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**An Investigation of the
Factors Affecting the
Occurrence and Abundance
of *Ranunculus penicillatus* in
Selected Rivers in Northern
Ireland**

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Prepared by Aquatic and Terrestrial Environmental Consultants (A.T.E.C.) under
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**An Investigation of the Factors Affecting the Occurrence and Abundance of
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**Prepared by: Dr Jane Preston, Emma Muise, Dr Alex Portig &
Prof. Ian Montgomery**
Prepared for: Mr Tony Waterman, The Environment & Heritage Service

Introduction

Floating mats of River Water-crowfoot *Ranunculus penicillatus* var. *penicillatus* are widespread in rivers and often constitute an important structural feature of the river channel. They may modify water flow, promote fine sediment deposition and provide shelter and food for fish and invertebrate animals. The habitat type is widespread in rivers in the UK, especially on softer and more mineral rich substrates. It is absent from rivers seriously affected by pollution and siltation.

In-stream grazing by cattle can rapidly destroy beds of *R. penicillatus* var. *penicillatus*, and buffer zoning, by means of stock-proof fencing, is a good way of protecting not only the bankside and marginal plants but also in-stream plants such as Water crowfoot.

R. penicillatus var. *penicillatus* occurs only in fast-flowing rivers, where it is capable of growing in torrent conditions, as well as in more slow-flowing sections which have a high current velocity during flood periods only. It occurs in a substantial number of rivers in Wales, Ireland and western England (Holmes, 1980).

There have been few studies carried out into the factors affecting the growth and distribution of *R. penicillatus* var. *penicillatus*. However, studies carried out on a closely related sub-species *Ranunculus penicillatus* subsp. *pseudofluitans* have revealed that it favours good water quality and minimal amounts of silt. In addition, it is often found associated in the channel with other aquatic macrophyte species such as *Callitriche obtusangula* or *C. platycarpa*, *Berula erecta*, *Apium nodiflorum*, *Rorippa nasturtium-aquaticum*, *Myostis scorpiodes*, *Veronica anagallis-aquatica* and *Veronica beccabunga* (English Nature). One would expect similar environmental conditions to favour the occurrence of *R. penicillatus* var. *penicillatus*.

The distribution of *R. penicillatus* subsp. *pseudofluitans* is limited in Northern Ireland. Moderately extensive beds of this sub-species are restricted to several hundred metres of river downstream of Dunadry (J199849) on the Sixmile Water in County Antrim. In comparison, *R. penicillatus* var. *penicillatus* is found to occur on numerous rivers in Northern Ireland (Fig. 1). However, extensive beds of the plant have been found to occur on three rivers in Northern Ireland (Fig. 2, Table 1). These rivers are the Ballinderry and Owenkillew rivers in Co. Tyrone and the Swanlinbar river in Co. Fermanagh (Fig. 2). These rivers have been targeted as potential sites for the monitoring and conservation of *R. penicillatus* var. *penicillatus* in Northern Ireland.



Figure 1. Distribution of *Ranunculus penicillatus* var. *penicillatus* on rivers in Northern Ireland. Information taken from Rivers Conservation Macrophyte Database and based on 1000m surveys at selected sites.
Approx. scale 1: 910,000

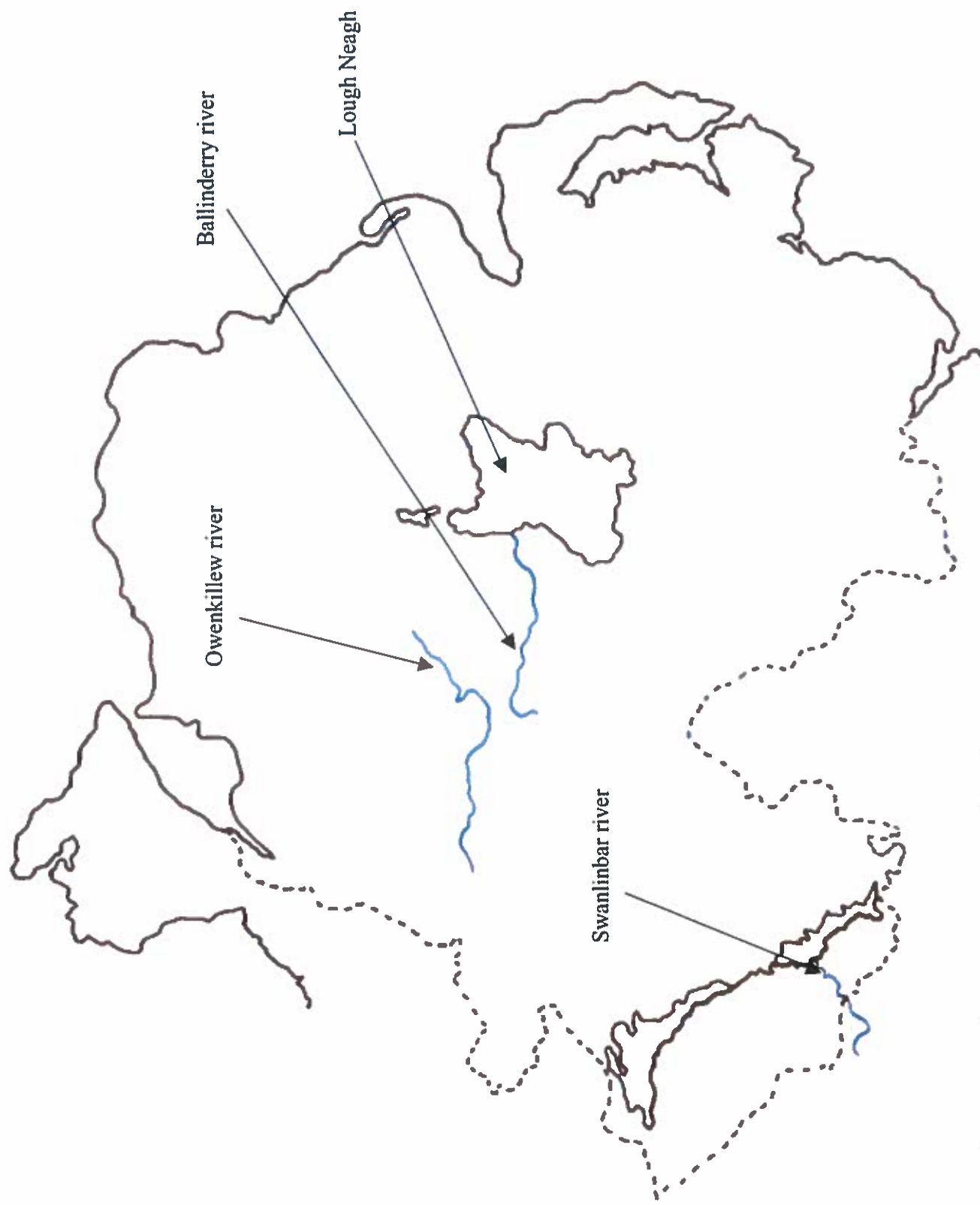


Figure 2. Location of the three target rivers in Northern Ireland.
Approx. scale 1: 800,000

Table 1. Occurrence and extent of *R. penicillatus* var. *penicillatus* in 'target' rivers in Northern Ireland.

River	Total Length of River	Length <i>R. penicillatus</i> var. <i>penicillatus</i> occurrence
Owenkillew	42km	35km
Ballinderry	25km	24km
Swanlinbar	10km	6km

Objectives & Methods

The present study aimed to investigate the factors affecting the growth and distribution of *R. penicillatus* var. *penicillatus* on the three 'target' rivers listed in Table 1.

The main objectives were firstly to carry out a statistical analysis of existing data on *R. penicillatus* var. *penicillatus* in target rivers in order to determine the suite of physical parameters controlling its occurrence and abundance. These parameters can be used in conservation management plans for each target river. The second objective of the current investigation was to carry out further field work for the purposes of future management and monitoring of *R. penicillatus* var. *penicillatus* on each of the target rivers.

A. Statistical analysis of existing data on *R. penicillatus* var. *penicillatus*.

Introduction

This attempted to discover the suite of parameters that determine the distribution and abundance of *R. penicillatus* var. *penicillatus* in rivers in Northern Ireland. The analysis used existing data on the target rivers. The physical data on each section of river was extracted from the River Habitat Survey (RHS) database while details on the presence and abundance of *R. penicillatus* var. *penicillatus* was obtained from the Conservation Rivers Macrophyte Database. *R. penicillatus* var. *penicillatus* occurs on 65 sections of the three target rivers (Table 1).

Methods

1. Physical Parameters Effecting *R. penicillatus* var. *penicillatus* distribution

Multiple Discriminant Function Analysis was used to analyse sections of river where the *R. penicillatus* var. *penicillatus* was both present and absent on the three

target rivers. A selection of physical parameters were included in the analysis (Table 2).

Multiple Discriminant Function Analysis is used to determine which variables discriminate between two or more naturally occurring groups (Digby & Kempton, 1987). Discriminant functions are derived which discriminate between different groups of data. Structure coefficients indicate the importance of each physical variable within the discriminant function. The importance of these variables, based on their structure coefficients, can be ranked (Comrey, 1973).

Physical parameters collected during surveys of the three target rivers found to contain different abundances of *R. penicillatus* var. *penicillatus* were analysed using Multiple Discriminant Function Analysis (Table 2). Data used were collected during continuous surveys of 1000m sections of the three rivers and did not include any measurement of water quality, since this information was not available for every 1000m section of river surveyed. The abundance of *R. penicillatus* var. *penicillatus* was estimated on a scale of 0-2, where 0 indicates the absence of *R. penicillatus* var. *penicillatus* and 2 indicates the greatest abundance of *R. penicillatus* var. *penicillatus* (>0.5% channel cover) in each 1000m section.

Table 2. Physical parameters analysed using Discriminant Function Analysis.

Channel Features	
Flow Type	% occurrence of waterfall over 1000m
	% occurrence of cascade over 1000m
	% occurrence of rapid over 1000m
	% occurrence of riffle over 1000m
	% occurrence of run over 1000m
	% occurrence of glide over 1000m
	% occurrence of pool over 1000m
	% occurrence of ponded reaches over 1000m
Channel substrate	% of channel substrate not visible
	% of channel substrate composed of peat
	% of channel substrate composed of clay
	% of channel substrate composed of silt
	% of channel substrate composed of sand
	% of channel substrate composed of gravel / pebble
	% of channel substrate composed of cobble
	% of channel substrate composed of boulder
	% of channel substrate composed of bedrock
Channel Features	No. of unvegetated mid-channel bars
	No. of vegetated mid-channel bars
	No. of mature islands
Channel Dimensions	Water width
	Water depth
	Bank-to Width
Plant Cover	% macrophyte cover
Bank Features	% Occurrence of trees
	Shading of the channel

Results

The results showed that 80% of the variation in the physical data is explained by the first function ($\chi^2=144$, d.o.f=50, $p<0.00001$). This function is made up of the physical parameters listed in Table 3. Thus, *R. penicillatus* var. *penicillatus* occurrence is significantly associated with these physical parameters (Table 3).

Table 3. Physical parameters found to be significantly associated with the occurrence and abundance of *R. penicillatus* var. *penicillatus*.

Physical Parameters +vely Correlated	Correlation coefficient	Significance
% occurrence of run	0.16	P<0.05
% occurrence of glide	0.18	P<0.05
% occurrence of pool	0.18	P<0.05
% of gravel / pebble channel substrate	0.21	P<0.05
Physical Parameters -vely Correlated		
% occurrence of trees	-0.11	P<0.05
% occurrence of rapids	-0.25	P<0.05
% occurrence of ponded reaches	-0.27	P<0.05
% of channel substrate composed of bedrock	-0.2	P<0.05

Flow regime appears to be an important physical parameter governing the occurrence of *R. penicillatus* var. *penicillatus*. The occurrence of the plant is positively correlated with run, glide and pool. This would suggest that *R. penicillatus* var. *penicillatus* is restricted to areas of river with a moderate flow regime. The occurrence of *R. penicillatus* var. *penicillatus* is also positively correlated with gravel/pebble channel substrate. This type of substrate would allow the growth of extensive root systems providing anchorage and attachment on the river bed.

The flow regimes of rapids and ponded reaches are negatively correlated with the occurrence of *R. penicillatus* var. *penicillatus*. Thus, *R. penicillatus* var. *penicillatus* occurs less frequently where the flow regime is either very fast or very slow. This supports the positive correlations described above. The occurrence of *R. penicillatus* var. *penicillatus* is also negatively correlated with the percentage of bedrock channel substrate and the percentage occurrence of bankside tree cover.

Bedrock channel substrate would not allow the settlement and growth of the plant whilst the occurrence of bankside trees would cause excessive shading of the channel and prevent photosynthetic growth.

Discriminant Function Analysis also provides details of the number of sections of river that have been classified by the analysis as having the correct abundance of *R. penicillatus* var. *penicillatus*. Here the analysis predicts the abundance of *R. penicillatus* var. *penicillatus* that the section of river should have, given its suite of physical parameters, and compares this to the actual abundance of the plant recorded during surveys. Results from the analysis indicated that 88% of river sections were classified as having the correct abundance of *R. penicillatus* var. *penicillatus* (Table 4).

Table 4. Percentage of sections of river that were classified as having the correct abundance of *R. penicillatus* var. *penicillatus* (Number of sections is indicated in brackets).

	Abundance of 2	Abundance of 1	Absent
Abundance of 2	92% (33)	8% (3)	0%
Abundance of 1	15% (4)	85% (23)	0%
Absent	0%	14% (2)	86% (12)

Of the sites that were misclassified, 2 sections of river where *R. penicillatus* var. *penicillatus* was absent were classified as having an estimated abundance of 1. These sites were sections 10 and 24 on the Owenkillev. In addition, 4 sections which had an abundance of 1 were misclassified as having an estimated abundance of 2. These were sections 2 and 8 on the Owenkillev, section 7 on the Swanlinbar and section 1 on the Ballinderry. Sections 15 and 18 on the Owenkillev and section 9 on the Swanlinbar were misclassified as having a lower abundance of *R. penicillatus* var. *penicillatus*.

Misclassifications are due to the fact that the physical parameters used in the analysis do not perfectly predict the occurrence of *R. penicillatus* var. *penicillatus* and that other, unmeasured variables may be affecting the occurrence of the plant.

2. Macrophyte Species Associated with the occurrence of *R. penicillatus*.

Methods

Detrended Correspondance Analysis (DECORANA) was used to analyse data on aquatic macrophyte species to determine the suite of macrophyte species associated with the occurrence of *R. penicillatus* var. *penicillatus*.

Ordination techniques order 'sites' along several different axes (in imaginary, multi-dimensional space) according to their similarity to one another using mathematical derivations of site scores. Each axis is an environmental gradient related to one or more physical characteristics. Ordination techniques can be of great value in understanding the causes of variation in communities.

Macrophyte data from the three target rivers was analysed using community analysis. The method adopted was Detrended Correspondence Analysis, using the program DECORANA (Hill & Gauch, 1980).

Results

DECORANA compares samples / species looking for similarity in community composition. Species with similar environmental tolerances occur close together on the species ordination (Fig. 3). Samples with similar species composition occur close together on the samples ordination (Fig. 4). In both cases, axes 1 and 2 are the same and should be thought of as environmental gradients related to one or more physical characteristics.

Figure 2 shows the plot of macrophyte species produced from the species ordination. The closer the species are in relation to the position of *R. penicillatus* var. *penicillatus* the greater the association there is between macrophyte species. The closest 10 aquatic macrophyte species to *R. penicillatus* var. *penicillatus* are listed in Table 5. Table 6 gives the total number of occurrences and the percentage occurrence of each of these species with *R. penicillatus* var. *penicillatus*.

Decorana All Rivers All Species

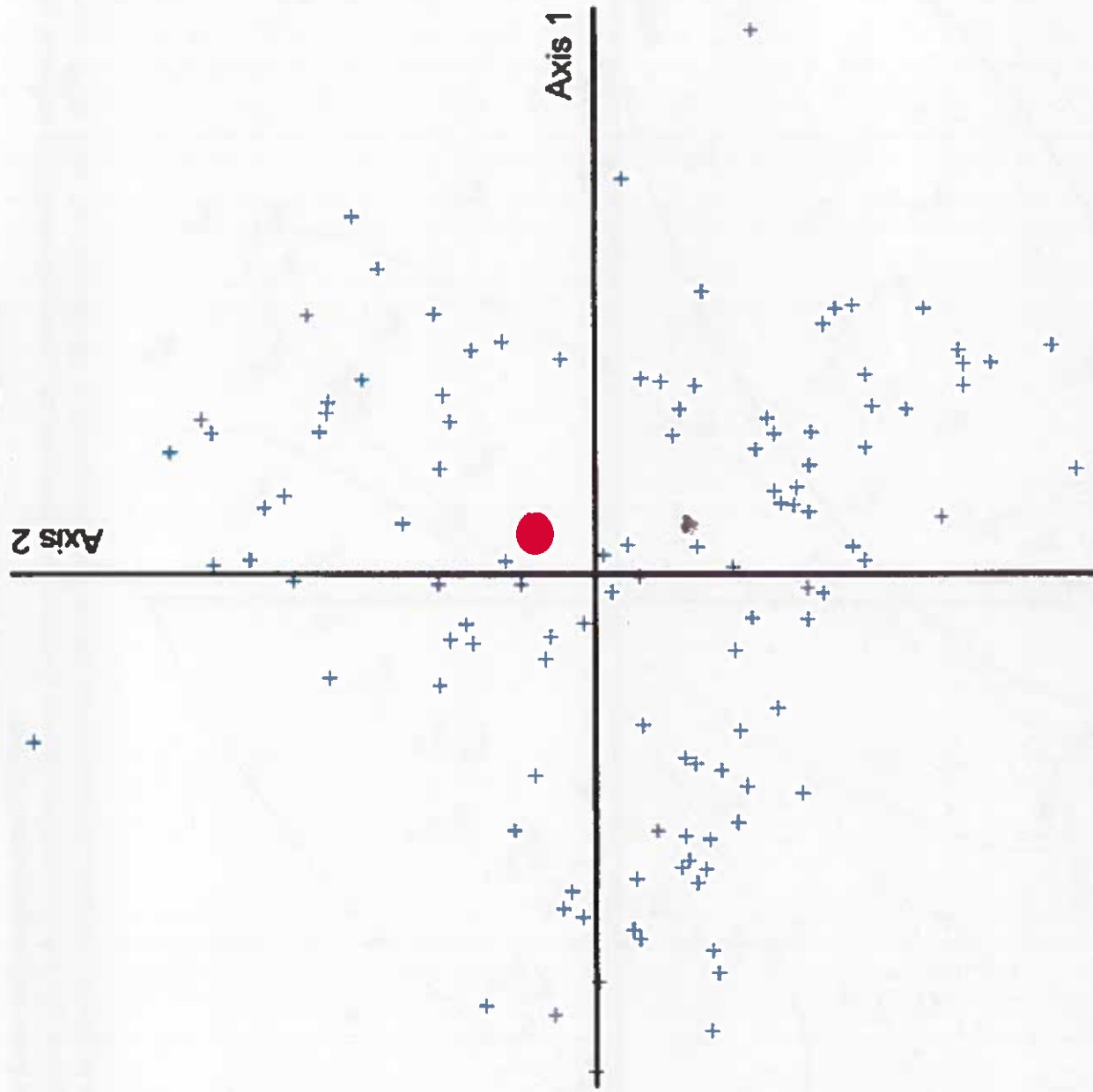


Figure 3. Plot produced from DECORANA outputs showing the distribution of macrophyte species in relation to *Ranunculus penicillatus* var. *penicillatus*. The position of *R. penicillatus* var. *penicillatus* is highlighted in red.



Table 5. List of macrophyte species found to be associated with the occurrence of *R. penicillatus* var. *penicillatus* on the three target rivers in Northern Ireland.

Species Name	Common Name - Phylum
<i>Cardamine pratensis</i>	Cuckoo Flower - Higher plant
<i>Callitriche stagnalis</i>	Mud Water Starwort - Higher plant
<i>Potamogeton crispus</i>	Curled Pondweed - Higher Plant
<i>Rorippa nasturtium-aquaticum</i>	Water-cress - Higher Plant
<i>Oenanthe crocata</i>	Hemlock Water Dropwort
<i>Eleocharis palustris</i>	Common Spike-rush
<i>Equisetum palustre</i>	Marsh Horsetail
<i>Phalaris arundinacea</i>	Reed Canary-grass
<i>Lemanea fluviatilis</i>	Green Algae
<i>Cinclidotis fontinaloides</i>	Moss

Table 6. Percentage occurrence of associated macrophyte species with *R. penicillatus* var. *penicillatus* and total number of occurrences of each species on the three target rivers in Northern Ireland.

Species Name	% Occurrence with <i>R. penicillatus</i>	Total No. of Occurrences
<i>Phalaris arundinacea</i>	74	57
<i>Oenanthe crocata</i>	65	48
<i>Rorippa nasturtium-aquaticum</i>	17	12
<i>Equisetum palustre</i>	17	14
<i>Cinclidotis fontinaloides</i>	15	10
<i>Callitriche stagnalis</i>	11	7
<i>Eleocharis palustris</i>	8	5
<i>Potamogeton crispus</i>	6	5
<i>Cardamine pratensis</i>	5	3
<i>Lemanea fluviatilis</i>	2	1

Higher plants associated with the occurrence of *R. penicillatus* var. *penicillatus* include several species normally associated with the margins of river channels such as Water-cress *Rorippa nasturtium-aquaticum*, Hemlock Water Dropwort *Oenanthe crocata*, Marsh Horsetail *Equisetum palustre* and Reed Canary-grass *Phalaris arundinacea*. Higher plant species associated with *R. penicillatus* var. *penicillatus* in the channel include Water-cress *Rorippa nasturtium-aquaticum*. The moss *Cinclidotis fontinaloides* is also found associated with *R. penicillatus* var. *penicillatus* attached to rocks and boulders in the channel. Species that occur infrequently such as *Callitriche stagnalis*, *Eleocharis palustris*, *Potamogeton crispus*, *Cardamine pratensis* and *Lemanea fluviatilis* cannot be used as reliable associate species (Table 6).

The species found associated with *R. penicillatus* var. *penicillatus* are largely characteristic of rivers showing a moderate degree of enrichment such as Water-cress, Hemlock Water Dropwort and Reed Canary Grass.

Figure 3 shows the plot of samples produced from the samples ordination. From the plot it is evident that the samples are grouped in clusters that approximate to each river. This shows that samples of macrophytes are similar from each river or that each river is distinguishable by its macrophyte composition. The spread of samples on each river shows a similar trend. It is likely that the spread of the samples in each case relates to a gradient of altitude ranging from upland sites on each river in the bottom right-hand corner of the plot to lowland sites near the bottom of each river (Fig. 4). These are represented in the upper left-hand corner of the plot (Fig. 4). It is interesting to note that the Ballinderry and the Owenkillew, both in Co. Tyrone, are separated on the plot by the Swanlinbar in Co. Fermanagh. This is indicative of distinct differences in macrophyte community composition between these rivers. Plant communities in the upper reaches of the Owenkillew are classed as a Type 10, reflecting the altitude, land-use and the hard underlying geology. Type 10 communities occur in the north and west of Britain and are dominated by acidophilous bryophytes and upland grasses (AERC, 1997). Further downstream, macrophyte communities are a Type 8, found at moderate altitude in northern and western Britain. Type 8 communities show signs of some enrichment (AERC, 1997). In comparison, the Ballinderry has a river community Type 8 in its upper reaches. The plant community is dominated by the mosses *Fontinalis* spp. and *Rhyncostegium ripariodes* and *R. penicillatus* var. *penicillatus*. However, the lower reaches of the Ballinderry

are characterised by river community type 7. Therefore, the differences in macrophyte community composition are reflected in the samples ordination shown in Figure 3. These differences may be due to differences in land-use between the Owenkillew and the Ballinderry. The Owenkillew flows through the Sperrins and would be less impacted by past drainage schemes and intensive agricultural practices. The Owenkillew would also be less enriched than reaches of the Ballinderry downstream of Cookstown.

B. Further Field Work on *R. penicillatus* var. *penicillatus* rivers

Methods

The generic guidelines for the conservation of *R. penicillatus* var. *penicillatus* recommend that there should be at least one monitoring stretch for every 5 km of river (English Nature). Therefore, a total of 15 sections of the target rivers were surveyed (Table 7) for *R. penicillatus* var. *penicillatus* presence, % cover, substrate composition, flow type, presence of silt, bankside tree cover, associated macrophyte species and any other parameters that have significance within the analysis.

A visual inspection of each of the rivers was made for the presence of silt and the occurrence of *Enteromorpha intestinalis*, *Myriophyllum spicatum*, *Vaucheria* or *Cladophora* spp.

The distribution of *R. penicillatus* var. *penicillatus* was mapped along each monitoring section and characteristic photographs were taken of extensive beds of *R. penicillatus* var. *penicillatus*.

Multiple Discriminant Function Analysis was repeated using the more accurate estimates of *R. penicillatus* var. *penicillatus* abundance estimated during the re-survey of each target river.

Table 7. Total number of sections surveyed on target rivers for the abundance and distribution of *R. penicillatus* var. *penicillatus*

River Name	Sections Re-surveyed
Ballinderry	6
Owenkillew	8
Swanlinbar	2

Results

Table 8 lists the sections re-surveyed for the distribution and abundance of *R. penicillatus* var. *penicillatus*.

Table 8. Sections of river re-surveyed for the abundance and distribution of *R. penicillatus* var. *penicillatus*.

River Name	Section Re-surveyed for <i>R. penicillatus</i> var. <i>penicillatus</i>
Ballinderry	4
	8
	12
	19
	20
	22
Owenkillew	4
	11
	15
	19
	26
	30
	34
Swanlinbar	39
	1
	2

Distribution maps, physical data and associated macrophyte species are listed individually for each section of river re-surveyed (Appendix 1).

The most extensive beds of *R. penicillatus* var. *penicillatus* on the Swanlinbar are found in a stretch of river flowing downstream from Coragh (H204282) to near Glassdrumman bridge at H226289. *R. penicillatus* var. *penicillatus* tends to be absent from deeper stretches of the Swanlinbar where the river has been deepened and resectioned. The channel substrate tends to be dominated by gravel/pebble and cobble substrate where there are extensive beds of Stream Water-crowfoot.

In the sections of river surveyed on the Ballinderry, Stream Water-crowfoot was generally found to be extensive. The plant tended to be found in greatest abundance at shallow riffles and was frequently associated with either Water-starwort *Callitriche* sp. or Floating Pondweed *Potamogeton natans*. Like the Swanlinbar, *R. penicillatus* var. *penicillatus* tended to be absent from deeper, more shaded areas of river.

Extensive beds of Stream Water-crowfoot were also found on the Owenkillev where, like the Ballinderry, the plant was found associated with *Callitriche* sp. and *P. natans*. Percentage coverage was found to be greatest at shallow riffles and where the channel substrate was dominated by gravel/pebble and cobble.

Multiple Discriminant Function Analysis was repeated using the more accurate abundance data gathered during the re-survey of each river. Results were similar to those obtained during the initial analysis. However, in addition to the suite of parameters in the original analysis, bank top width was also found to be negatively correlated with the occurrence of *R. penicillatus* var. *penicillatus*. Since bank top width is directly related to channel width, this negative association implies that *R. penicillatus* var. *penicillatus* occurs less frequently where the channel is wide. In the three target rivers, the lower, wider sections of river tend to have a more marginal scattered distribution of Stream Water-crowfoot. This is probably due to heavy flows and unstable substrate in the centre of the channel.

Conclusions

R. penicillatus var. *penicillatus* was found to be abundant on the sections of the three rivers surveyed during the current investigation. The most luxuriant beds of *R. penicillatus* var. *penicillatus* were found along sections of the Owenkillev and Ballinderry. It is likely that the absence of the plant from sections of the Swanlinbar is due to the river having been resectioned and modified in the past. The current analysis on the three target rivers revealed that *R. penicillatus* var. *penicillatus* occurs in association with areas of slower water characterised by run, glide and pool and on gravel / pebble substrate. The occurrence of rapids, bedrock and tree cover was negatively associated with the occurrence of the plant. Further analysis using more accurate estimates of *R. penicillatus* var. *penicillatus* abundance revealed a further negative association with bank top width.

In the majority of sections, *R. penicillatus* var. *penicillatus* was found to be at its optimal abundance. However, suitable areas along sections 10, 14 and 28 on the Owenkillev, section 7 on the Swanlinbar and section 1 on the Ballinderry may be suitable for recolonisation by *R. penicillatus* var. *penicillatus*.

Analysis of aquatic plant data found several plant species to be associated with *R. penicillatus* var. *penicillatus* occurrence. These plants included marginal species such as Marsh Horsetail *Equisetum palustre*, Watercress *Rorippa nasturtium-aquaticum*, Reed Canary Grass *Phalaris arundinacea* and Hemlock Water-dropwort *Oenanthe crocata*. Associated aquatic species include the bryophyte *Cinclidotis fontinaloides* and the higher plant Water-cress *Rorippa nasturtium-aquaticum*.

During the current survey, *R. penicillatus* var. *penicillatus* was often found in association with Water-starwort *Callitriche indet.* and Broad-leaved Pondweed *Potamogeton natans* on both the Ballinderry and the Owenkillev.

Siltation was evident on all rivers and is a problem that must be addressed in the future. Damage to banks and channel by cattle is a significant source of silt. This was observed to be a problem on all three rivers surveyed. The creation of stock-fenced buffer strips along river banks would alleviate this problem and increase the general health of the river. In addition, cattle wading can decimate beds of *R. penicillatus* var. *penicillatus* and Freshwater Pearl Mussel *Margaritifera margaritifera*.

Engineering works to the channel and banks can significantly affect the occurrence and abundance of *R. penicillatus* var. *penicillatus* by changing the physical composition of the river channel. Future management of rivers for *R. penicillatus* var. *penicillatus* should highlight the need for greater consultation between conservation bodies such as the Environment and Heritage Service (Department of the Environment, N.I.) and the Rivers Agency (Department of Agriculture and Rural Development, N.I.).

In order to effectively manage and conserve rivers for *R. penicillatus* var. *penicillatus* future monitoring programmes should aim to re-survey selected sections of target rivers on a regular basis (approx. 5 years). Monitoring strategies should also include an estimate of the health of *R. penicillatus* var. *penicillatus* plants and beds.

Recommendations

- The creation of stock-fenced buffer strips along river banks to alleviate cattle poaching and increased siltation levels.
 - Effective management and monitoring of in-river engineering works to safeguard extensive beds of *R. penicillatus* var. *penicillatus*
 - Target suitable areas of each target river for recolonisation of *R. penicillatus* var. *penicillatus*.
 - Re-survey selected sections of target rivers on a regular basis (approx. 5 years).
 - Produce monitoring strategies to estimate of the health of *R. penicillatus* var. *penicillatus* plants and beds.
-

- **Appendix 1.**

Distribution Maps, Section Details & Photographs

River Name **Swanlinbar**

Section **V01**

Associated Macrophyte Species

Lemanea fluviatilis

Cinclidotis fontaniloides

Rhynchosstegium riparoides

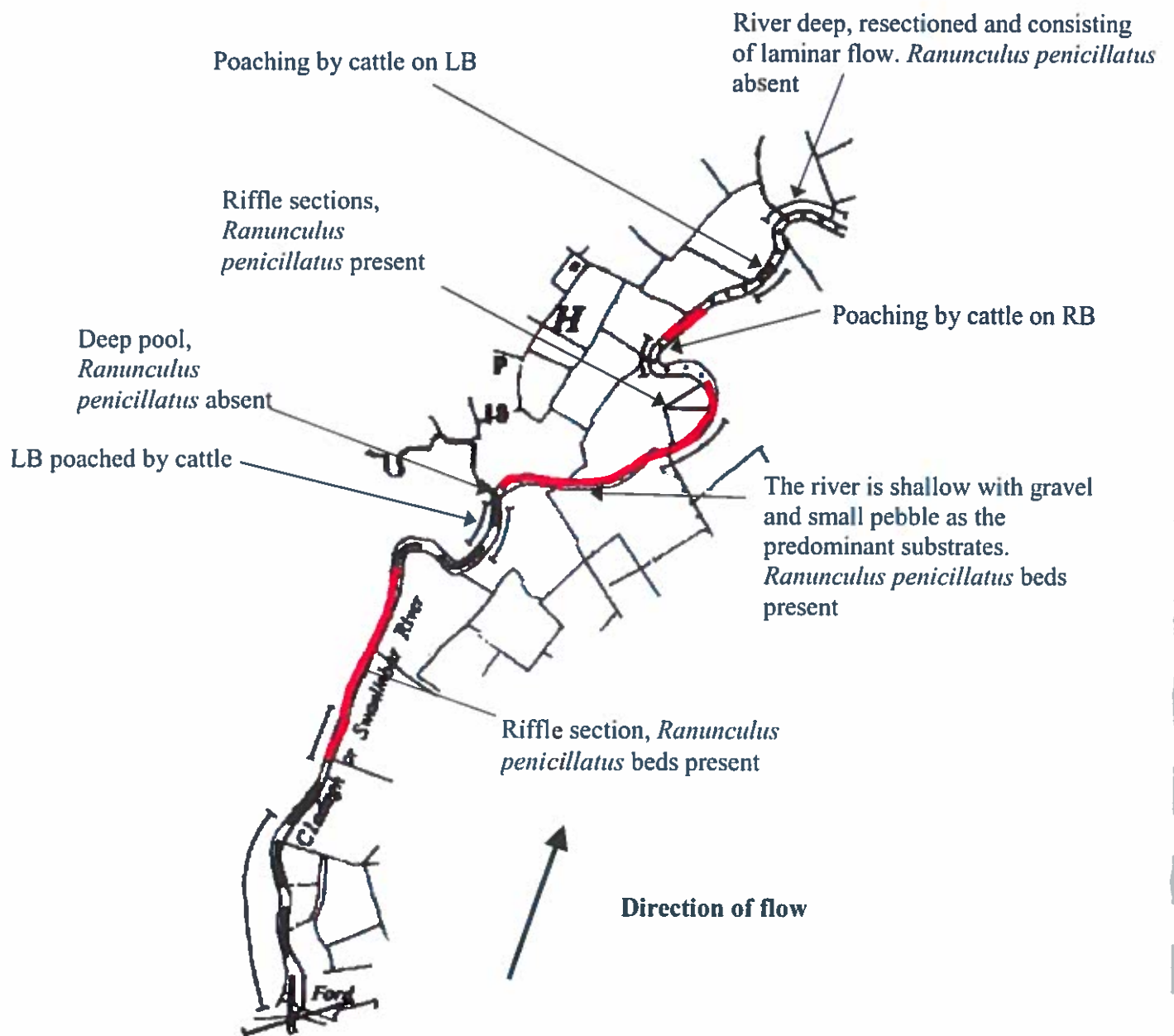
Callitriche indet.

Potamogeton crispus

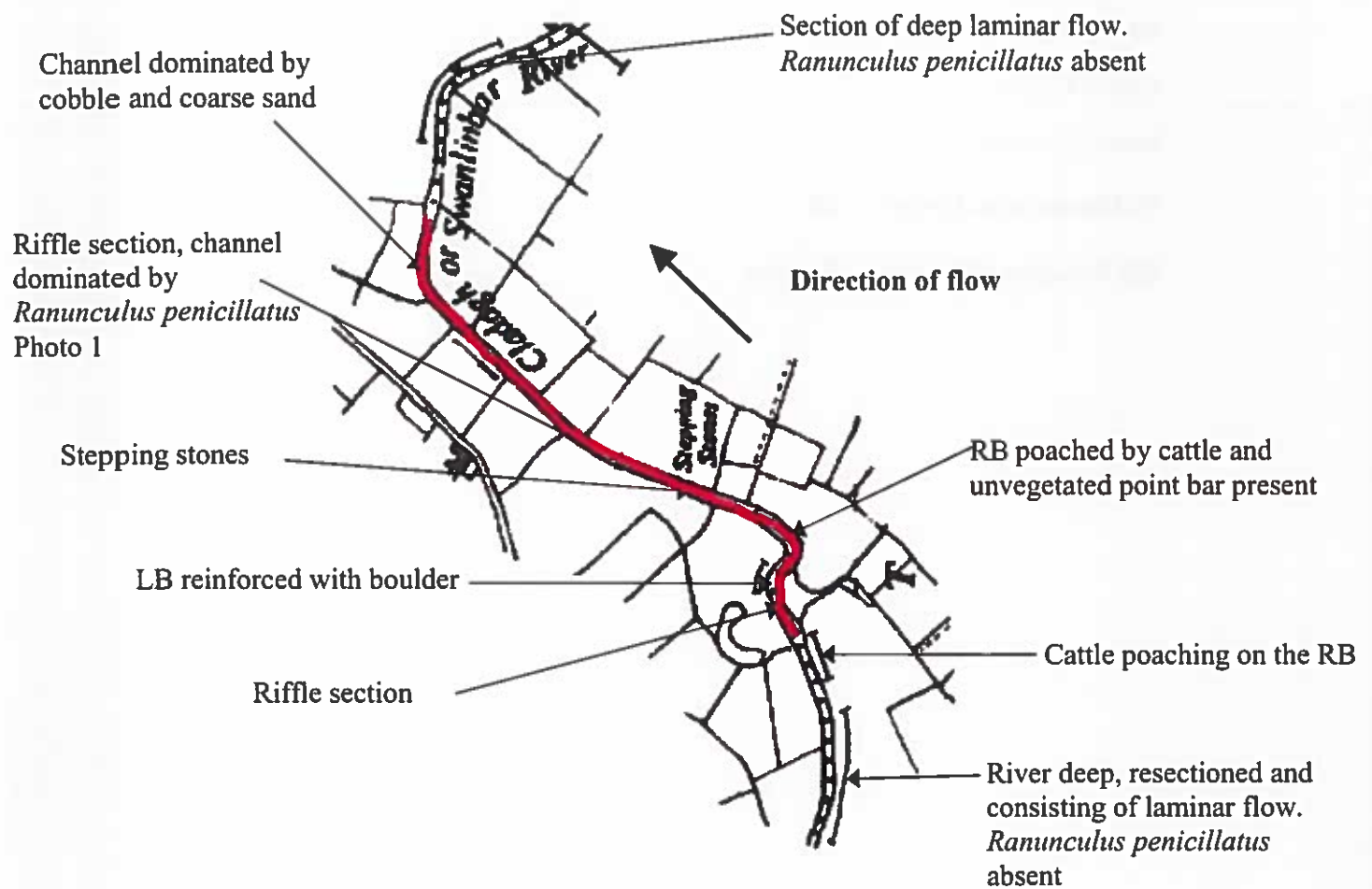
% Ranunculus Cover **55**

Silt Presence/Absence **Present**

Swanlinbar River Section 1



Swanlinbar River Section 1
continued



River Name **Swanlinbar**

Section **V02**

Associated Macrophyte Species

Lemanea fluviatilis

Cinclidotis fontaniloides

Rhynchosstegium riparoides

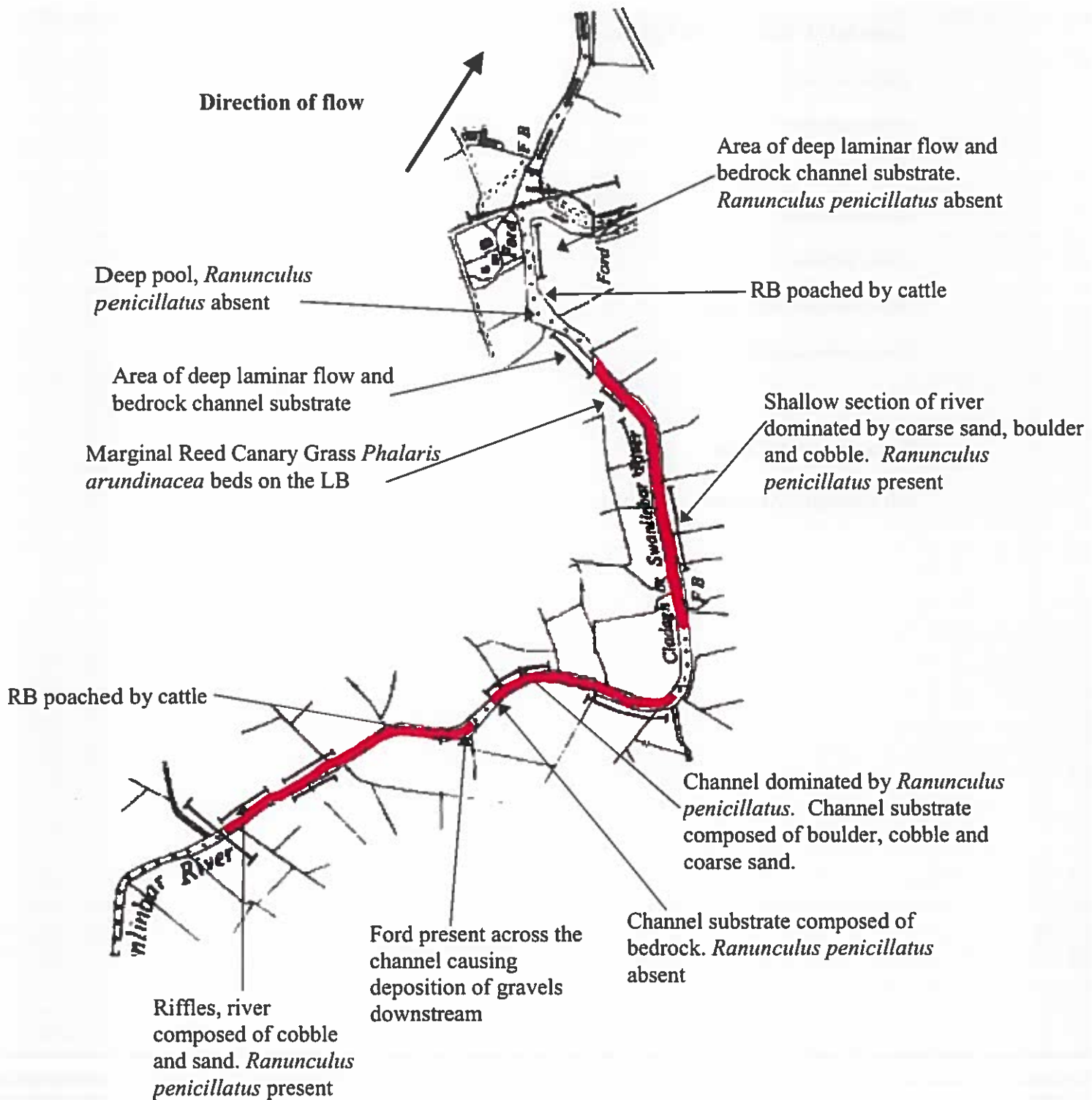
Callitriche indet.

Potamogeton crispus

% Ranunculus Cover **60**

Silt Presence/Absence **Present**

Swanlinbar River Section 2



River Name **Ballinderry**

Section **Z04**

Associated Macrophyte Species

Callitriche indet.

Caltha palustris

Fontinalis antipyretica

Glyceria fluitans

Juncus bulbosus

Rhynchosstegium riparioides

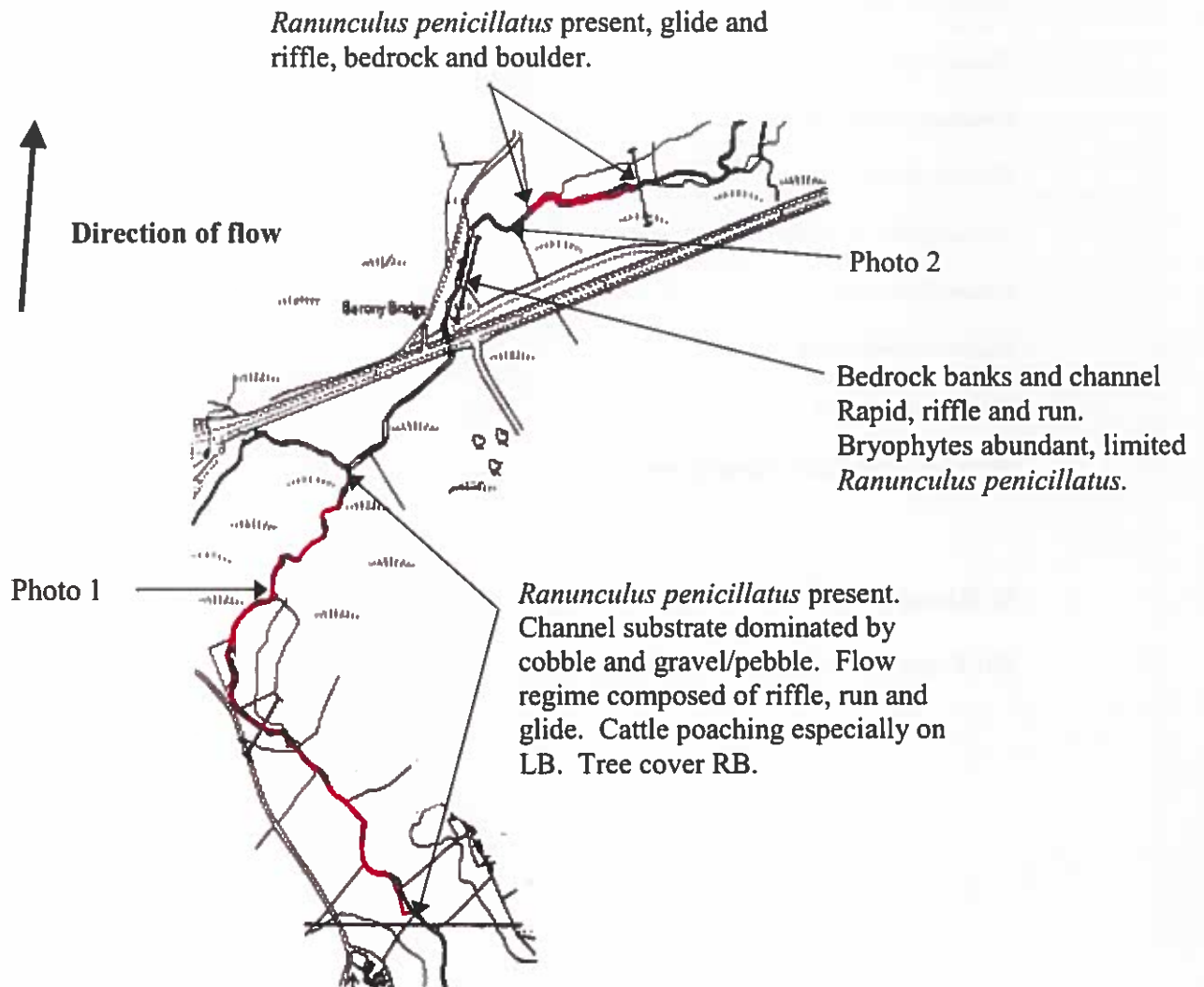
Veronica beccabunga

% Ranunculus Cover **50**

Silt Presence/Absence **Present**

Ballinderry River Section 4

Ranunculus penicillatus
occurs at shallow riffles



River Name **Ballinderry**

Section **Z08**

Associated Macrophyte Species

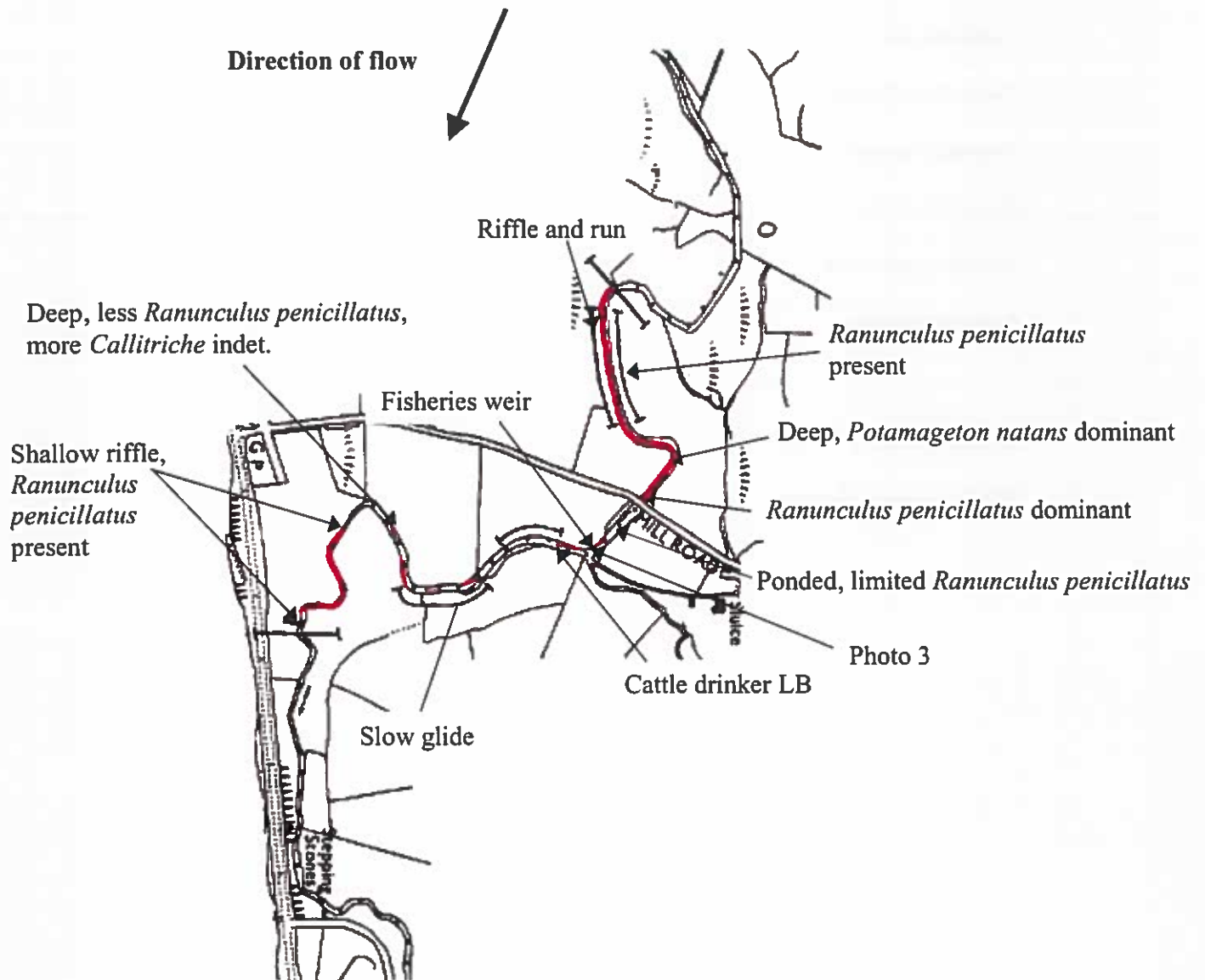
- Callitriche indet.*
- Equisetum fluviatile*
- Fontinalis antipyretica*
- Glyceria fluitans*
- Myriophyllum spicatum*
- Oenanthe crocata*
- Phalaris arundinacea*
- Potamogeton natans*
- Rorippa nasturtium-aquaticum*

% Ranunculus Cover **45**

Silt Presence/Absence **Present**

Ballinderry River Section 8

Flow regime mainly run and glide, few riffles. *Ranunculus penicillatus* found on gravel and pebble substrate.



River Name **Ballinderry**

Section **Z12**

Associated Macrophyte Species

Callitriche indet.

Fontinalis antipyretica

Fontinalis squamosa

Oenanthe crocata

Phalaris arundinacea

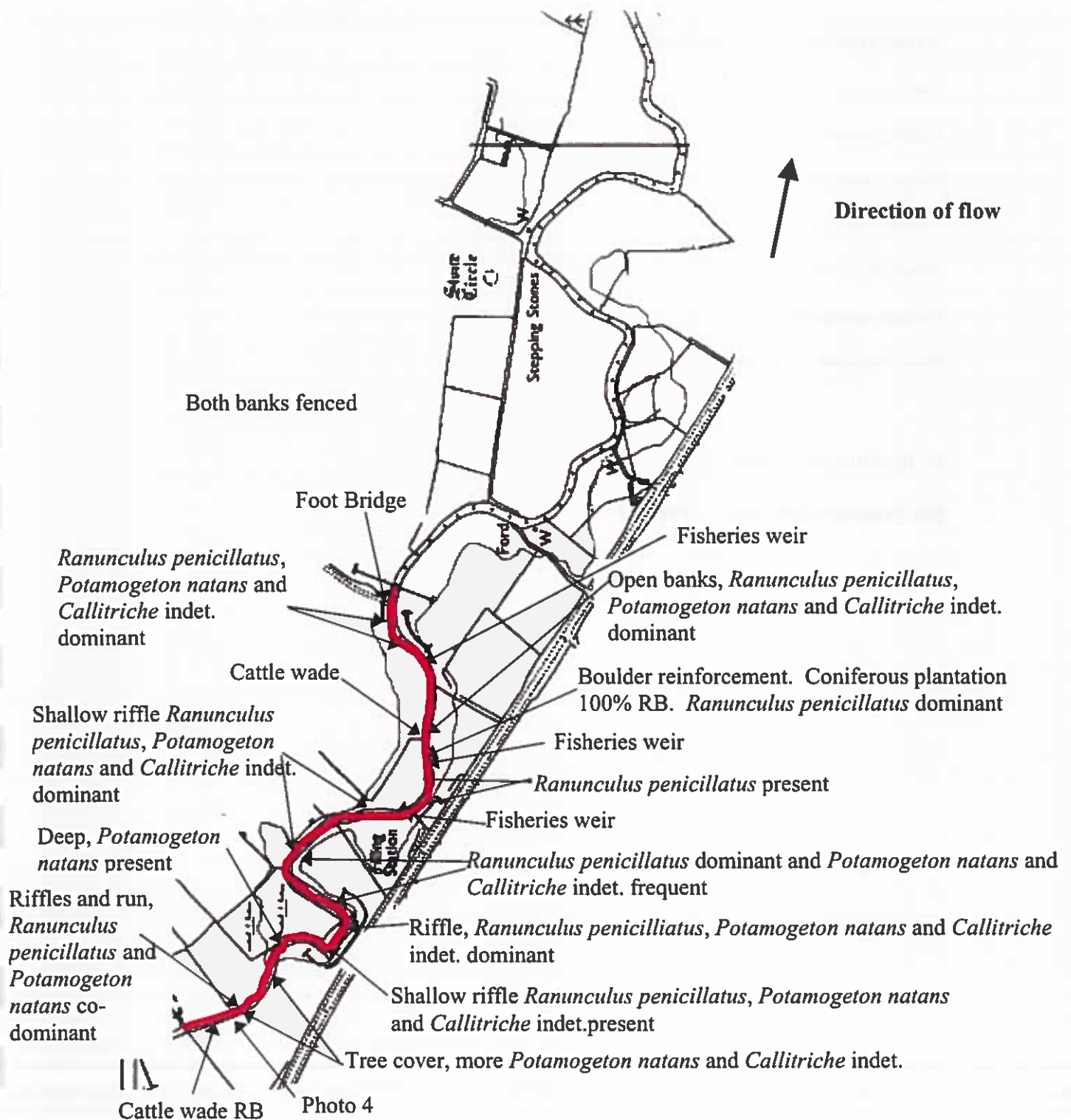
Potamogeton natans

% Ranunculus Cover **40**

Silt Presence/Absence **Absent**

Ballinderry River Section 12

Ranunculus penicillatus present on gravel/pebble and sand substrate



River Name **Ballinderry**

Section **Z19**

Associated Macrophyte Species

Amblystegium fluviatile

Callitriche indet.

Elodea canadensis

Fontinalis squamosa

Oenanthe crocata

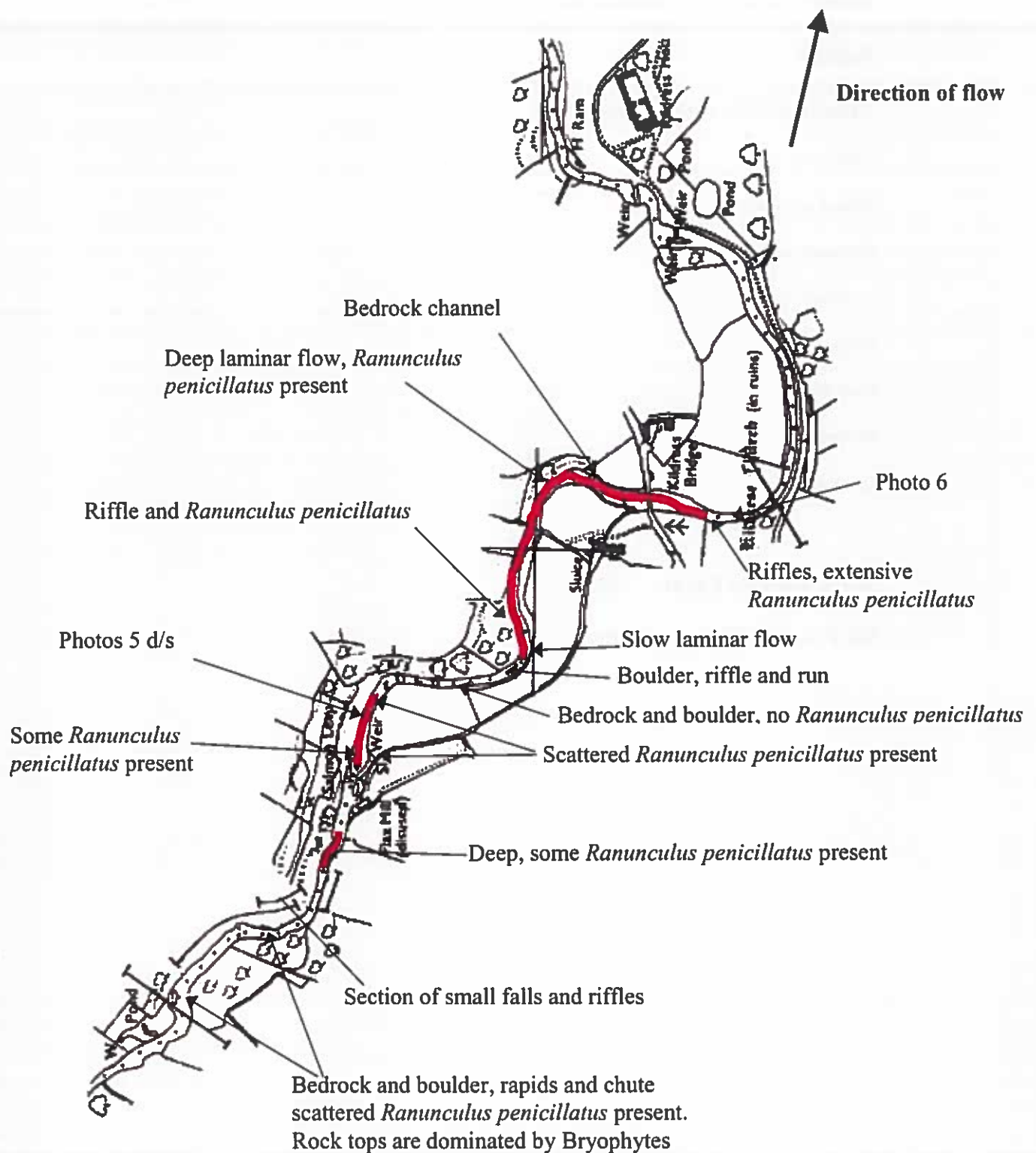
Phalaris arundinacea

Rhynchostegium riparioides

% Ranunculus Cover **10**

Silt Presence/Absence **Present**

Ballinderry River Section 19



River Name **Ballinderry**

Section **Z20**

Associated Macrophyte Species

Callitriche indet.

Elodea canadensis

Fontinalis antipyretica

Fontinalis squamosa

Oenanthe crocata

Phalaris arundinacea

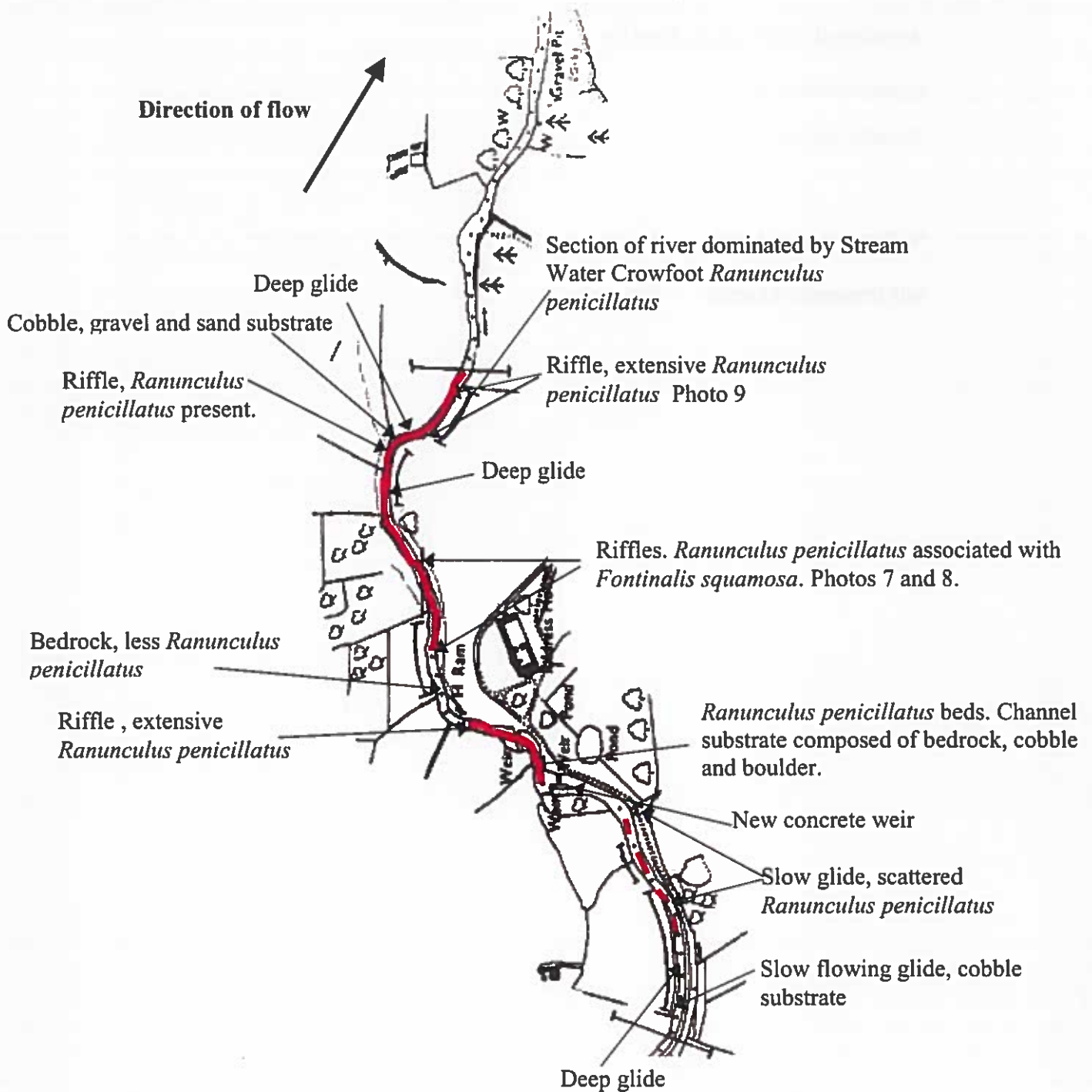
Rorippa nasturtium-aquaticum

Sparganium erectum

% Ranunculus Cover **25**

Silt Presence/Absence **Present**

Ranunculus penicillatus occurs predominantly at riffles



River Name **Ballinderry**

Section **Z22**

Associated Macrophyte Species

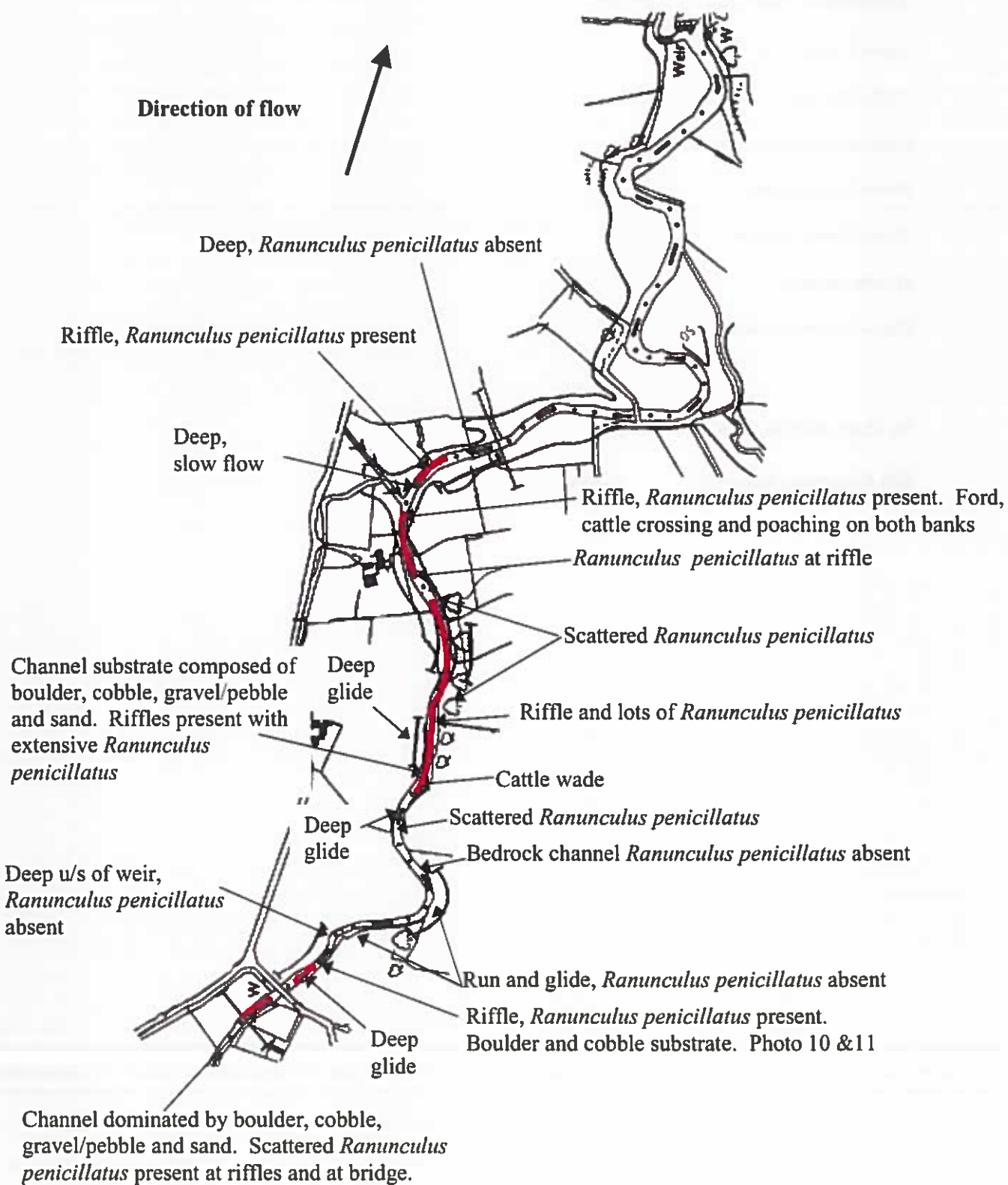
Fontinalis antipyretica

Oenanthe crocata

% Ranunculus Cover **50**

Silt Presence/Absence **Present**

Ballinderry River Section 22



River Name Owenkillew

Section O04

Associated Macrophyte Species

Agrostis stolonifera

Callitriche indet.

Equisetum fluviatile

Fontinalis squamosa

Hygrohypnum luridum

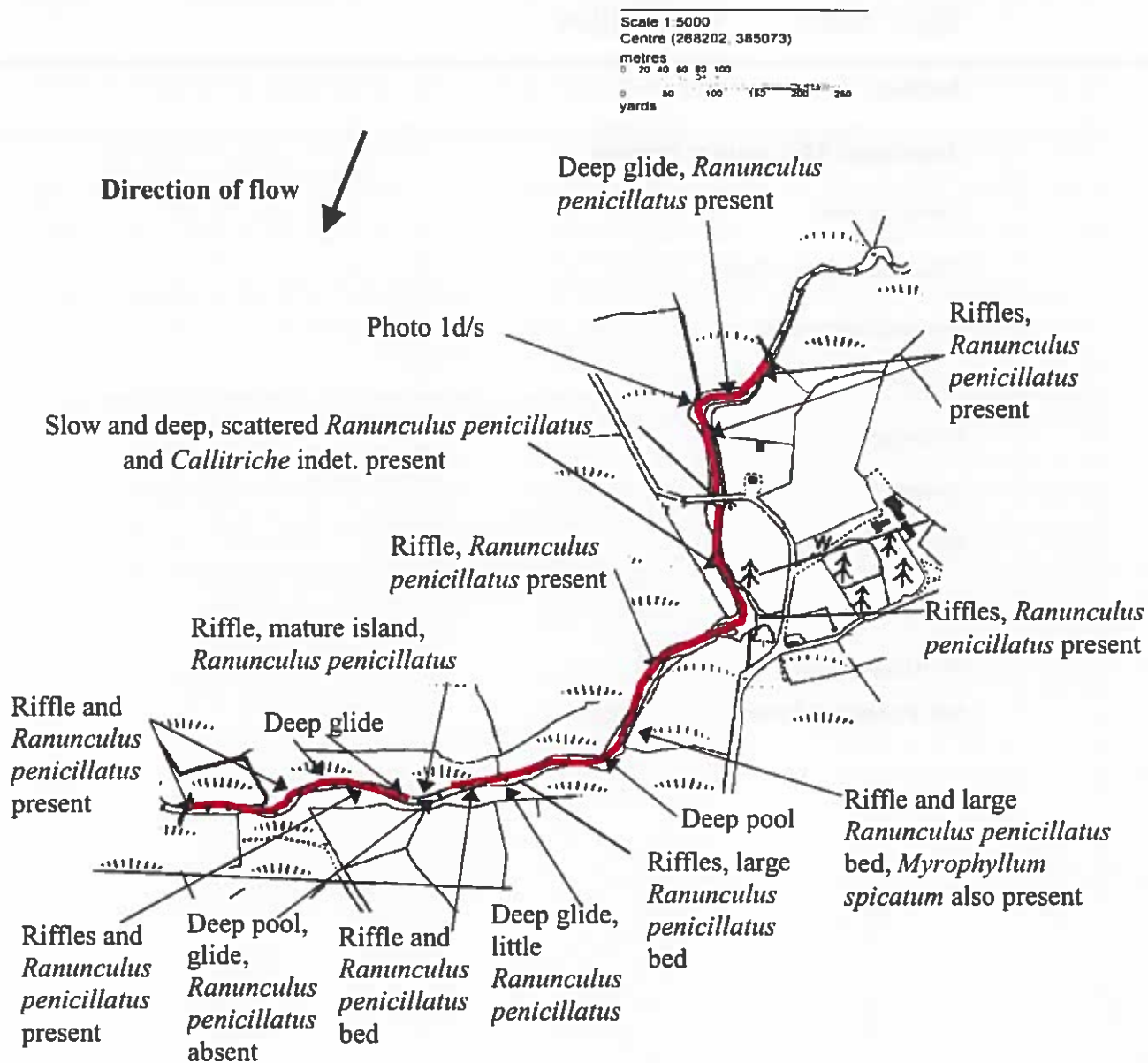
Mentha aquatica

Myriophyllum spicatum

% Ranunculus Cover 40

Silt Presence/Absence Absent

River Owenkillew Section 4



River Name **Owenkillew**

Section **O11**

Associated Macrophyte Species

Callitriche indet.

Filamentous green algae

Fontinalis antipyretica

Phalaris arundinacea

Potamogeton natans

Sparganium emersum

Sparganium erectum

% Ranunculus Cover **60**

Silt Presence/Absence **Absent**

River Owenkillew Section 11

Scale 1:5000
Centre (284128, 383861)
metres
0 20 40 60 80 100
yards
0 50 100 150 200 250

Direction of flow



Riffles, *Ranunculus penicillatus* present

Sparganium emersum and *Potamogeton natans* dominant. Deep glide

Large riffle and *Ranunculus penicillatus* bed

Riffles, *Ranunculus penicillatus* bed

Deep glide no *Ranunculus penicillatus*

Callitriche indet., *Potamogeton natans* and *Ranunculus penicillatus* at riffle

Riffles, large *Ranunculus penicillatus*

Riffle, *Ranunculus penicillatus* bed, *Callitriche* indet., *Potamogeton natans* and *Sparganium emersum* present

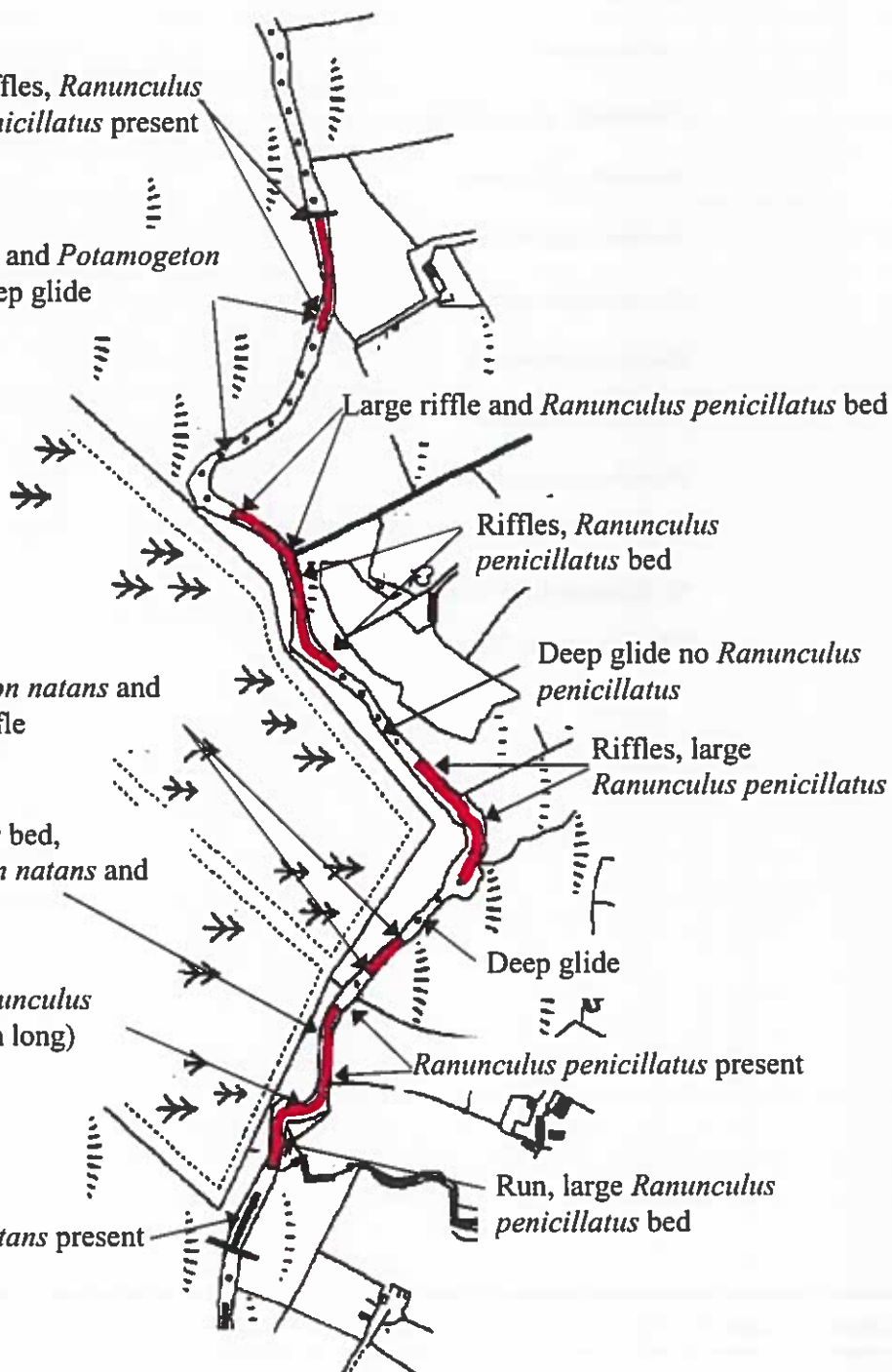
Deep glide

Photo 2 Riffle, with large *Ranunculus penicillatus* bed, (approx. 20m long)

Ranunculus penicillatus present

Deep glide, *Potamogeton natans* present

Run, large *Ranunculus penicillatus* bed



River Name **Owenkillew**

Section **O15**

Associated Macrophyte Species

Callitriche indet.

Caltha palustris

Filamentous green algae

Fontinalis antipyretica

Fontinalis squamosa

Myriophyllum spicatum

Phalaris arundinacea

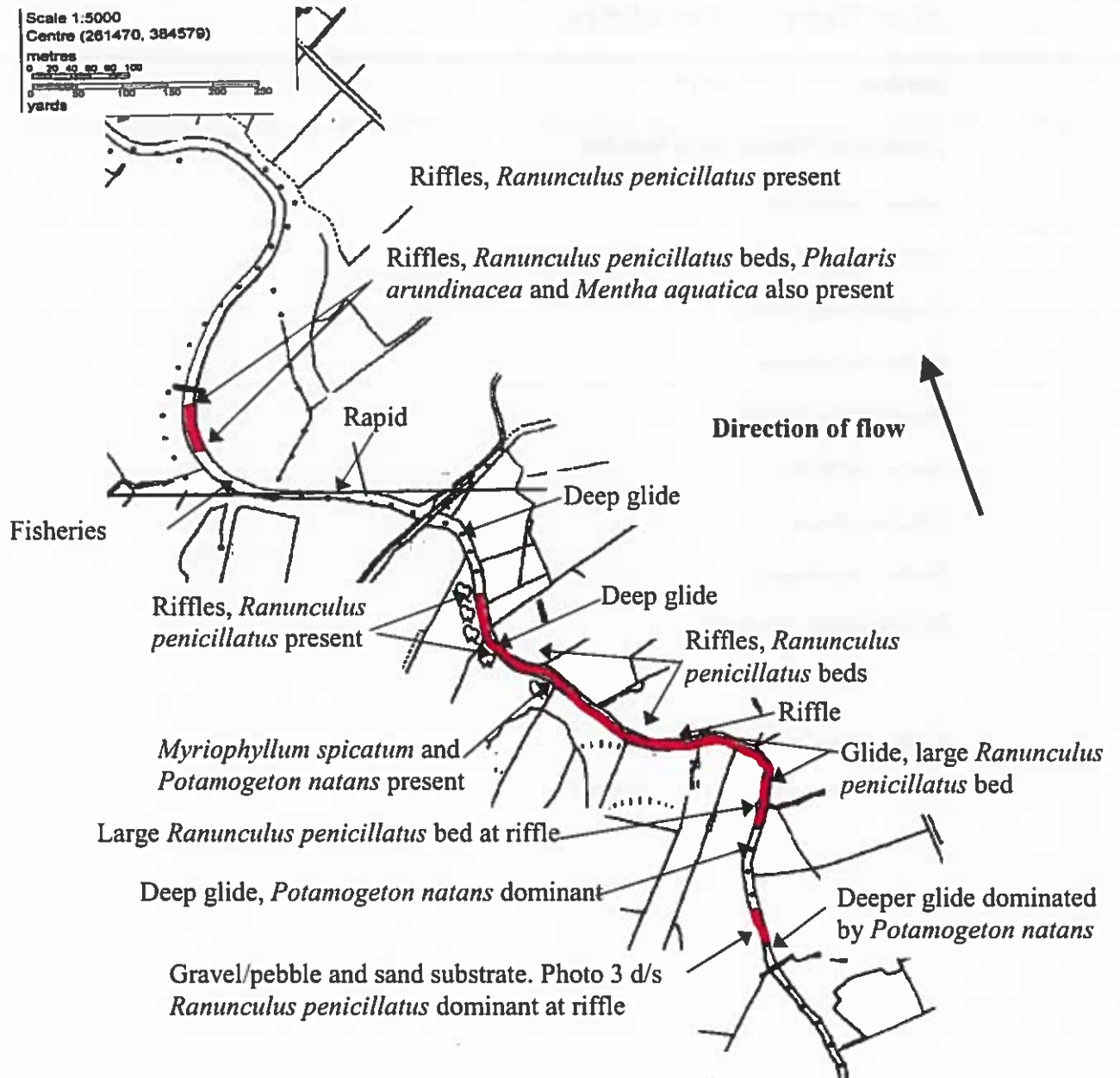
Potamogeton natans

Rhynchostegium riparioides

% Ranunculus Cover **50**

Silt Presence/Absence **Absent**

River Owenkillew Section 15



River Name **Owenkillew**

Section **O19**

Associated Macrophyte Species

Agrostis stolonifera

Callitriche indet.

Fontinalis antipyretica

Fontinalis squamosa

Hygrohypnum luridum

Juncus acutiflorus

Oenanthe crocata

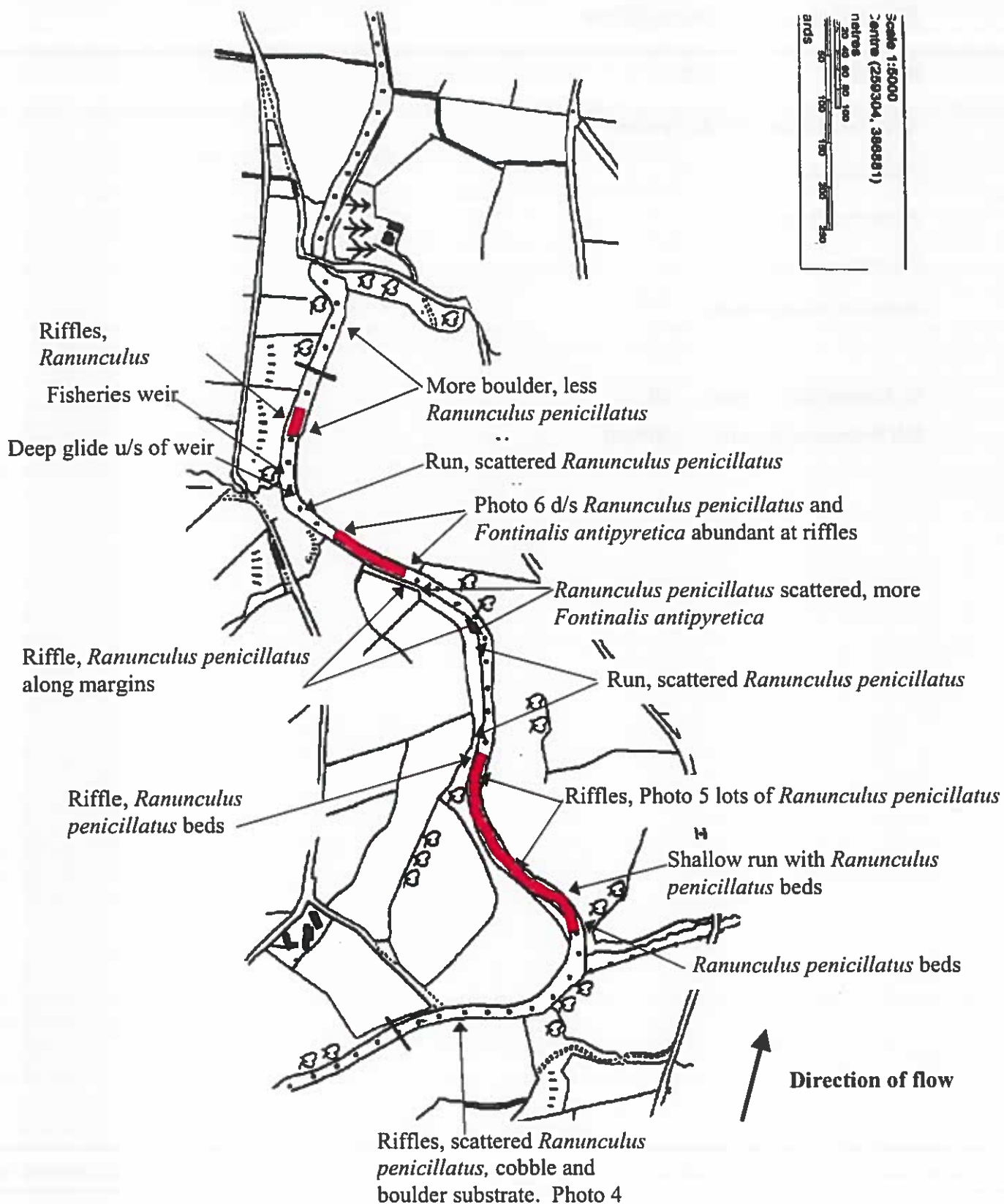
Phalaris arundinacea

Rhynchostegium riparioides

% Ranunculus Cover **20**

Silt Presence/Absence **Absent**

River Owenkillew Section 19



River Name **Owenkillew**

Section **O26**

Associated Macrophyte Species

Fontinalis antipyretica

Fontinalis squamosa

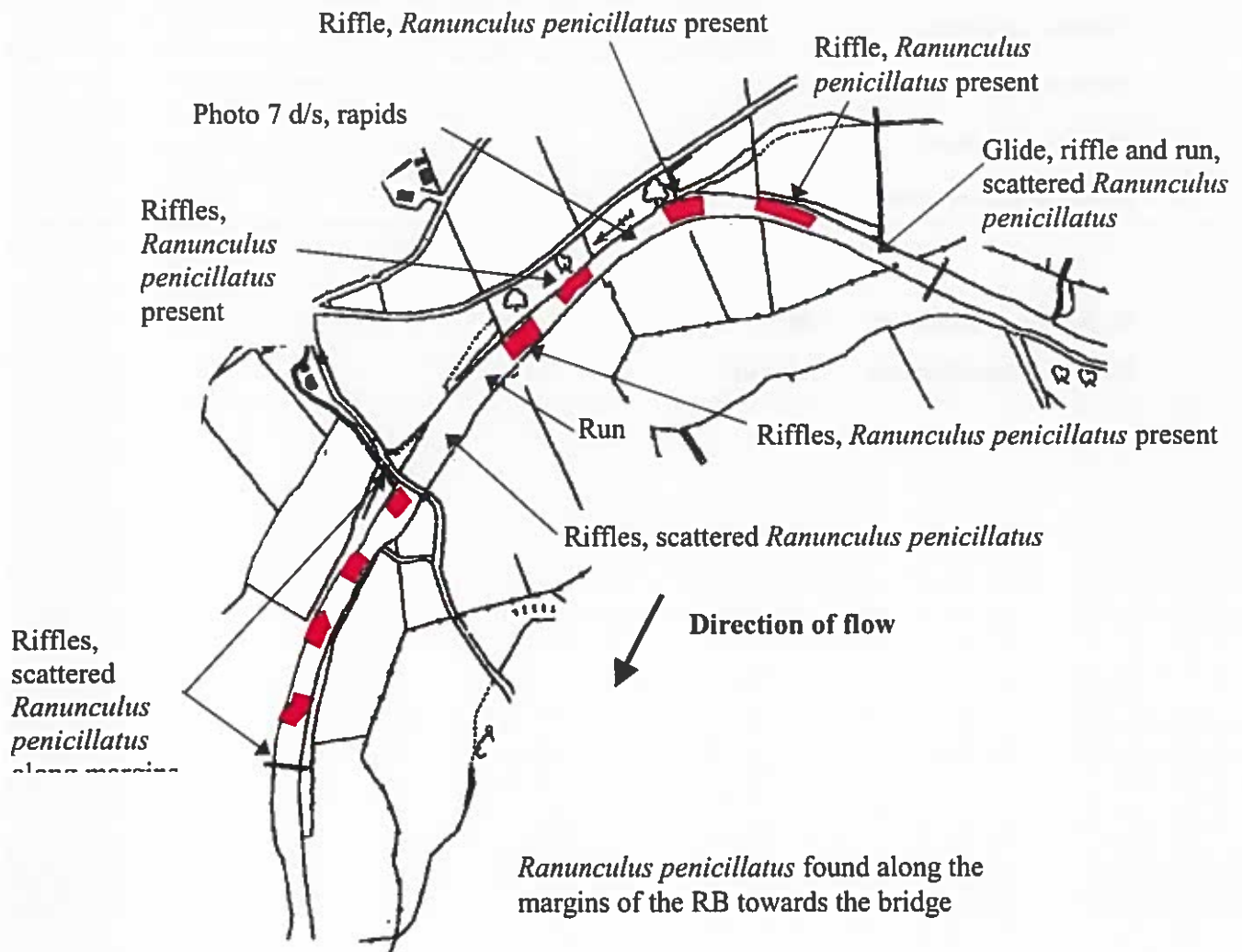
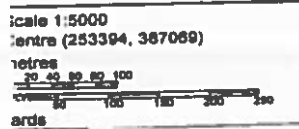
Racomitrium aciculare

Rhynchostegium riparioides

% Ranunculus Cover **10**

Silt Presence/Absence **Absent**

River Owenkillew Section 26



River Name **Owenkillew**

Section **O30**

Associated Macrophyte Species

Fontinalis antipyretica

Juncus acutiflorus

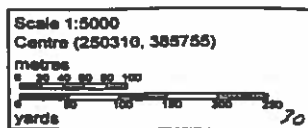
Phalaris arundinacea

Rhynchosstegium riparioides

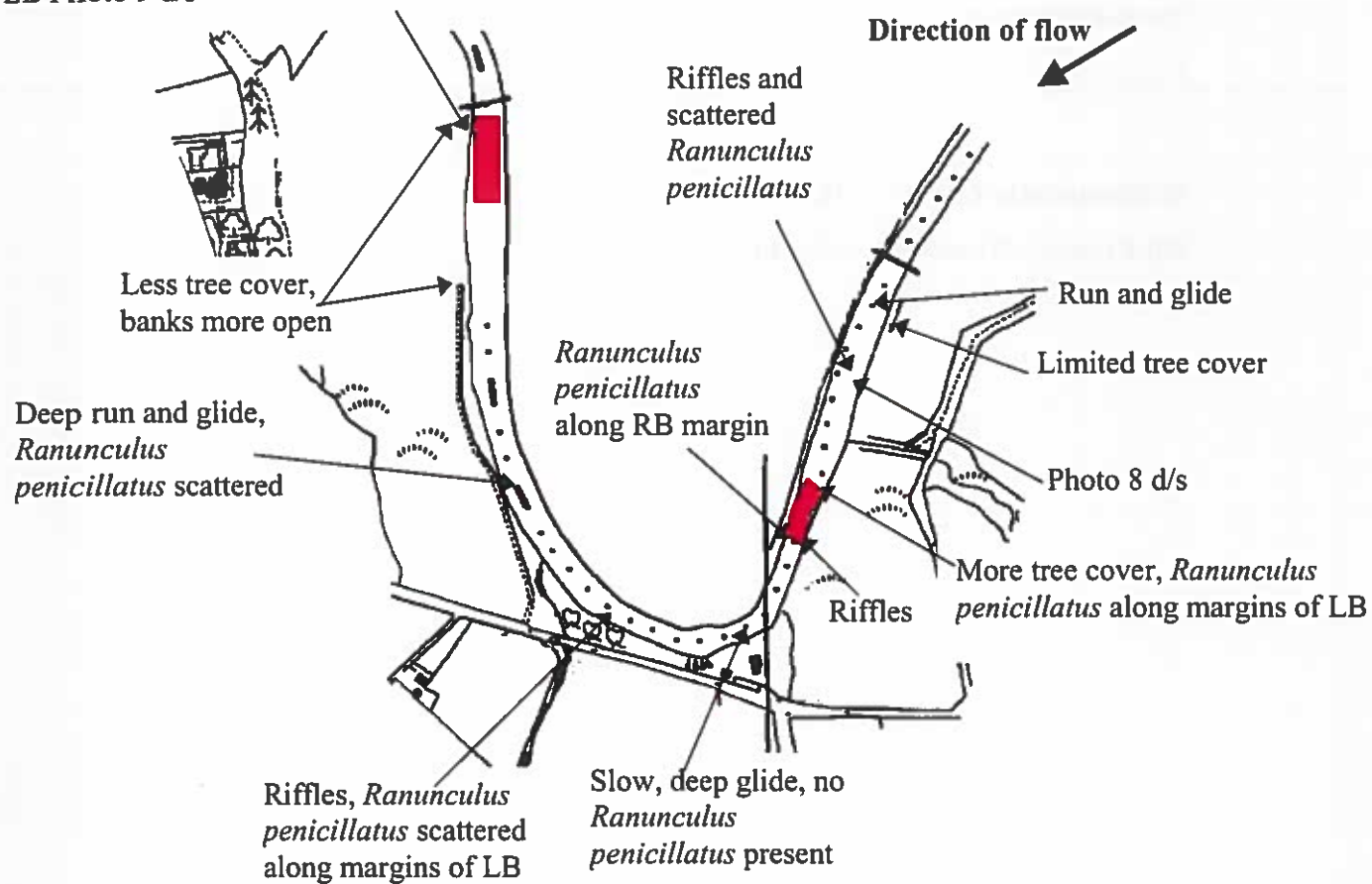
% Ranunculus Cover **20**

Silt Presence/Absence **Absent**

River Owenkillew Section 30



Ranunculus penicillatus present at riffles.
Extensive beds found along margins of the
LB Photo 9 d/s



River Name **Owenkillew**

Section **O34**

Associated Macrophyte Species

Callitriche indet.

Fontinalis antipyretica

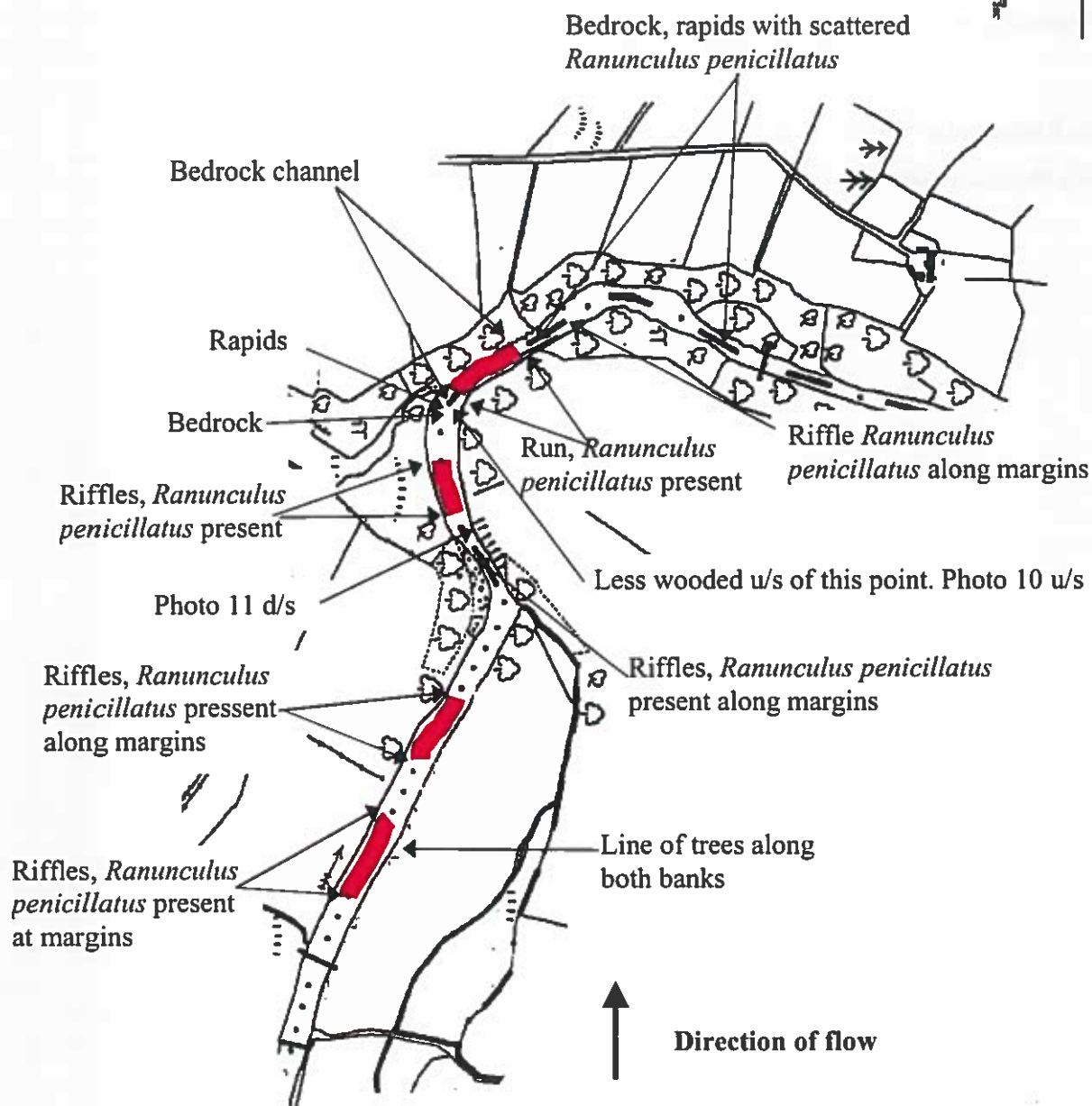
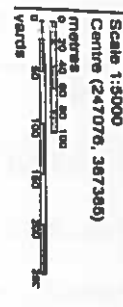
Fontinalis squamosa

Phalaris arundinacea

% Ranunculus Cover **10**

Silt Presence/Absence **Absent**

River Owenkillew Section 34



River Name **Owenkillew**

Section **O39**

Associated Macrophyte Species

Callitriche indet.

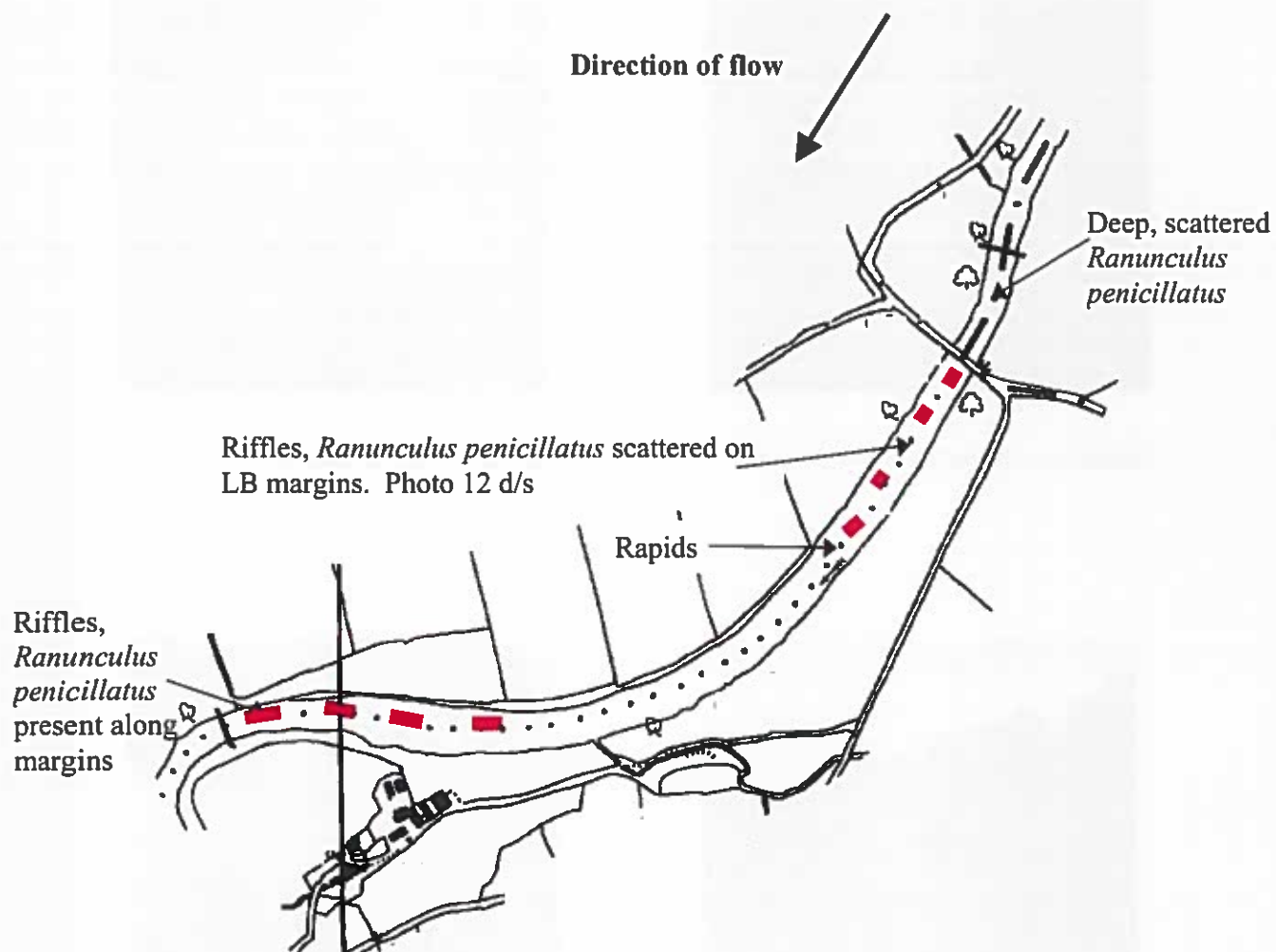
Fontinalis squamosa

% Ranunculus Cover **0**

Silt Presence/Absence **Absent**

River Owenkillew Section 39

Scale 1:5000
Centre (243510, 387185)
metres
0 20 40 60 80 100
yards
0 50 100 150 200 250





Ballinderry River Section 4 Photo 1



Ballinderry River Section 4 Photo 2



Ballinderry River Section 8 Photo 3



Ballinderry River Section 12 Photo 4



Ballinderry River Section 19 Photo 5



Ballinderry River Section 19 Photo 6



Ballinderry River Section 19 Photo 7



Ballinderry River Section 20 Photo 8



Ballinderry River Section 20 Photo 9



Ballinderry River Section 20 Photo 10



Ballinderry River Section 22 Photo 11



Ballinderry River Section 22 Photo 12



Photo 13



Photo 14



Photo 15



Photo 16

Photos 13 - 16. General Photographs of the Ballinderry River showing *Ranunculus penecillatus*



Owenkilleg River Section 4 Photo 1 d/s



Owenkilleg River Section 11 Photo 2



Owenkilleg River Section 15 Photo 3



Owenkilleg River Section 19 Photo 4



Owenkillew River Section 19 Photo 5



Owenkillew River Section 19 Photo 6



Owenkillew River Section 26 Photo 7



Owenkillew River Section 30 Photo 8



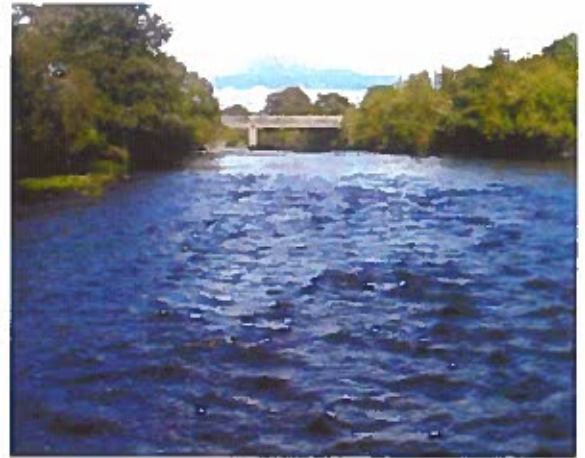
Owenkillew River Section 30 Photo 9



Owenkillew River Section 34 Photo 10



Owenkillew River Section 34 Photo 11



Owenkillew River Section 39 Photo 12



Swanlinbar River Section 1 Photo 1



General Photograph: *R. penicillatus* associated with *Callitriche* indet.



General Photograph: *R. penicillatus* associated with *Potamogeton natans*.

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