



Deucheran Hill 2 Wind Farm Appendix 7.3: Fish and Habitat Survey of The Upper Carradale Water & Tributaries Argyll, 2024

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Background

Argyll Fisheries Trust undertook surveys of salmonid fish populations and fish habitat in the upper Carradale Water and several tributaries on behalf of Natural Power Consultants Limited.

Main findings

- Stream habitats in the 4th order main channel of the upper **Barr Water** and 3rd order channel of the **Narrachan Burn** were largely suitable for salmonid fish. The 3rd and 2nd order channels of the larger tributaries: **Rhonodale Burn**, lower reaches of **Allt Duecheran**, **Drochaid Burn** and **Abhain Bheag** were also suitable for salmonid fish and where Juvenile Atlantic salmon and brown trout were found by the fish survey.
- There is some potential habitat that may be suitable for freshwater pearl mussel in the main channel of the upper Carradale Water but none were found by this survey. The low visibility of deeper water habitat due to peat-stained colour of the water were sub-optimal for surveys of mussels.
- Some fine sediments (mainly sand and some silt was evident on depositional features and at the edges of most channels where forestry and track maintenance activities occurred during the survey.
- Stream habitats in higher gradient 1st and 2nd order **tributary channels** provide less suitable and unsuitable habitat for trout spawning and early life-stage juveniles (fry).
- The survey found a degraded culvert on the **Rhonodale Burn** which may affect the upstream passage of migratory fish and may therefore affect the results of the fish survey.

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1. INTRODUCTION

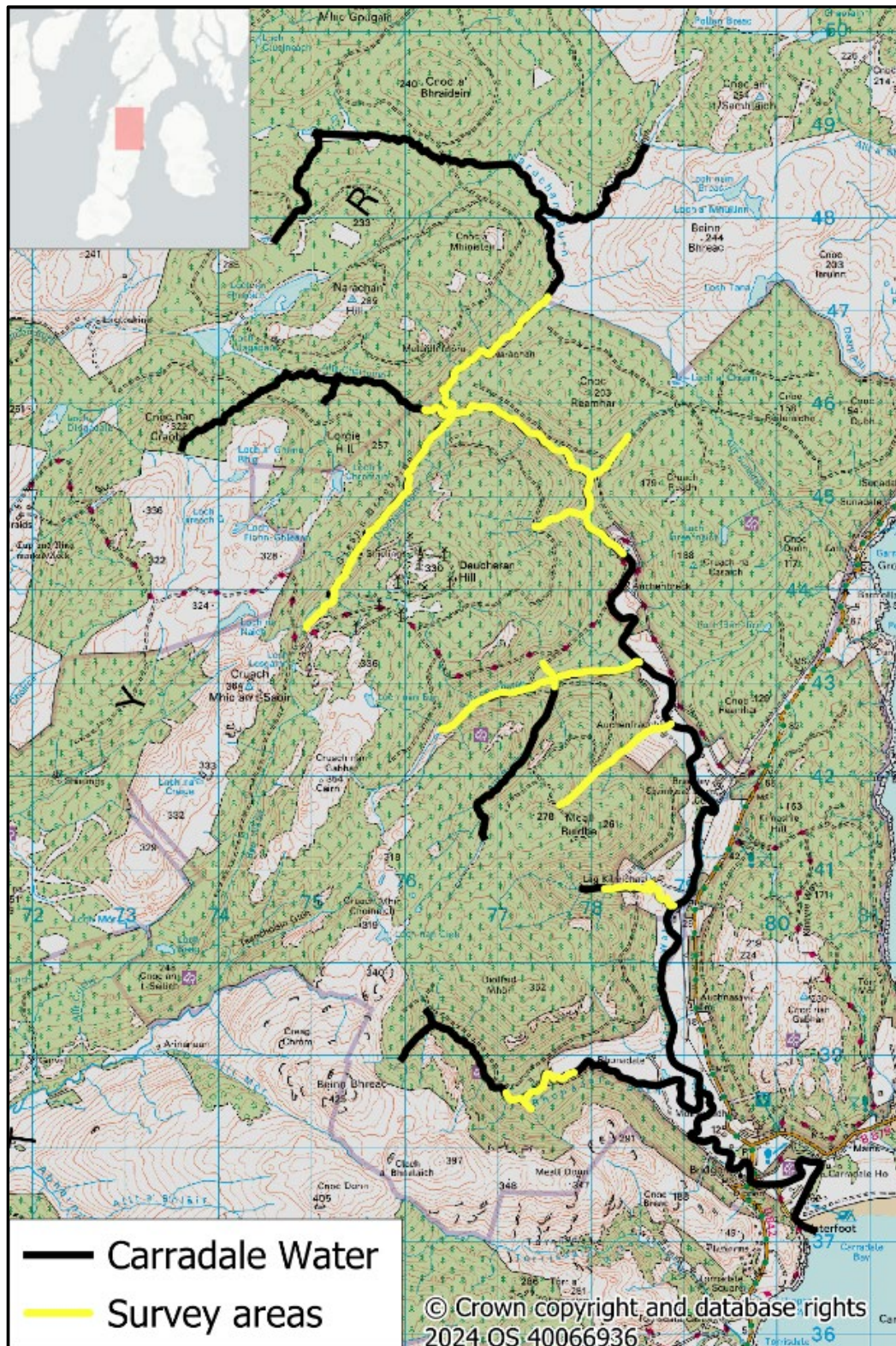
The Carradale Water catchment is located on the East of the Kintyre peninsula, Argyll and Bute (Figure 1.0). Flowing from North to South, the 13.65 Km length of the main channel is fed by three major headwater tributaries: the Narrachan Burn from the north-east, Allt Chaltuinn from the north-west and the Drochaid Burn from the west. Additional significant tributaries: Allt Breac-Laraich, Allt Deucheran, Allt a' Chaorainn, Abhainn Bheag and the Rhonodale Burn flow from the west and Allt a' Bhaile from the east.

Land use in the upper catchment is predominantly commercial forestry on the hillsides and farming of livestock on improved and semi-improved grassland on the valley floor. Broadleaf woodland present in the riparian margin of the Upper Barr Water and the lower tributaries but dissipates at higher altitudes.

An active rod and line fishery for Atlantic salmon and sea-run brown trout (sea trout) operates downstream of Auchenbreck run by the Carradale Angling Club. Fisheries in the area are administered by the Argyll District Salmon Fishery Board. To inform the management of fisheries, Argyll Fisheries undertook a baseline survey of fish habitat (downstream of Auchenbreck) and fish population in 2005 (AFT, 2007) as part of a wider study of fisheries in Knapdale and Kintyre. Further studies of fish populations have been undertaken at fewer sites in 2009 to inform fishery management, in 2018 and 2021 as part of the National electrofishing Programme for Scotland (NEPS) that inform government conservation policy for Atlantic salmon. Fish populations of the Carradale Water are also being monitored as part of the SEPA sea lice regulatory framework to inform the regulatory process for aquaculture.

To inform the proposed repower and extension of the existing wind farm site at Deucheran Hill and an access road on the West side of Carradale Water catchment, Argyll Fisheries Trust (AFT) undertook surveys of fish and fish habitat in the main channel and several tributaries. The aim of the surveys was to better understand the distribution of fish and condition of their habitats in the upper catchment and tributaries flowing from the west side of the catchment.

Fig. 1.0 Location of Carradale Water survey reaches



2. METHODS

The methodology used to survey of fish habitat (section 2.1) and fish populations (section 2.2) are described below:

2.1 Habitat Surveys

To assess the fish habitat, two methods were combined to identify morphological characteristics of the river channel which infer their relative susceptibility to change and their suitability for salmonid fish and freshwater pearl mussel. The location of the start and end points of the survey sections are given in Appendix II.

2.1.1 Morphological characteristics

The survey divided each watercourse into separate reaches with similar geomorphic river channel types (Table 2.1) according to a Morphological Impact Assessment Tool (SNIFFER, 2006). The tool offers a means of describing both the characteristics of the river channel (see Appendix I) and grouping these characteristics relative to their resilience and resistance to disturbance. Each site was also categorised based on the Strahler stream order (Strahler, 1952).

Table 2.1.1 River channel types based on resistance and resilience to change (SNIFFER, 2006)

Resistance/resilience classes	Channel types	Class	Increasing sensitivity →
High resistance (bed and bank) –	Bedrock, Cascade	A	
Low resilience (bed and Bank)			
High resistance (bank) Medium resistance Bed -	Step-Pool, Plane bed	B	
Low resilience (bank) low resilience bed			
Medium resistance (bed and Banks) -	Low gradient passive meandering	F	
Low resilience (bed and banks)			
Low resistance (bed and Bank) –	Plane-riffle, Pool-riffle, Braided, Wandering	C	
medium resilience (bed and Bank)			
Medium resistance (bank) low resistance (bed)	Groundwater dominated (Chalk)	E	
Low resilience (bed and banks)			
Low resistance (bed and Bank) –	Low gradient active meandering	D	
Low resilience (bed and banks)			

2.1.2 Fish and freshwater pearl mussel habitat suitability

Each separate section identified by the survey of geomorphic channel type was also assessed for their potential to support fish (Atlantic salmon and brown trout) and freshwater pearl mussel.

For the purposes of identifying the general suitability of the habitat for salmonid fish over the study site, the characteristics of the fish habitat were categorised (Table 2.2) in relation to the gradient of the channel, the stream bed substrates and bankside cover for fish. The categories used are: highly suitable (shaded green), suitable (shaded yellow), less suitable (shaded orange) and unsuitable (shaded red).

Table 2.1.2 Categories of suitability of salmonid fish habitat

Category	Line colour	Characteristics
Highly suitable		Low-to-moderate gradient. Stable mix of coarse substrates. Frequent bankside cover for fish and shaded by trees.
Suitable		Low-to-moderate gradient. Mainly stable mix of coarse & fine substrates. Bankside cover for fish present.
Less suitable		Moderate-to-high gradient. Highly unstable or compacted substrates. Bankside cover for fish present not present.
Unsuitable		High gradient. Bedrock substrates. Bankside cover for fish not present

The fish habitat survey was based on the Scottish Fisheries Coordination Centre habitat survey protocols (SFCC, 2007) which estimated the area of river habitat, the composition and stability of in-stream substrates, water flow types, and potential bank cover for fish. The location of significant features such as fish spawning sites, and obstacles to fish passage were recorded to allow mapping on Geographic Information System (GIS) software (Arc GIS version 10.6).

Photographs of the general characteristics of the watercourses were also taken (a selection of which are provided in appendix III).

Habitat that was potentially suitable for freshwater pearl mussels was also assessed according to those characteristics described by [Nature.scot](http://www.nature.scot).

2.2 Fish population surveys

The survey utilised electrofishing to sample fish between the 31st of October and 5th of November 2024 during low flow conditions when water temperatures ranged between 10.3 and 11.7 °C. The conductivity of the water at sampling sites ranged between 63 and 81 μsmn^{-1} .

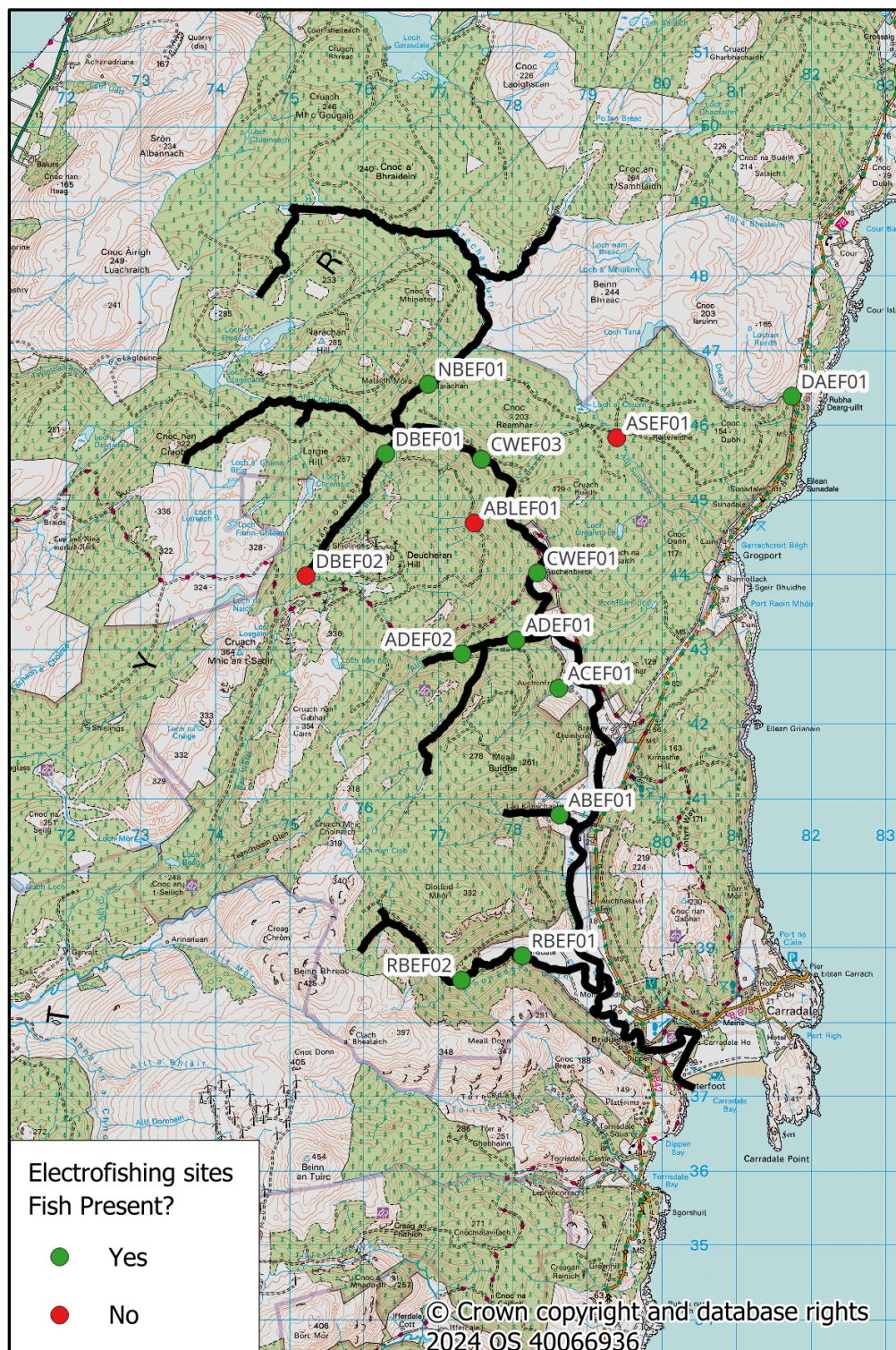
The assessment of the fish population was undertaken by electrofishing surveys at 13 sites within the proposed development site in the Carradale Water catchment (Table 2.1 and Figure 2.1) and two sites in adjacent catchments: Dearg Allt and Allt Sunadale which may be used for comparison over time. Surveys were undertaken according to protocols developed for the National electrofishing Programme for Scotland (Malcolm et. al., 2019b). A mixture of single and multi-pass fishing surveys were used over a known area of wetted stream habitat to provide estimates of fish density. Where the presence of fish was uncertain in smaller watercourses, a minimum of 50 m length of habitat was sampled as a single pass to identify the presence or absence (P/A) of fish.

Table 2.2.1 Electrofishing survey site location and survey type

Site Code	Catchment	Easting	Northing	No. runs	Temp (°C)
CWEF01	Carradale Water	178329	644014	1	11.0
CWEF02	Carradale Water	176629	615888	1	11.7
CWEF03	Carradale Water	177578	645538	3	11.0
NBEF01	Narrachan Burn	176864	646544	1	10.4
RBEF01	Rhonadale Burn	178126	638879	1	11.3
RBEF02	Rhonadale Burn	177310	638552	1	11.3
ADEF01	Allt Deucheran lower	178043	643114	1	11.0
ADEF02	Allt Deucheran middle	177317	642927	1	11.4
ABLEF01	Allt Breac-Laraich	177481	644682	1	10.5
ABEF01	Abhainn Bheag	178625	640767	1	10.8
DBEF01	Drochaid Burn Lower	176292	645613	1	11.0
DBEF02	Drochaid Burn middle	175225	643975	1	11.1
ACEF01	Allt a Chaoruinn	178614	642466	1	10.3
DAEF01	Dearg Allt	181744	646383	1	10.5
ASEF01	Allt Sunadale	179393	645826	3	10.7

The fish caught were processed at the end of each fishing pass and the fork length of all fish was measured to the nearest mm. An age class was assigned for salmonid fish only (fry 0+ years or parr >0+ years) at the time of sampling based on size observations. All fish were released after the completion of the survey.

Fig. 2.1 Habitat survey reaches and electrofishing survey site location



2 RESULTS

Results of the surveys are given separately for habitat (section 3.1) and fish (section 3.2). The location of the start and end points of each survey section the locations of obstacle features are given in Appendix II. Photographs of the general characteristics of the watercourses are given in Appendix III.

3.1 Habitat surveys

The results of the habitat survey coverage are summarised (Section 3.1.0) and detail is given of the stream channel characteristics (section 3.1.1) and suitability of the habitat for salmonid fish (section 3.1.2), the obstacles to fish migration and the connectivity of the habitats for fish (section 3.1.3) and for potential salmon and trout spawning sites (section 3.1.4).

3.1.0 Summary of survey coverage

The habitat survey was undertaken on 35 survey sections (Table 3.1.0 and Figure 3.1.0) in the main channel of the upper Carradale Water and its tributaries totalling 5.802 Hectares area along 15.507 Km of stream length. The survey identified some 4.924 Hectares (84.9 % of area) along 10.794 Km of stream length of channel types that are suitable for salmonid fish.

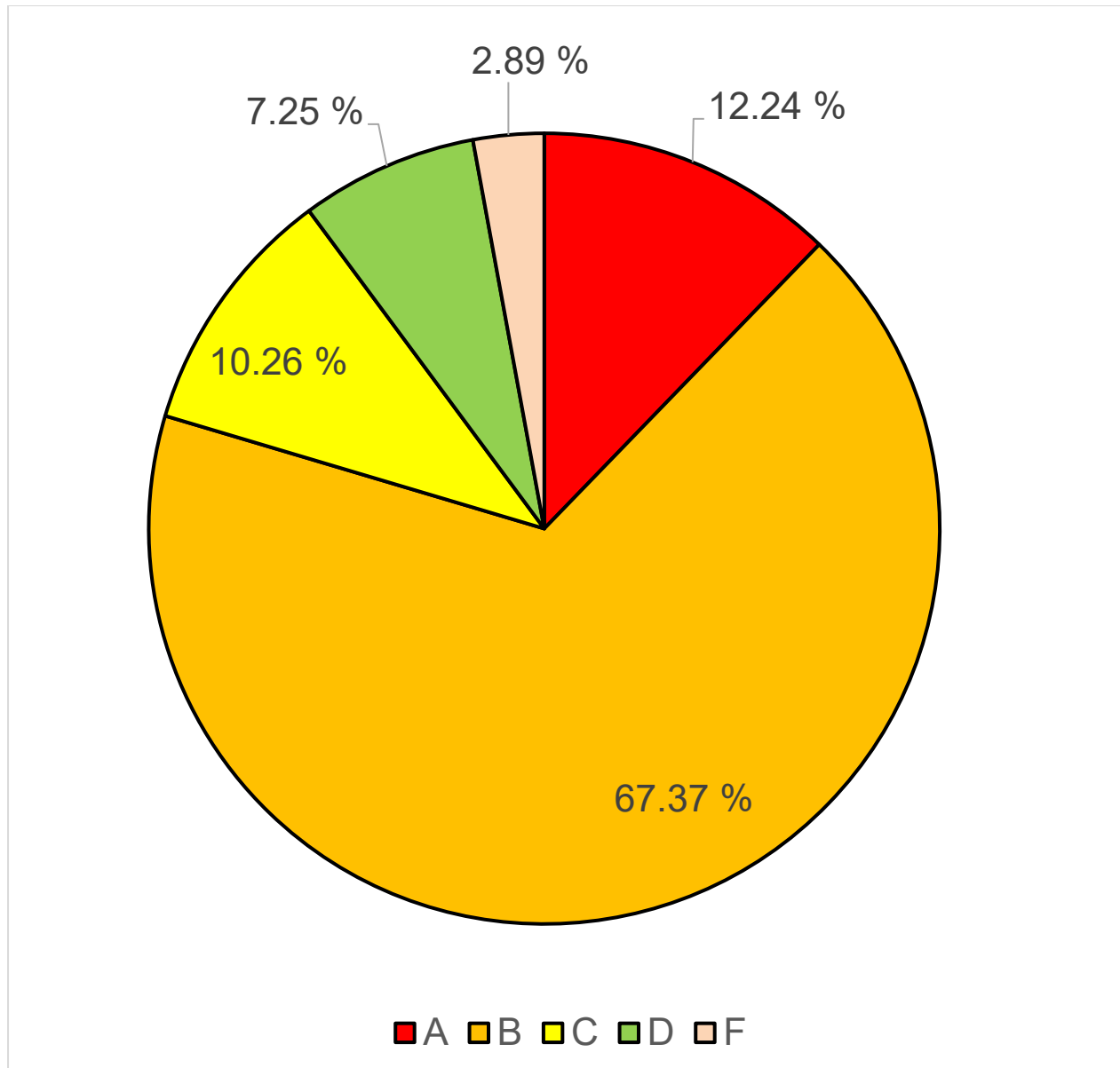
Table 3.1.0 Summary of habitat survey sections, length (Km) and area (Ha)

Watercourse	Section ID	No. Sections	Length (Km)	Area (ha)	Area (%)
Carradale Water	UCW01-05	5	2.894	2.282	39.3
Narrachan Burn	NB01-NB04	4	1.993	0.935	16.1
Rhonodale Burn	RB01-02 & RBT01	3	1.226	0.455	7.8
Abhainn Bheag	AB01-02	2	1.002	0.313	5.4
Allt a Chaoruinn	AAC01-02	2	0.825	0.118	2.0
Allt Deucheran	AD01-03 & tribs.	6	2.711	1.029	17.7
Allt Breac-Laraich	ABL01-02	2	0.605	0.063	1.1
Allt a' Bhaile	AAB01-03	3	0.706	0.058	1.0
Drochaid Burn	DB01-07	7	3.212	0.448	7.7
Allt Chaltuinn	AC01	1	0.333	0.100	1.7
Total		35	15.507	5.802	100
Suitable habitat			10.794	4.924	84.9

The proportion of stream channel of different geomorphic type and sensitivity classification are summarised as consisting of a smaller proportion of type A bedrock and cascade channels (12.24 %) that are resilient to disturbance and a higher proportion of type B channels (67.37 % of habitat

area) which are relatively resilient to disturbance. Of the less resilient channel types, the survey recorded smaller proportions of type C channels (10.26 %), type D channels (7.25 %) and type F channels (2.89 %), some of which (in smaller tributaries) was modified by channel straightening.

Fig. 3.1.0 Proportion of stream channel (% of area) of sensitivity classification



3.1.1 Stream channel characteristics

The type of river channel found by the survey are described separately for each survey reach below.

3.1.1.1 Upper Carradale Water

The type of river channel found (Table 3.1.1.1 and Figure 3.1.1.1) by the survey along 2.89 Km length of the 4th order channel of the Upper Carradale Water consisted mostly of (95.6 % of area) habitat that was generally less sensitive to change (type B channel) in four sections. The more resilient channel (type A) was found in one survey section (4.4 % of all habitats).

Table 3.1.1.1 Upper Carradale Water channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
UCW01	Plane bed / Plane-riffle	B/C	0.238	8	9	0.190	8.34	4
UCW02	Plane bed / bedrock	B/A	0.582	8	9	0.466	20.40	4
UCW03	Bedrock	A	0.166	6	9	0.100	4.36	4
UCW04	Plane bed / Plane-riffle	B/C	0.379	8	9	0.303	13.29	4
UCW05	Plane bed / bedrock	B/A	1.529	8	8	1.223	53.60	4
Carradale Wate			2.894			2.282	100	
Suitable habitat			2.728			2.182	95.64	

3.1.1.2 Narrachan Burn

The type of river channel found (Table 3.1.1.2 and Figure 3.1.1.1) along 1.99 Km of the 3rd order channel of the Narrachan Burn consisted mostly of (48.4 % of area) channel type that are generally resilient to disturbance in (type B) in two sections and resilient (type F) channel in one other section (11.8 %). The more sensitive channel type (type C) was found in one survey section (39.8 % of area).

Table 3.1.1.2 Narrachan Burn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
NB01	Plane bed / Plane-riffle	B/C	0.630	5	6	0.315	33.71	3
NB02	Pool-riffle / Plane bed	C/B	0.743	5	5	0.372	39.75	3
NB03	Step-pool / bedrock	B/A	0.344	4	4	0.138	14.72	3
NB04	Passive meander	F	0.276	4	4	0.110	11.81	3
Narrachan Burn			1.993			0.935	100	
Suitable habitat			1.717			0.824	88.186	

3.1.1.3 Rhonodale Burn

The type of river channel found (Table 3.1.1.3 and Figure 3.1.1.2) along 1.23 Km length of the 3rd order channel of the Rhonodale Burn consisted mostly of (85.7 % of area) sensitive channel (type D) in section RB01. The more resilient channel type (type B/A) was found in one survey section (13.3 % of all habitats) in the main channel (RB02) and a tributary (RBT01).

Table 3.1.1.3 Rhonodale Burn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
RB01	Active meander / plane riffle	D/C	0.975	4.0	5.0	0.390	85.7	3
RB02	Plane bed / bedrock	B/A	0.125	4.0	5.0	0.050	11.0	3
RBT01	Step-pool / plane bed	B	0.126	1.2	1.2	0.015	3.3	3
Rhonodale Burn		Total	1.226			0.455	100	
Suitable habitat		Total	1.226			0.455	100	

3.1.1.4 Abhainn Bheag

The type of river channel found (Table 3.1.1.4 and Figure 3.1.1.2) along 1.00 Km length of the 3rd order channel of the Abhainn Bheag consisted mostly of (63.0 % of area) sensitive channel (type C) in section AB01. The resilient channel (type A) was found in one survey section (37.0 % of area) further upstream (37.0 % of area).

Table 3.1.1.4 Abhainn Bheag channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
AB01	Plane-riffle	C	0.616	3.2	3.5	0.197	63.0	3
AB02	Bedrock / cascade	A	0.386	3.0	3.0	0.116	37.0	3
Abhainn Bheag			1.002			0.313	100	
Suitable habitat			0.616			0.197	62.99	

Fig. 3.1.1.1 Stream channel sensitivity classification for upper watercourses

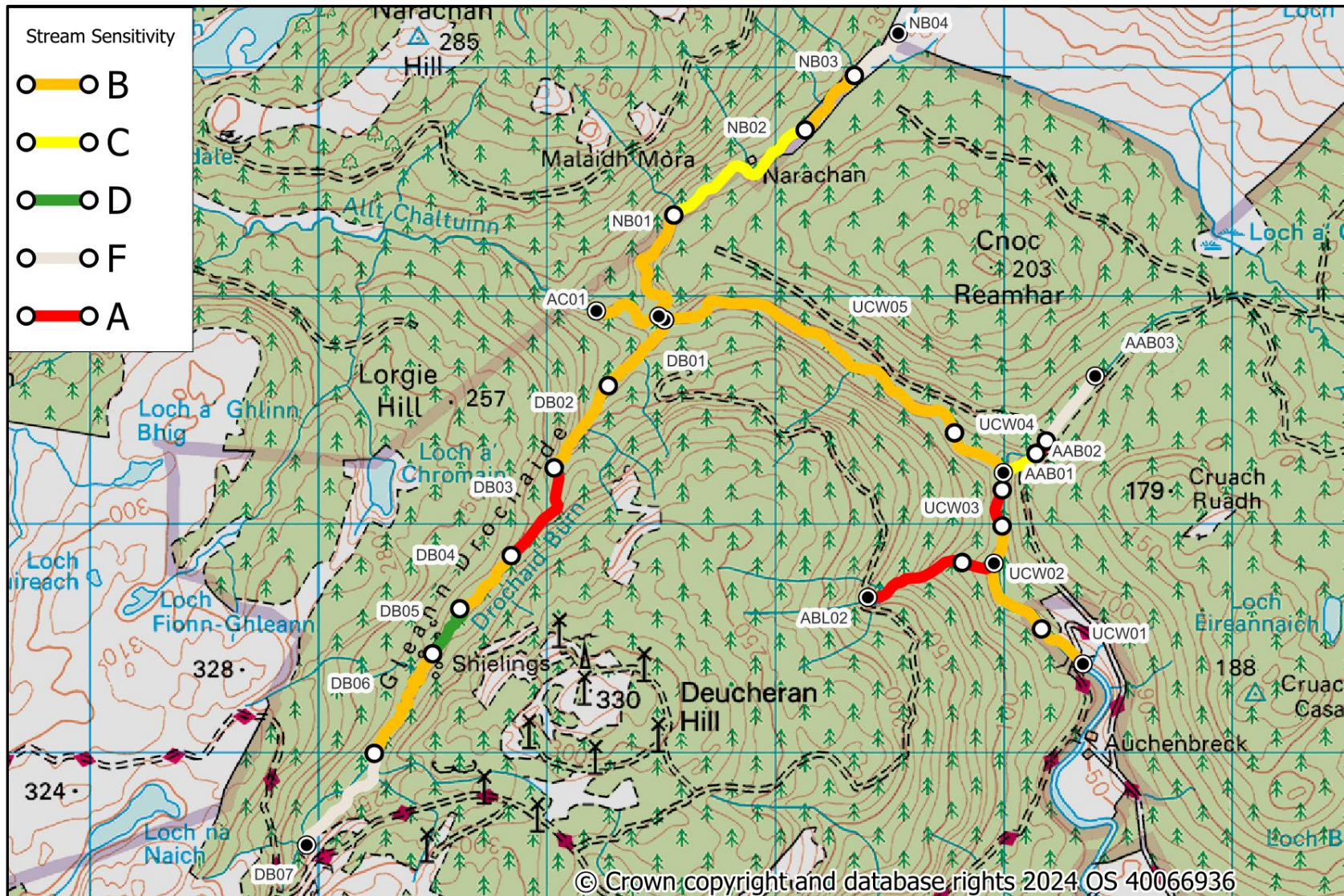
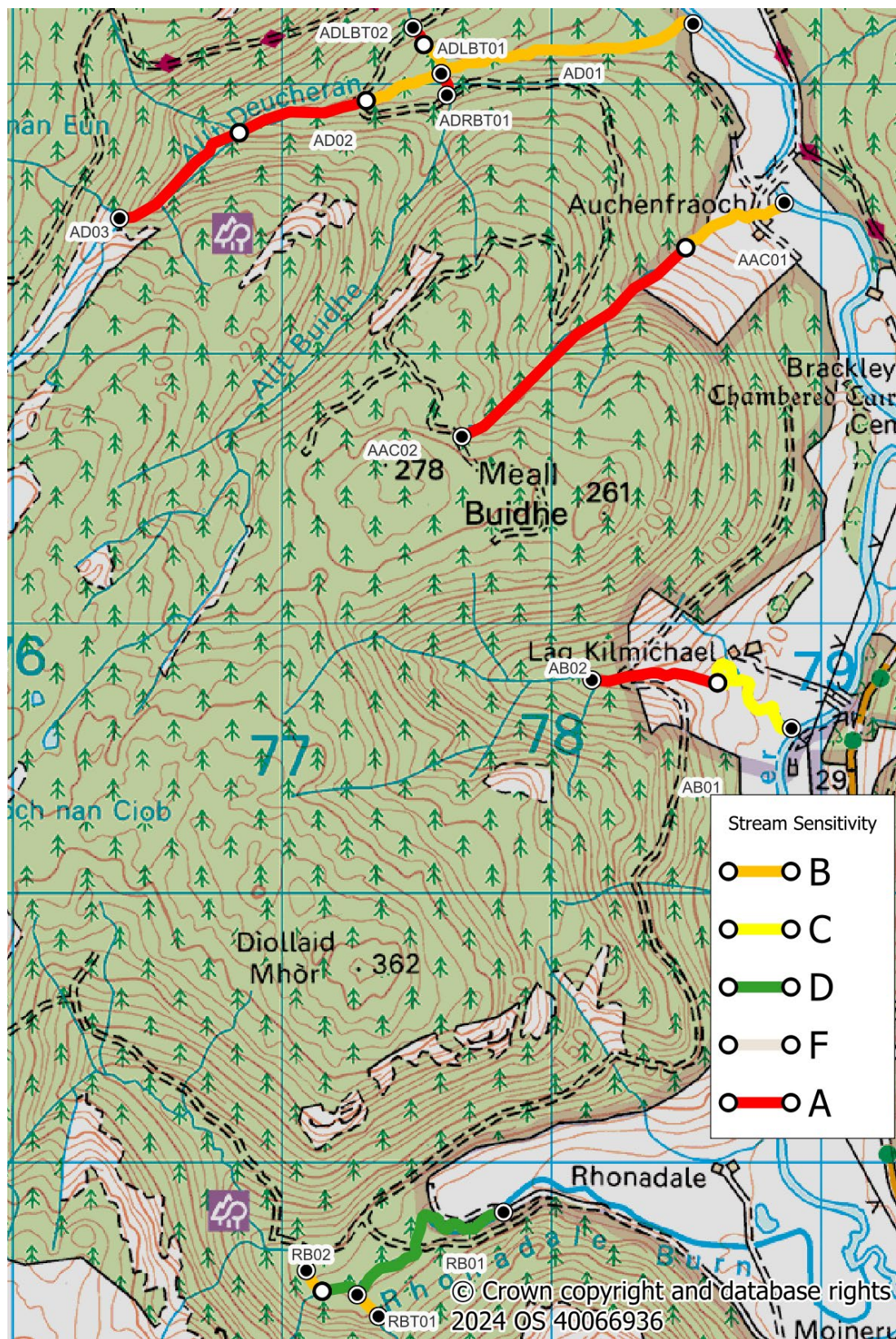


Fig. 3.1.1.2 Stream channel sensitivity classification for lower watercourses



3.1.1.5 Allt a' Chaoruinn

The type of river channel found (Table 3.1.1.5 and Figure 3.1.1.2) along 0.83 Km length of the 2nd order channel of the Allt a' Chaoruinn consisted mostly of (63.0 % of area) resilient channel (type A) in section AAC02 (50.8 % of area) and slightly less resilient channel (type B) in section AAC01 (49.2 % of area).

Table 3.1.1.5 Allt a' Chaoruinn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
AAC01	Step-pool / plane bed	B	0.324	1.8	2.0	0.058	49.2	2
AAC02	Bedrock / cascade	A	0.501	1.2	1.2	0.060	50.8	2
Allt a Chaoruinn			0.825			0.118	100	
Suitable habitat			0.324			0.058	49.24	

3.1.1.6 Allt Deucheran

The type of river channel found (Table 3.1.1.6 and Figure 3.1.1.1) along 1.33 Km length of the 3rd order main channel of the Allt Deucheran and one section of a 2nd order tributary consisted of (48.3 % of area) less sensitive channel (type B) in sections AD01 and ADLBT01. Resilient channel (type A and A/B) was found in four sections (51.7 % of area) of the upper main channel (AD02 & AD03) and tributaries (ADLBT02 and ADRBT01).

Table 3.1.1.6 Allt a' Chaoruinn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
AD01	Plane bed / Bedrock	B/A	1.333	5.5	6.5	0.733	71.2	3
AD02	Bedrock / Step-pool	A/B	0.506	3.5	4.0	0.177	17.2	2
AD03	Bedrock / cascade	A	0.583	1.5	2.0	0.087	8.5	2
ADLBT01	Step-pool / plane bed	B	0.125	1.0	1.0	0.013	1.2	2
ADLBT02	Cascade / Step-pool	A/B	0.076	1.0	1.0	0.008	0.7	2
ADRBT01	Bedrock / cascade	A	0.088	1.3	1.3	0.011	1.1	2
Allt Deucheran			Total			1.029	100	
Suitable habitat			Total			0.746	72.45	

3.1.1.7 Allt Breac-Laraich

The type of river channel found (Table 3.1.1.7 and Figure 3.1.1.1) along 0.61 Km length of the 2nd order channel of the Allt Breac-Laraich consisted of resilient channel (type A and A/B) in both survey sections (100 % of area).

Table 3.1.1.7 Allt Breac-Laraich channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
ABL01	Bedrock / Step-pool	A/B	0.144	1.2	1.2	0.017	27.3	2
ABL02	Bedrock / cascade	A	0.461	1.0	1.0	0.046	72.7	2
Allt Breac-Laraich			0.605			0.063	100	
Suitable habitat			0.000			0.000	0.00	

3.1.1.8 Allt a' Bhaile

The type of river channel found (Table 3.1.1.8 and Figure 3.1.1.1) along 0.71 Km length of the 1st order main channel of Allt a' Bhaile consisted of sensitive channel (type C) in section AAB01 (45.5 % of area), and resilient channel (type A) in section AAB02 (10.2 % of area) and modified (type F) channel in section AAB03 (44.4 % of area).

Table 3.1.1.8 Allt a' Bhaile channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
AAB01	Pool-riffle / Plane bed	C/B	0.264	1.0	1.0	0.026	45.5	1
AAB02	Bedrock / cascade	A	0.074	0.8	0.8	0.006	10.2	1
AAB03	Passive modified	F	0.368	0.7	0.7	0.026	44.4	1
Allt a' Bhaile			0.706			0.058	100	
Suitable habitat			0.264			0.026	45.45	

3.1.1.9 Drochaid Burn

The type of river channel found (Table 3.1.1.9 and Figure 3.1.1.1) along 0.71 Km length of the 2nd order main channel of the Drochaid Burn consisted mostly of (68.0 % of area) less sensitive (type B) channel in four sections, and resilient channel (type A) in section DB03 (18.2 % of area). One section (DB07) consisted of modified (type F) channel (7.0 % of area).

Table 3.1.1.9 Drochaid Burn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
DB01	Plane bed / Plane riffle	B/C	0.404	2	2.5	0.081	18.0	2
DB02	Step-pool / bedrock	B/A	0.439	3	5	0.132	29.4	2
DB03	Bedrock / Step-pool	A/B	0.453	1.8	1.8	0.082	18.2	2
DB04	Plane bed / bedrock	B/A	0.342	1.2	1.2	0.041	9.2	2
DB05	Active meander	D	0.305	1	1	0.031	6.8	2
DB06	Step-pool / bedrock	B/A	0.638	0.8	0.8	0.051	11.4	2
DB07	modified channel	F	0.631	0.5	0.5	0.032	7.0	1
Drochaid Burn			3.212			0.448	100	
Suitable habitat			2.128			0.335	93.19	

3.1.1.10 Allt Chaltuinn

The type of river channel found (Table 3.1.1.10 and Figure 3.1.1.1) along 0.33 Km length of the 3rd order channel of Allt Chaltuinn consisted of relatively resilient channel (type B) in section AC01.

Table 3.1.1.10 Allt Chaltuinn channel sensitivity class and dimensions

Section ID	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Strahler Order
AC01	Plane bed / plane riffle	B	0.333	3.0	4.0	0.100	100.0	3
Allt Chaltuinn			0.333			0.100	100	
Suitable habitat			0.333			0.100	0.00	

3.1.2 Suitability of fish habitat

The suitability of the habitat for salmonid fish found by the survey are summarised and are described separately below.

The survey found 3 survey sections along 1.59 Km of stream channel (14.7 % of total habitat area) that were assessed as being highly suitable for juvenile salmonid fish (shaded green in Table 3.1.2.0 and Figures 3.1.2.1 and 3.1.2.2), 9 survey sections along 5.03 Km (38.4 % of habitat) was assessed as being suitable (shaded yellow), 13 survey sections along 5.54 Km of channel (38.1 % of habitat) was assessed as being less suitable (shaded orange), and 9 sections along 3.67 Km (8.7 % of habitat) that were unsuitable for salmonid fish.

Table 3.1.2.0 Summary of habitat suitability for salmonid fish

Fish Suitability	No. Sections	Length (Km)	Area (ha)	Area (%)
Highly suitable	3	1.59	0.884	14.7
Suitable	9	5.03	2.302	38.4
Less suitable	13	5.54	2.283	38.1
Unsuitable	9	3.67	0.522	8.7

3.1.2.1 Highly suitable fish habitat

The highly suitable habitat was found in 3 survey sections, two of which were found in the upper Carradale Water (UCW01 and UCW04) and one survey section in the Rhonodale Burn (Table 3.1.2.1 and Figure 3.1.2). These survey sections had a wide variety of habitat for fry, mixed juvenile, deep juvenile in addition to spawning and pool refuge habitats. Additionally, a high proportion of riverbanks had riparian woodland and there was little or no bedrock substrate that offers no instream cover for fish.

Table 3.1.2.1 Proportion (%) of habitat suited to salmonid fish in highly suitable habitat

ID	Spawning	Fry	Mixed Juvenile	Deep Juvenile	Adult Pool	Bedrock
UCW01	1.3	20.0	29.6	20.0	24.2	5.0
UCW04	0.7	15.0	52.2	15.0	17.2	0
RB01	2.5	20.0	53.0	10.0	14.5	0

3.1.2.2 Suitable fish habitat

The suitable habitat was found in 2 survey sections of the Narrachan Burn (NB01 and NB02), the upper Carradale Water (UCW02), and the lower reaches of tributary streams: Abhainn Bheag (AB01), Allt Deucheran (AD01) and its tributary (ADLBT01), Allt a' Bhaile (AAB01), Deucheran Burn (DB01) and Allt Chaltuinn (AC01). These survey sections had a wide variety of habitat for fry, mixed juvenile, deep juvenile but fewer spawning and pool refuge habitats, a lower proportion of riverbanks had riparian woodland and some bedrock substrate when compared to highly suitable habitats.

Table 3.1.2.2 Proportion (%) of habitat suited to salmonid fish in suitable habitat

ID	Spawning	Fry	Mixed Juvenile	Deep Juvenile	Adult Pool	Bedrock
UCW02	0	10.0	44.8	30.0	5.2	10.0
NB01	0.1	20.0	62.9	10.0	7.0	0
NB02	0.1	25.0	18.4	45.0	6.5	5
AB01	0	40.0	49.5	10.0	0	0
AD01	0	10.0	55.0	20.0	0	15.0
ADLBT01	0	25.0	60.0	10.0	0	5.0
AAB01	1.5	80.0	18.5	0.0	0	0.0
DB01	2.2	20.0	44.9	20.0	7.9	5.0
AC01	1.1	15.0	68.7	10.0	5.2	0.0

3.1.2.3 Less suitable fish habitat

The less suitable habitat (Table 3.1.2.3) was found in 2 survey sections of the upper Carradale Water (UCW03 and UCW05), the Narrachan Burn (NB03 and NB05), and tributary streams: Rhonodale Burn (RB02) and a tributary (RBT01), Allt a' Chaoruinn (AB01), Allt Deucheran (AD02) and its tributary (ADRB01), Allt Breach-Laraich (ABL01), and three sections of the Deucheran Burn (DB02, DB03 and DB05) and Allt Chaltuinn (AC01). These survey sections had a variety of habitat for fry, mixed juvenile, deep juvenile but fewer spawning and pool refuge habitats, a lower proportion of riverbanks had riparian woodland and some bedrock substrate when compared to highly suitable habitats.

Table 3.1.2.3 Proportion (%) of habitat suited to salmonid fish in less suitable habitat

ID	Spawning	Fry	Mixed Juvenile	Deep Juvenile	Adult Pool	Bedrock
UCW03	0	5.0	6.0	30.0	9.0	50.0
UCW05	0.1	15.0	65.5	15.0	4.4	0
NB03	0	5.0	30.0	25.0	0	40.0
NB04	0	0.0	30.0	70.0	0	0
RB02	0	25.0	20.0	45.0	0	10.0
RBT01	1.0	5.0	64.0	25.0	0	5.0
AAC01	0	10.0	65.0	10.0	0	15.0
AD02	0	5.0	40.0	30.0	0	25.0
ADRBT01	0	10.0	25.0	30.0	0	35.0
ABL01	0	10.0	50.0	10.0	0	30.0
DB02	0.7	10.0	41.3	30.0	3.0	15.0
DB04	0	15.0	43.3	15.0	11.7	15.0
DB05	0	15.0	70.0	15.0	0	0.0

3.1.2.4 Unsuitable fish habitat

The unsuitable habitat was mainly found in the middle and upper reaches of the tributaries: Abhainn Bheag (AB02), Allt Deucheran (AD02) and its tributary (ADLBT02), Allt Breach-Laraich (ABL03 and ABL03), and three sections of the Deucheran Burn (DB03, DB06 and DB07). These survey sections had limited habitat for fry, mixed juvenile, deep juvenile but no spawning and pool refuge habitats, and a higher proportion of bedrock substrate when compared to highly suitable habitats.

Table 3.1.2.4 Proportion (%) of habitat suited to salmonid fish in suitable habitat

ID	Spawning	Fry	Mixed Juvenile	Deep Juvenile	Adult Pool	Bedrock
AB02	0	5.0	25.0	10.0	0	60.0
AD03	0	0.0	40.0	20.0	0	40.0
ADLBT02	0	0.0	40.0	20.0	0	40.0
ABL02	0	5.0	25.0	10.0	0	60.0
AAB02	0	5.0	45.0	10.0	0	40.0
AAB03	0	20.0	60.0	20.0	0	0.0
DB03	0	5.0	30.0	30.0	0	35.0
DB06	0	15.0	70.0	15.0	0	0.0
DB07	0	15.0	70.0	15.0	0	0.0

Fig. 3.1.2.1 Survey sections and habitat suitability for fish in upper watercourses

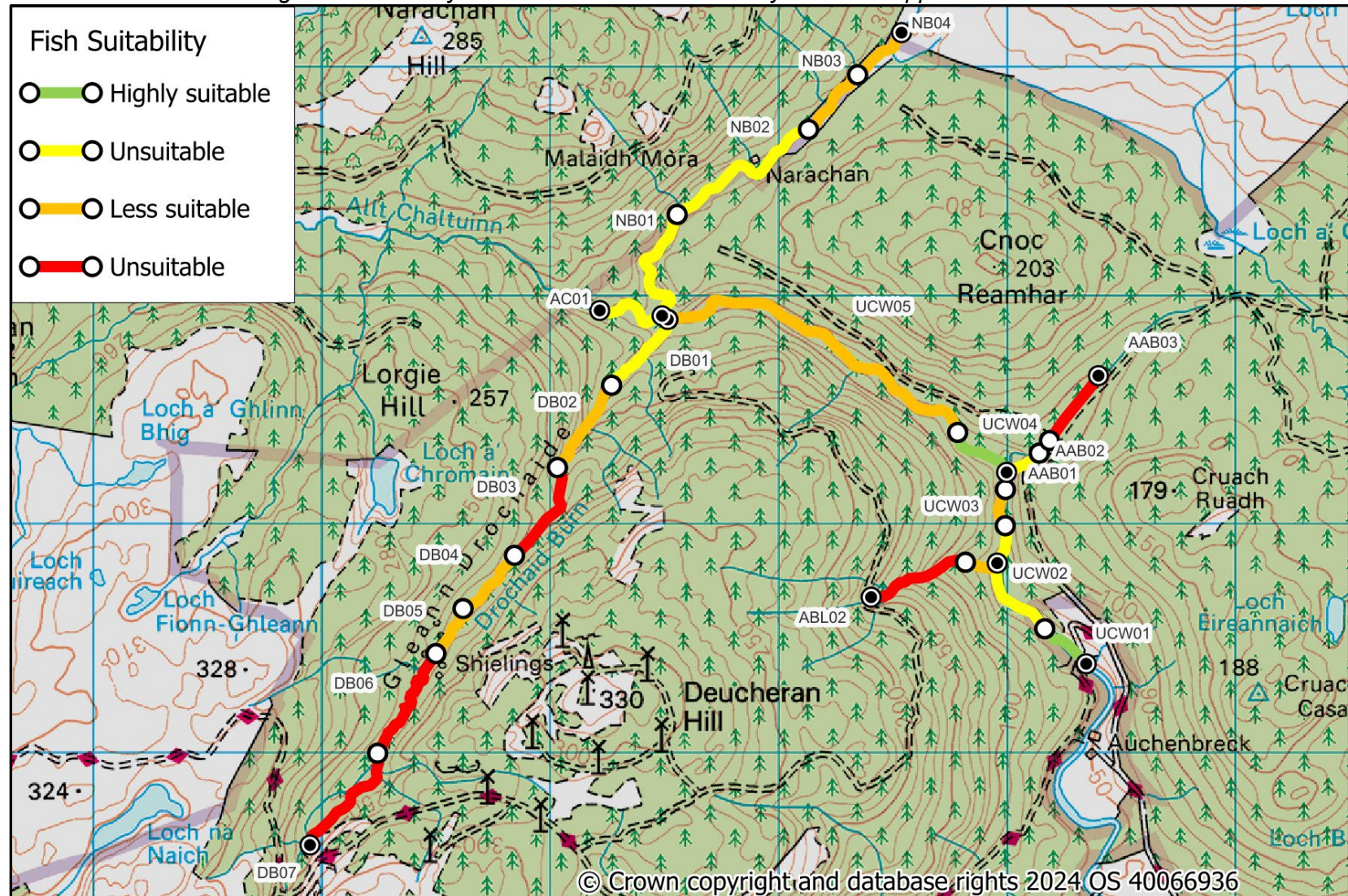
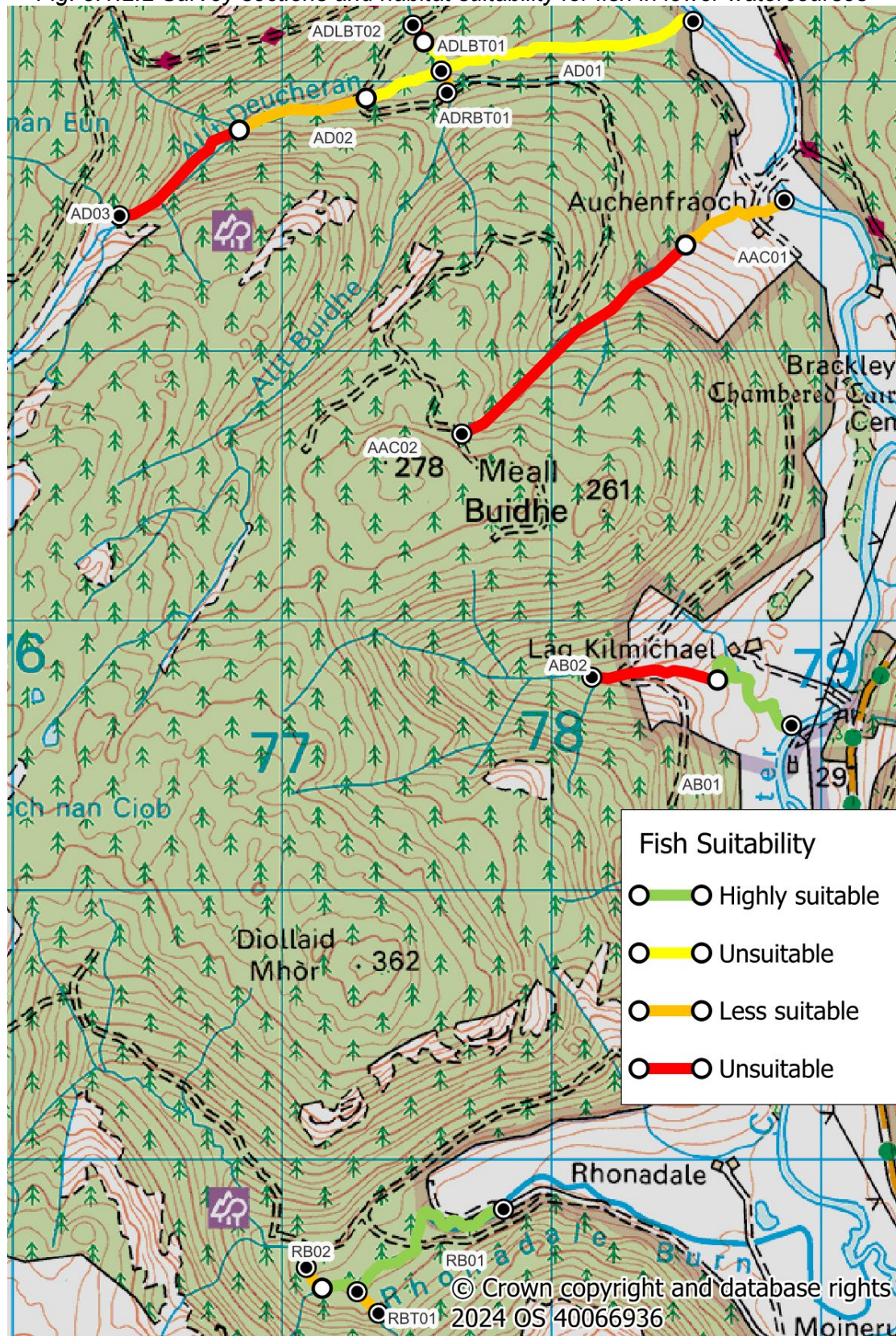


Fig. 3.1.2.2 Survey sections and habitat suitability for fish in lower watercourses



3.1.3 Obstacles to fish passage

A total of 24 obstacles to upstream passage of fish were identified in 14 different survey sections (Table 3.1.3 and Figure 3.1.3). Ten of the obstacles appeared passable (Yes (S/F) depending on species and flow conditions) and three obstacles where fish passage was Unsure. Obstacles to fish migration in an upstream direction consisted of impassable (No u/s) cascades (CSCD) and waterfalls (WF) at 11 sites.

Table 3.1.3 Location, type, and pass ability of obstacles

ID	Easting	Northing	Type	Height (m)	Length (m)	yes (S/F)	Unsure	No (u/s)
UCW03-01	177962	745066	CSCD	2	30	1		
NB03-01	177132	746724	WF	1	1	1		
RB01-01	177823	638815	CU	1	20		1	
RB01-02	177356	638597	LWD Dam	2	4		1	
RB02-01	177091	638599	WF / CSCD	5	10			1
AB01-01	178614	640793	WF / CSCD	5	30			1
AAC01-01	177563	642432	WF/CSCD	6	25			1
ABL01-01	177818	644821	WF/CSCD	15	5			1
ABL02-01	177406	644678	CU/WF	10	30			1
AAB01-01	178142	645308	WF/CSCD	3	1			1
AAB02-01	178187	645363	CU/WF	1.5	4			1
ADF02-01	176842	642821	WF/CSCD	20	10			1
ADLBT01-01	177527	643148	WF/CSCD	3	3			1
ADRBT01-01	177613	642960	WF/CSCD	3	3			1
DB01-01	176464	645793	CSCD	1	5	1		
DB01-02	176477	645809	CSCD	2	10	1		
DB01-03	176436	645769	CSCD	2	10	1		
DB01-04	176414	645768	WF	1	1	1		
DB02-01	176186	645481	CSCD	1.5	15	1		
DB02-02	176187	645454	CSCD	1	4	1		
DB02-03	176154	645421	CSCD	3	20	1		
DB02-04	176119	645369	WF	2	1		1	
DB02-05	176098	645341	CSCD	1.5	8	1		
DB02-06	176098	645341	WF	10	2			1

The one man-made obstacle in the suitable fish habitat of the Rhonodale Burn (which is likely to affect the results of the fish survey) was found at a track culvert at the downstream end of section RB01 (ID RB01-01 shown in Figure 3.1.3.1) where the floor of the culvert has degraded (Figure 3.1.3.2).



Fig. 3.1.3.1 Culvert obstacle RB01-01

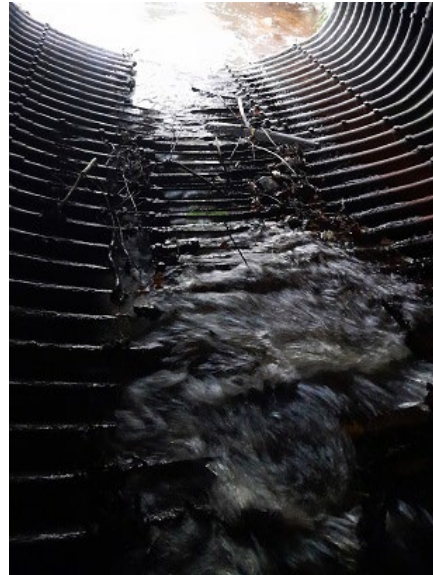


Fig. 3.1.3.2 Degraded culvert floor RB01-01

The main natural obstacles in suitable fish habitat likely to influence the distribution of fish were found at DB02-06 (Figure 3.1.3.3) and AD02-01 (Figure 3.1.3.4).



Fig. 3.1.3.3 Waterfall obstacle DB02-06



Fig. 3.1.3.4 Cascade obstacle AD02-01

Figure 3.1.3.5 Distribution of obstacles to fish migration in upper watercourses

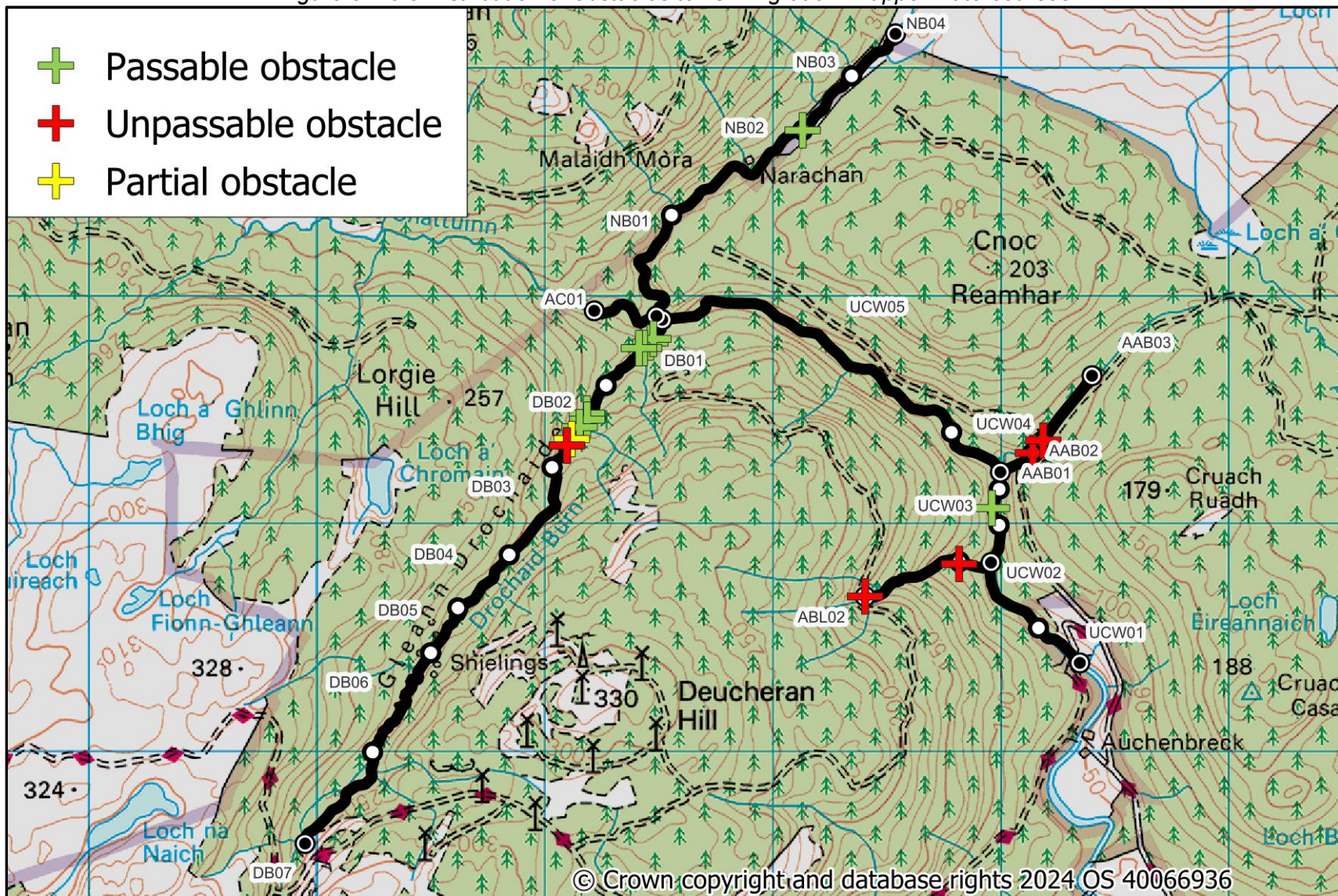
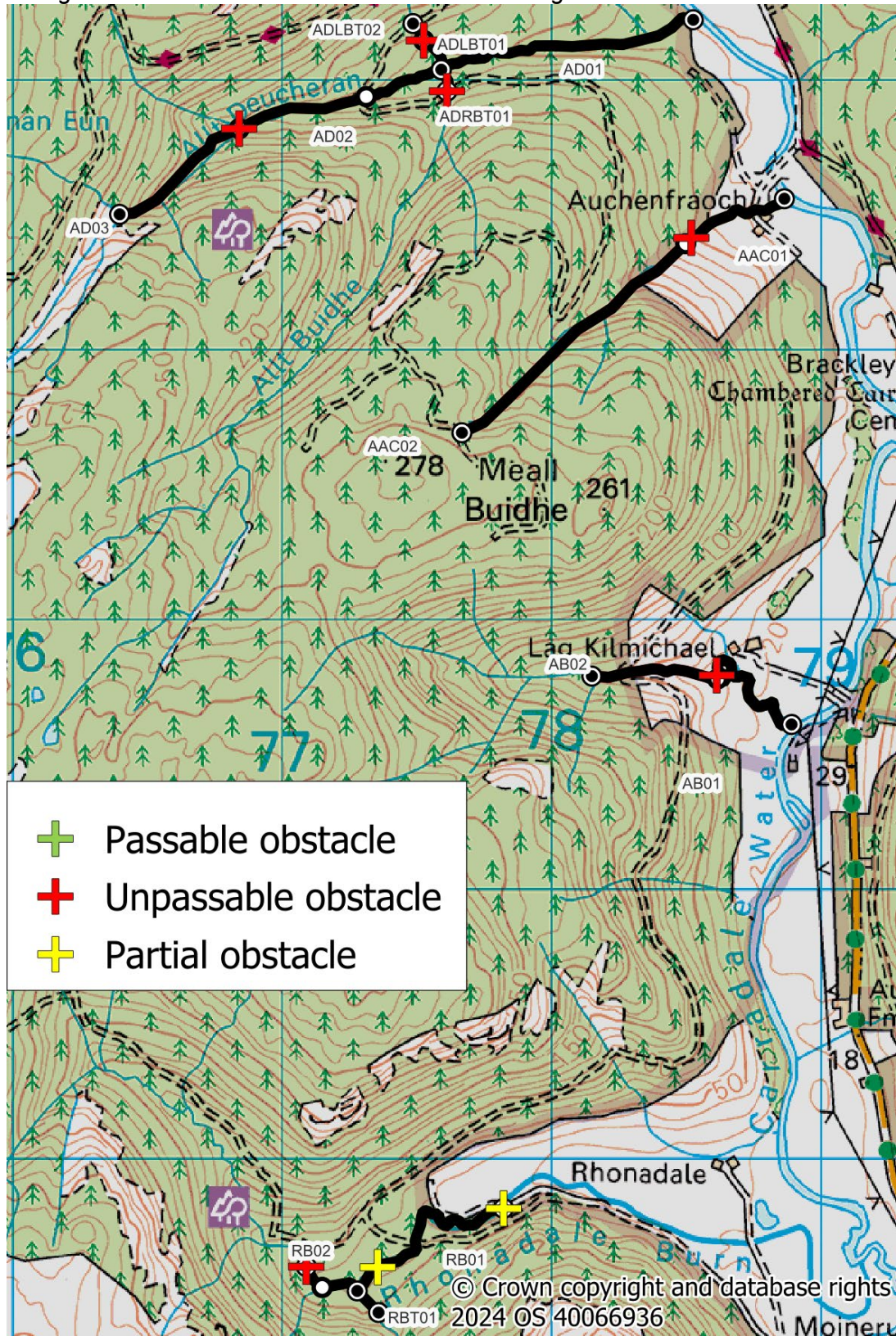


Figure 3.1.3.6 Distribution of obstacles to fish migration in lower watercourses



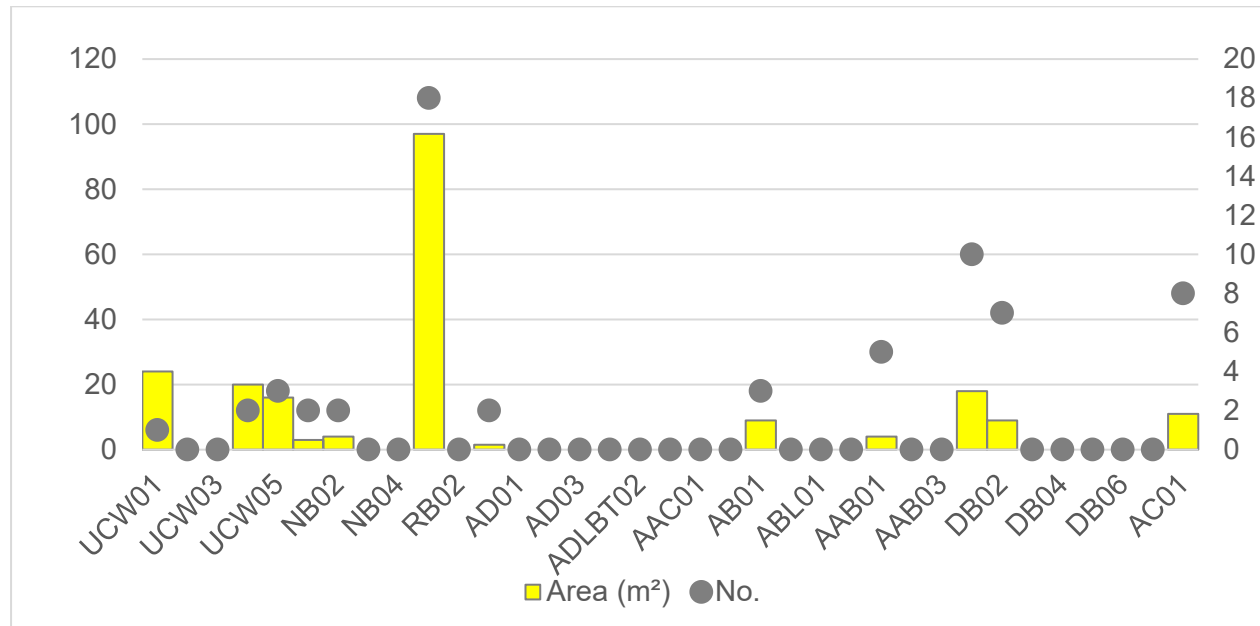
3.1.4 Spawning habitat

The habitat that may have potential for salmonid fish spawning included a total of 63 locations (Table 3.1.4. and Figure 3.1.4. The distribution maps are given in Appendix IV) of 216.5 m², 65 m² (30 %) of which was assessed as being made up of optimal stable substrates. The most significant spawning sites were found in Rhonodale Burn (98.5 m²), Carradale Water (60 m²), Drochaid Burn (27 m²) and Allt Chaltuinn (11 m²).

Table 3.1.4 Number and area (m²) of spawning sites

Section	No. Spots	Area (m ²)	Opt.(m ²)	Opt. %
Carradale Water	6	60	24	40.0
Narrachan Burn	4	7	1	14.3
Rhonodale Burn	20	98.5	18	18.3
Abhainn Bheag	3	9	0	0.0
Allt a Chaoruinn	0	0		
Allt Deucheran	0	0		
Allt Breac-Laraich	0	0		
Allt a' Bhaile	5	4	0	0.0
Drochaid Burn	17	27	17	63.0
Allt Chaltuinn	8	11	5	45.5
Total	63	216.5	65	30.0

Fig. 3.1.4 Number and area (m²) of spawning sites



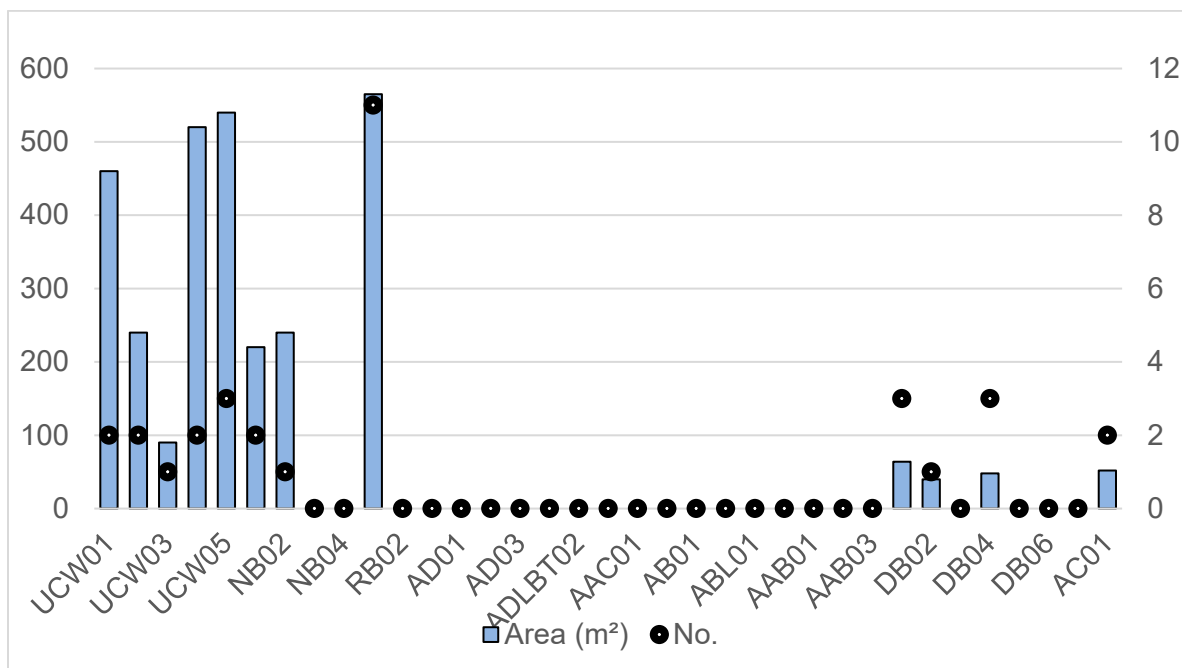
3.1.5 Adult refuge habitat

The habitat that may have potential for salmonid fish refuge (pools) found included a total of 33 locations (Table 3.1.5. and Figure 3.1.5. The distribution maps are given in Appendix IV) of 3,079 m², 780 m² (25.3 %) of which was assessed as being of optimal depth (> 1 m). The most significant pool sites were found in the Carradale Water (1,850 m²), Rhonodale Burn (565 m²), Narrachan Burn (460 m²) and Drochaid Burn (152 m²).

Table 3.1.5 Number and area (m²) of pool sites

Section	No. Pools	Area (m ²)	Opt.(m ²)	Opt. %
Carradale Water	10	1850	740	40.0
Narrachan Burn	3	460	0	0.0
Rhonodale Burn	11	565	0	0.0
Abhainn Bheag	0	0		
Allt a Chaoruinn	0	0		
Allt Deucheran	0	0		
Allt Breac-Laraich	0	0		
Allt a' Bhaile	0	0		
Drochaid Burn	7	152	40	26.3
Allt Chaltuinn	2	52	0	0.0
Total	33	3,079	780	25.3

Fig. 3.1.5 Number and area (m²) of pool habitats



3.2 Fish Population Surveys

The results of the fish survey are described in terms of the distribution of fish across the study area (section 3.2.1), estimates of the density of fish present at survey sites (section 3.2.2), and the habitat found at survey sites (section 3.2.3).

3.2.1 Fish distribution

The results of the surveys undertaken at 15 sites (Table 3.2.1 and Figure 2.1) where 119 juvenile salmonid fish were found at 13 sites. A total of 35 juvenile salmon were found at 7 sites and a total of 84 juvenile trout were found at 12 sites.

Table 3.2.1 Summary of fish survey site dimensions, area, and no. of fish sampled

Survey site details					Salmon		Trout	
Site Code	Stream Order	Avg. width (m)	Length (m)	Area (m ²)	Fry	Parr	Fry	Parr
CWEF01	3	5.64	25.5	143.8	9	3		
CWEF02	3	7.88	14.5	114.3	3	1	1	
CWEF03	3	8.82	12.1	106.7		2	1	1
NBEF01	3	4.26	24.8	105.6	1		1	1
RBEF01	3	7.82	18.1	141.5	9		4	2
RBEF02	3	4.64	22.1	102.5			10	
ADEF01	3	6.58	15.8	104.0		3	1	4
ADEF02	2	4.66	30.5	142.1				5
ABLEF01	2	1.54	30.0	46.2				
ABEF01	2	3.22	42.5	136.9	2	2	20	6
DBEF01	3	3.78	41.1	155.4				3
DBEF02	2	0.42	50.0	21.0				
ACEF01	2	2.06	50.0	103.0				5
DAEF01	2	4.04	25.6	103.4				3
ASEF01	3	2.24	45.5	101.9			6	10
Total				1628.4	24	11	44	40

3.2.2 Estimates of fish density

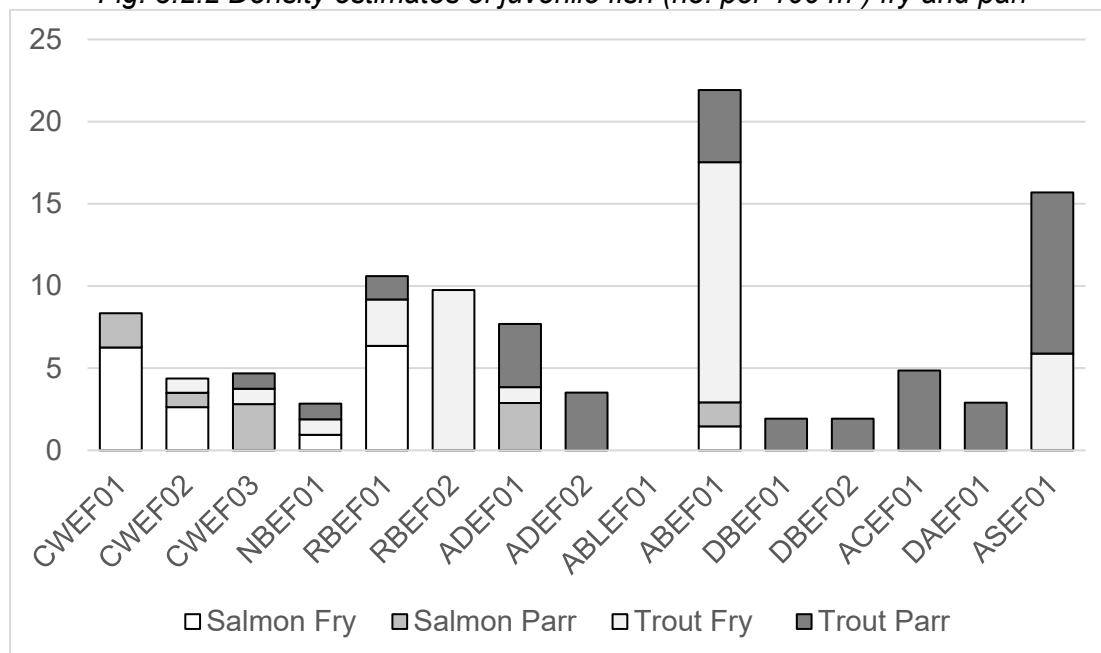
In the 3rd order stream channels (Table 3.2.2 and Figure 3.2.2) the estimate of the density (no. of fish per 100 m²) of salmon fry ranged from 2.63 fry in the upper Carradale Water (CWEF02) to 6.36 fry per 100 m² in the lower Rhonodale Burn (RBEF01) and 1.46 fry per m² in Abhainn Bheag (ABEF01) at the one site in a 2nd order channel where salmon were found. the estimate of the density (no. of fish per 100 m²) of salmon parr ranged from 0.88 parr in the upper Carradale Water (CWEF02) to 2.89 parr per 100 m² in Allt Deucheran (ADEF01) and 1.46 parr per m² in Abhainn Bheag (ABEF01) at the one site in a 2nd order channel where salmon were found.

Table 3.2.2 Estimates of Fish density (no. per 100 m²)

Site No.	Stream order	Salmon		Trout	
		Fry	Parr	Fry	Parr
CWEF01	3	6.26	2.09	0.00	0.00
CWEF02	3	2.63	0.88	0.88	0.00
CWEF03	3	0.00	2.81	0.94	0.94
NBEF01	3	0.95	0.00	0.95	0.95
RBEF01	3	6.36	0.00	2.83	1.41
RBEF02	3	0.00	0.00	9.75	0.00
ADEF01	3	0.00	2.89	0.96	3.85
ADEF02	2	0.00	0.00	0.00	3.52
ABLEF01	2	0.00	0.00	0.00	0.00
ABEF01	2	1.46	1.46	14.61	4.38
DBEF01	3	0.00	0.00	0.00	1.93
DBEF02	2	0.00	0.00	0.00	1.93
ACEF01	2	0.00	0.00	0.00	4.85
DAEF01	2	0.00	0.00	0.00	2.90
ASEF01	3	0.00	0.00	5.89	9.81

In the 3rd order stream channels (Table 3.2.2 and Figure 3.2.2) the estimate of trout fry density ranged from 0.88 fry in the upper Carradale Water (CWEF02) to 9.75 fry per 100 m² in the upper Rhonodale Burn (RBEF02). The estimate of trout parr density in 3rd order channels ranged from 0.94 parr in the upper Carradale Water (CWEF03) to 9.81 parr per 100 m² in Allt Sunadale (ASEF01). In 2nd order channels, trout fry density was 14.61 fry per m² in Abhainn Bheag (ABEF01) and the density of trout parr ranged from 1.93 parr per 100 m² in the Deucheran Burn (DBEF02) to 4.85 parr per 100 m² in Allt a Chaoruinn (ACEF01).

Fig. 3.2.2 Density estimates of juvenile fish (no. per 100 m²) fry and parr



3.2.3 Habitat at fish survey sites

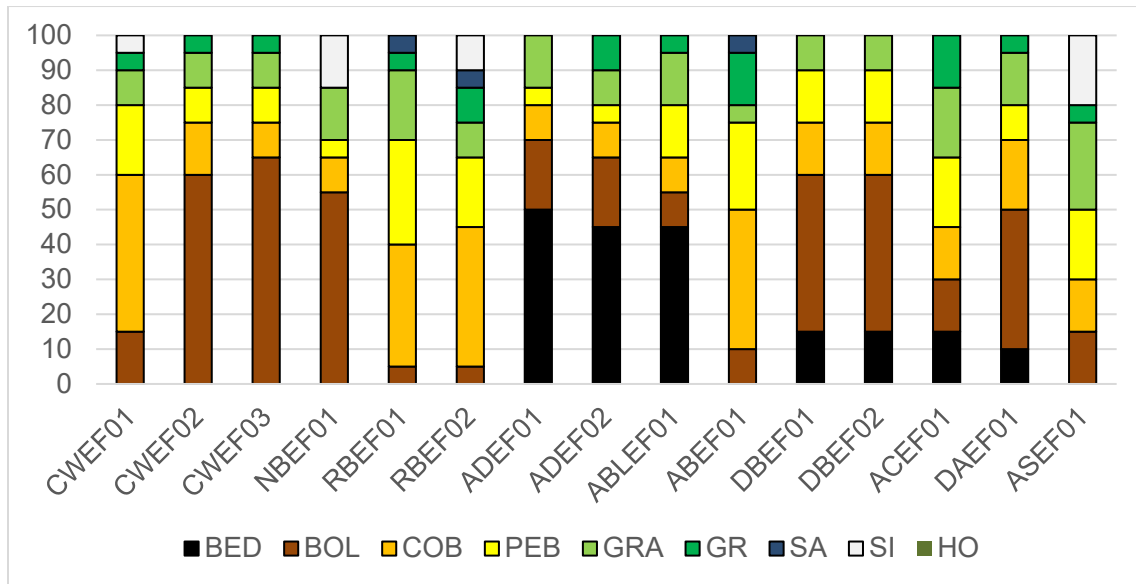
The proportion of riverbed substrates at survey sites (Table 3.2.3 and Figure 3.2.3) mostly consisted mostly of suitable coarse substrates, including boulder (BOL) cobble (COB), pebble (PEB) and gravel (GRA).

Table 3.2.3 Proportion of stream bed substrates (%) at survey sites

Site No.	BED	BOL	COB	PEB	GRA	GR	FI
CWEF01	0	15	45	20	10	5	5
CWEF02	0	60	15	10	10	5	0
CWEF03	0	65	10	10	10	5	0
NBEF01	0	55	10	5	15	0	15
RBEF01	0	5	35	30	20	5	5
RBEF02	0	5	40	20	10	10	15
ADEF01	50	20	10	5	15	0	0
ADEF02	45	20	10	5	10	10	0
ABLEF01	45	10	10	15	15	5	0
ABEF01	0	10	40	25	5	15	5
DBEF01	15	45	15	15	10	0	0
DBEF02	15	45	15	15	10	0	0
ACEF01	15	15	15	20	20	15	0
DAEF01	10	40	20	10	15	5	0
ASEF01	0	15	15	20	25	5	20

A higher proportion of less favourable bedrock (BED) were found at three sites: ADEF01, ADEF02 and ABLEF01 and fine (FIN) substrates, which consisted of silt, sand and organic material were present in smaller proportions.

Figure 3.2.3 Proportion (%) of stream bed substrates at survey sites



4. DISCUSSION

The findings of the fish and habitat surveys are discussed below in relation to the morphological channel type, channel resilience to change and the suitability of the habitat for salmonid fish, and the likely distribution of fish and freshwater pearl mussel.

4.1 River Channel type and resilience

The variation in morphological channel types found in the survey infer that some of the habitat where fish were found may be susceptible to change in relation to infrastructure development.

The reaches of the most sensitive fish habitat in the lower Rhonodale Burn (RB01) and a smaller patch of the Duecheran Burn (DB05) in type D channels in the Narrachan Burn (NB02), lower reaches of Abhainn Bheag (AB01) and Allt a' Bhaile (AAB01) in type C channels. The fish surveys suggest that sections RB01 and AB01 are the amongst the most important habitats for fish recruitment, while section AAB01 had a higher proportion of fine sediments which may be a result of road maintenance and or forestry works ongoing during the survey. Section DB05 is upstream of impassable waterfalls that prevent migratory salmonid fish from reaching the site but there are some productive habitats for fish downstream of the barrier.

The more resilient step-pool and plane bed channels (type B) were found in most habitat reaches. Fine sediments (mainly sand) were noted to be present on side bars and in sheltered spots behind boulders, suggesting that existing forestry and infrastructure may have some influence on the condition of these habitats. The most resilient bedrock and cascade channels (type A) were generally found where there was a higher gradient of fall along the channel which were generally less accessible to fish with a higher frequency of obstacles to fish passage and have a relatively low availability of spawning habitat. These habitats are less likely to be affected by changes in land use or an increase in the supply of fine sediments.

4.2 Fish habitat suitability and condition

While this survey found some existing signs of the active forestry land use with the watercourses, the habitats for fish appear generally productive. The release of fine sediment via the forest and agriculture drainage networks contribute to the deposition of fine sediment in the type B, C and D channels some of which appear to be generated upstream of the survey area in the upper reaches of Allt Chaltuinn and Narrachan Burn outside of the survey and development area. The clarity of the water during the survey was tainted by peat, making the assessment of the fine sediment in the wider and deeper channels less reliable. However, finer sediments are likely to be deposited

at the edges of the channel, so may be fairly represented by this study. In general, the larger coarse substrates appear relatively stable despite a higher frequency of flood flows experienced in recent years. The channel straightening (and possibly widening) found in sections AAB03 and DB07 are likely to reduce the condition and productivity of the habitat for fish. The stream bed substrates found at these sites mostly consisted of smaller fine or gravel substrates which also suggest the flow within the channel is unable to mobilise the current load of finer particles regularly, affecting the in-stream habitat for fish. Additionally, 1st order stream channels are also likely to become dry during drought conditions, making the presence of fish more unlikely when compared to larger 2nd, 3rd and 4th order stream channels surveyed where fish were found by this survey. The fish survey results indicate that fish are likely to inhabit much of the habitat surveyed in the 2nd, 3rd and 4th order channels that are accessible and have sufficient habitat complexity to support different age classes of salmonid fish. The composition of the substrates in these channels is better suited to spawning, incubation of eggs provide cover for the larger juvenile life-stages (fry and parr). These channels also have occasional pool habitats that older juveniles (parr) and adult trout may utilise as refuge.

4.3 Fish habitat connectivity and likely fish distribution

The major obstacles to fish movement influence the likely distribution of fish within the survey reaches. Fish population and habitat survey results suggest that salmon are present throughout the main channel of the upper Carradale Water and the Narrachan Burn and the larger tributaries: Rhonodale Burn, Allt Deucheran and Abhainn Bheag and sea trout were seen spawning in the lower section of the Drochaid Burn, downstream of an impassable waterfall during the survey and freshly made spawning redds were also found in Allt Chaltunn. The degraded condition of the culvert found at the downstream end of the survey reach on the Rhonodale Burn (RB01) may influence the connectivity of the productive habitat upstream, particularly if it continues to degrade and affects the results of future fish surveys. Therefore, the removal or replacement of the culvert is an opportunity for fisheries and the consistency of results of fish surveys. There is less potential for brown trout to inhabit the upper reaches of the tributary streams upstream of impassable obstacles. One exception may be the Drochaid Burn where there was a sufficient area of habitat, but no trout were found by the fish survey in the less suitable habitat.

4.4 Freshwater Pearl mussels

The types of stream channel and substrates found in both the upper Carradale Water and Narrachan Burn may have some potential to support freshwater pearl mussel, but none were

found by this survey. However, the stained water colour may have obscured any visible signs of mussels so the survey conditions may not be considered as being optimal for identifying mussels.

5. CONCLUSIONS

Interpretation of the data collected by the survey undertaken in autumn 2024 provides several conclusions.

- Fish and habitat surveys in the main channel of the upper Carradale Water and Narrachan burn found habitat that are suitable for Atlantic salmon and brown trout and may have some limited potential to support Freshwater pearl mussel. Juvenile salmon and trout were also found in the lower reaches of most tributary streams where there is suitable habitat.
- Fish and habitat surveys also suggest the recruitment of salmon may be affected by a degraded culvert on the Rhonodale Burn, which may influence the results of future surveys.

The condition of the habitats for salmonid fish are affected by the settlement of finer sediment which is likely to be due to forestry activity and road maintenance. The fine sediment is likely to reduce the productivity of the habitat for salmonid fish and the suitability of the habitat for freshwater pearl mussel.

- The lower gradient channel types found in a small proportion of the habitats surveyed are likely to be more susceptible to disturbance or change compared to the more moderate gradient channel types found in most of the habitat. The lower gradient channels may provide opportunity for ongoing monitoring of any potential effects of development in the future. Any development of infrastructure and land use should consider the prevention of disturbance of the more susceptible and sensitive channel types of the upper Barr Water where the most productive salmon habitat is also present.

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