
Drain
slumped bank
Pasture
Pasture
3m ↔
3/4m ↕
1/4m ↑
90 ↗
cattle drink
2m ↑
70 ↗
→
slumped bank
Drain
1m ↔
1m ↔
Pasture
A
3m ↑
70 ↗
→
X
soil sample
1½m ↔
O3

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 4-4-5

Date 23/4/93

Surveyor JALD

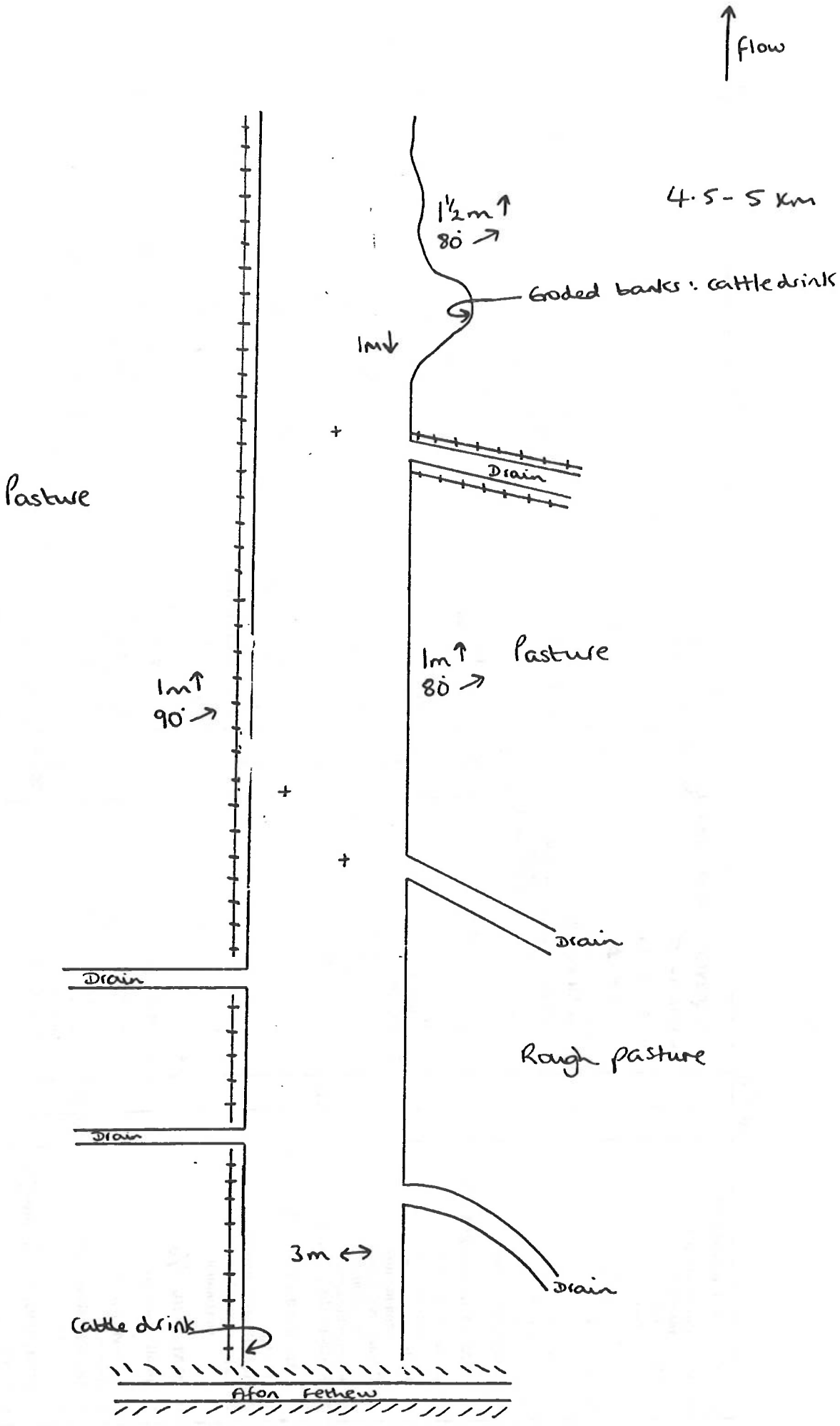
	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous semi-nat. plantation		
Mixed semi-natural plantation		
2. Scrub – dense		
scattered		
Carr – alder		
willow		
3. Parkland		
4. Recently felled wood		
B. GRASSLAND & MARSH %		
1. Acidic unimproved		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		
C. TALL HERB & 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. Heath/grassland – dry	100	100
6. wet		
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		

	LB	RB
G. OPEN WATER		
1. Standing - canal + % of adj. land in each stretch		
canal =		
ditch		2
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %.		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	100
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1M↑		
soft earth cliff >80°		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<3m	100	100
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %.		
Sparse open %.		
Reseeded or mown %.		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
width x% rocky, + bare		
shingle and rock		
shingle, rock + veg		
x earth - maturing		
earth - with trees		
developed		

	RIVER
RIVER HABITATS	
bridges/500m	
weirs/500m	
locks/500m	
inlet/500m	1
Depth <.25m %	
.25-<.5	
0.5-<1.0	100
>1.0m	
Width <1	
1-<5	100
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	
E emergents	
A submerged	
F floating	
algae % of stretch	

total = 100%


Flow
4·5 - 5 km
1½m ↑
80° ↗
Graded banks : cattle drink
1m ↓
Pasture
Drain
1m ↑
90° ↗
1m ↑
80° ↗
Pasture
Drain
Drain
Rough pasture
Drain
3m ↔
Drain
Cattle drink
Afon Fethew

	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation		
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland		10
C. TALL HERB & 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. Heath/grassland – dry	100	90
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN
Km No. 4-5-5
Date 23/4/93
Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + % of adj land in each stretch		
canal =		
ditch	2	3
dyke		
pond, pool, cut-off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	100	1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

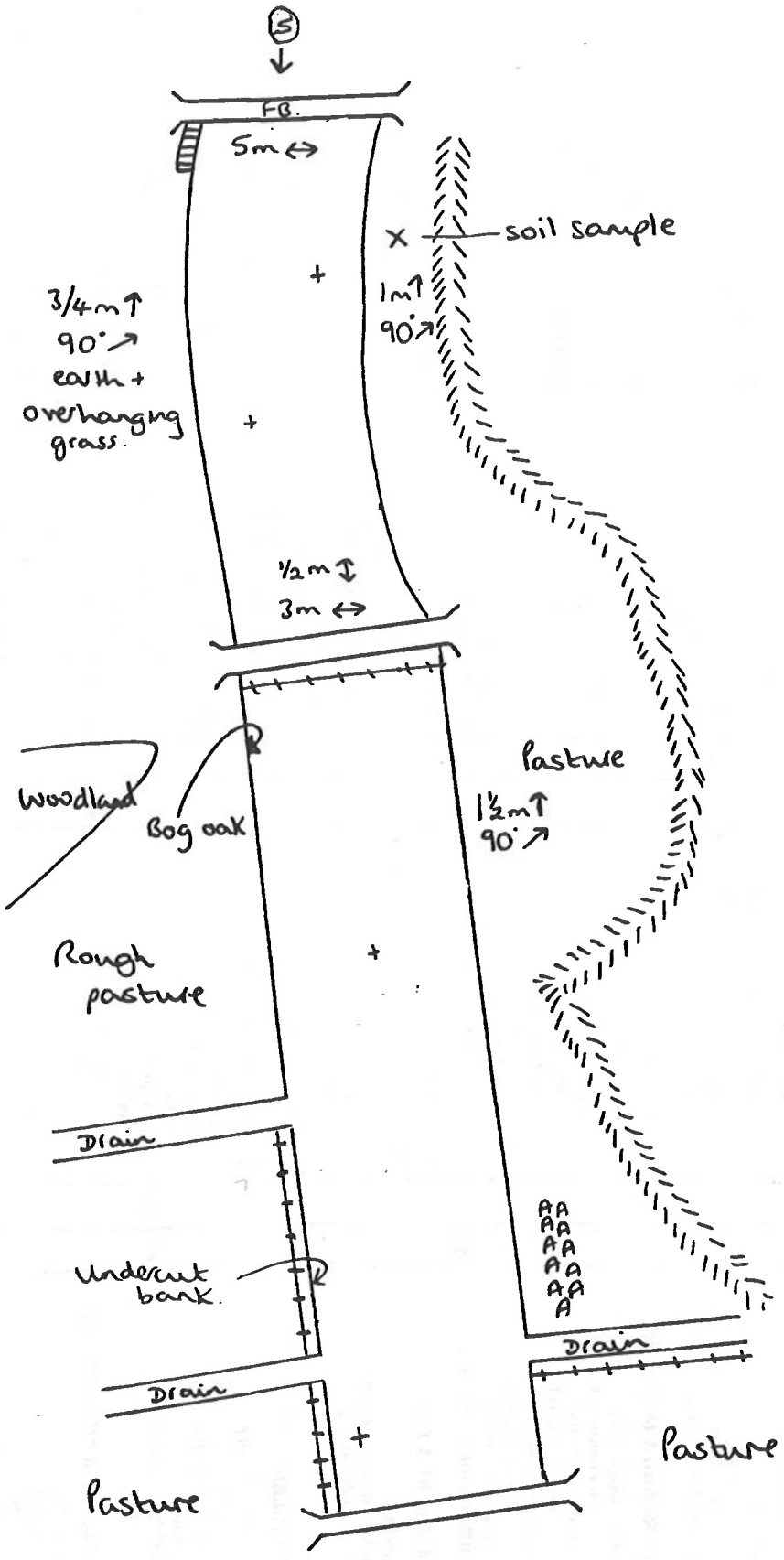
BANK FEATURES %	LB	RB
shell %		
solid earth cliff		
soft earth cliff		
rock cliff		
artificial		
FB flood bank adj		
FB flood bank set back		
levee		
Height <1m		
1-<2m	100	100
>2m		
Width <1m		
1-<2.5m	100	100
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS	RIVER
bridges/500m	
weirs/500m	
locks/500m	
inlet/500m	
Depth <.25m %	
.25-<.5	
.5-<1.0	100
>1.0m	
Width <1	100
1-<5	
5-<10	
10-<20	
>20	
Substrates	
BR bed rock	
b boulders	
c cobbles	
p pebbles	
g gravel	
s sand	
si silt/mud	100
cl clay	
peat	
Habitats and Flow	
pool	
slack	100
riffle	
rapids	
run	
waterfall	
protruding rocks	
Margins	
shingle ± bare	
shingle, vegetated	
mud	
sand	
FLORA %	
emergent veg < 1m wide	
emergent 1-2m wide	
emergent >2m wide	
total veget. area	
B bryophytes	total = 100%
E emergents	
A submerged	
F floating	
algae % of stretch	

Flow

Photographic record.

5 - 5·85 Km



	LG	RB
A. WOODLAND & SCRUB %		
1. Broad-leaved semi-nat. plantation	10	
Coniferous 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		
semi-improved		
Neutral unimproved		
semi-improved		
Calcareous unimproved		
semi-improved		
4. Improved/reseeded		
5. Marsh/marshy grassland	80	
C. TALL HERB & 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. Heath/grassland – dry	10	100
6. wet		
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		

RIVER DYSYNNI LOW LEVEL DRAIN

Km No. 5 – 5.85

Date 24/4/93

Surveyor JALD

	LB	RB
G. OPEN WATER		
1. Standing - canal + (% of adj land in each stretch)		
canal =		
ditch	2	1
dyke		
pond, pool, cut off %		
lake %		
gravel pit %		
reservoir %		
marina %		
2. Running		
stream < 1m wide		
1-5m		
5-10m		
>10		
I. ROCK		
1. cliff		
scree		
limestone pavement		
cave		
other		
2. artificial/waste		
J. MISCELLANEOUS		
arable		
amenity grassland		
ephemeral/short herb		
hedge +		
hedge =		
fence on bank	25	1
fence set back		
wall		
building		
caravans		
fish farm		
silage clamp		
sewage works		
garden		
stick pile		
flood debris		
road		
railway disused		
used		
other		

BANK FEATURES %	LB	RB
shelf %		
solid earth cliff 1m↑		
soft earth cliff >80°		
rock cliff		
artificial	1	
FB flood bank ach		
FB flood bank set back		
levee		95
Height <1m	100	
1-<2m		100
>2m		
Width <1m	100	100
1-<2.5m		
2.5-<5m		
>5m		
Slope <30°		
30-<60°		
60-<90°	100	100
>90°		
mud		
sand		
bare shingle		
vegetated shingle		
earth	100	100
natural cobbles		
natural boulders		
BANK VEGETATION		
Conifer		
Oak, Ash, Sycamore		
P Willow recent pollard		
W Willow old, not pollard		
S Standard willows		
A Alder		11
Other trees		
Young trees		
Thick Scrub/shrubs %		
Sparse Scrub/shrubs %		
Reed/Sedge %		
Dense open %		
Sparse open %		
Reseeded or mown %		
Exposed tree roots		
ISLANDS		
Rocky, vegetated		
rocky, + bare		
shingle and rock		
shingle, rock + veg		
earth - maturing		
earth - with trees		
developed		

RIVER HABITATS		RIVER
bridges/500m		3
weirs/500m		
locks/500m		
inlet/500m		
Depth <.25m	%	100
.25-<.5		
0.5-<1.0		
>1.0m		
Width <1		100
1-<5		
5-<10		
10-<20		
>20		
Substrates		
BR bed rock		
b boulders		
c cobbles		
p pebbles		
g gravel		
s sand		
si/mud		100
cl clay		
peat		
Habitats and Flow		
pool		
slack		100
riffle		
rapids		
run		
waterfall		
protruding rocks		
Margins		
shingle ± bare		
shingle, vegetated		
mud		
sand		
FLORA %		
emergent veg < 1m wide		
emergent 1-2m wide		
emergent >2m wide		
total veget area		
B bryophytes		total 10 100%
E emergents		
A submerged		
F floating		
algae % of stretch		

DSPACE

https://dspace.org/

Welsh region: River Arrow, Dreneuydd/Broadway Reen, Dysynni Low Level Drain

Dunderdale, J. A. L.; Morris, J.

1996
National Rivers Authority
https://dspace.lib.cranfield.ac.uk/handle/1826/21151
Dunderdale JAL, Morris J. (1996) Welsh region: River Arrow, Dreneuydd/Broadway Reen, Dysynni Low Level Drain, Annex of R&D note 456

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