Fish Habitat Survey of

Killean Wind Farm, Kintyre, Argyll, 2024

For further information on this report please contact:

Argyll Fisheries Trust
Cherry Park
Inveraray
Argyll
PA32 8XE
Telephone: 01499 302322
E-mail: info@argyllfisheriestrust.co.uk

This report should be quoted as:

Argyll Fisheries Trust (2024). Fish Habitat Survey of Killean Wind Farm, Kintyre, Argyll, 2024.

Fish Habitat Survey of Killean Wind Farm, Kintyre, Argyll, 2024.

Background

Argyll Fisheries Trust undertook surveys of fish habitat on the watercourses of two river catchments: Killean Burn and Tayinloan Burn at the proposed Killean wind Farm site on behalf of Renewable Energy Systems Limited.

Main findings

- The watercourses within proposed wind farm site are located upstream of the likely distribution of migratory salmonid fish (Atlantic salmon and sea-run brown trout. Therefore, any fish population present is likely to consist of resident brown trout and European eel.
- The survey found most of the stream habitat in smaller 1st order channels, including 18.6 % of habitat area in the Killean Burn and 11.8 % of habitat area is unsuitable for resident brown trout.
- A proportion of the 2nd and 3rd order channels are suitable for supporting populations of resident brown trout, including 33 % of habitat in the Killean Burn and 2.0 % of habitat area in the Tayinloan Burn.
- The suitable habitat consisted mostly of low-to moderate gradient plane-riffle and step-pool stream channel types with a mix of coarse substrates and suitable flow types.
- A proportion of the potentially suitable habitat in the Killean Burn was found to have been modified by channel straightening and dredging which is likely to affect the productivity of the habitat for fish.
- Brown trout may also utilise some less suitable habitat in both catchments which were mainly associated with step-pool and peat river channel types.
- No freshwater pearl mussels were found by the survey.

Acknowledgements

Argyll Fisheries Trust thanks Renewable Energy systems Limited and the landowners for the opportunity to undertake this assessment of fish habitats.

CONTENTS PAGE

LIST OF FIGURES PAGE

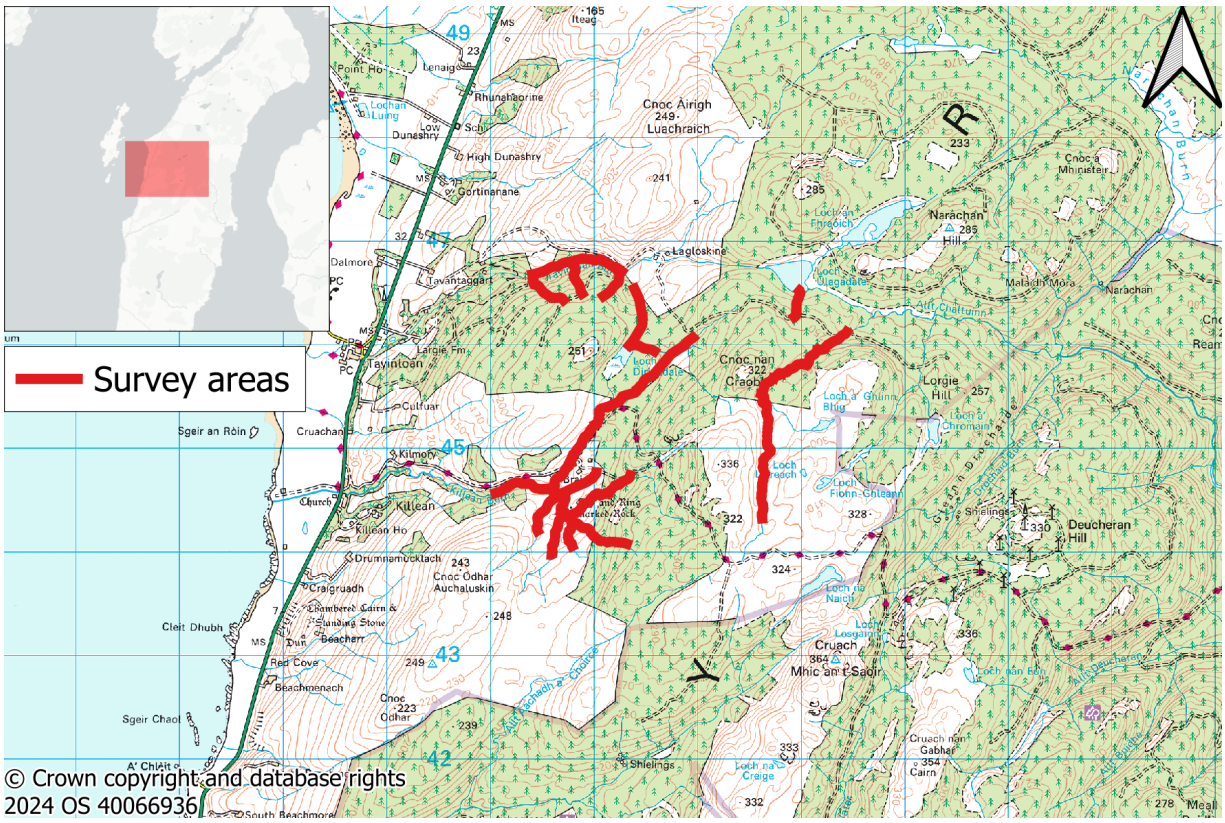
LIST OF TABLES PAGE

1. INTRODUCTION

To inform the development of infrastructure at a proposed wind farm site on the western side of the Kintyre peninsula, Argyll Fisheries Trust (AFT) undertook surveys of fish habitat in the two watercourses: the Killean Burn and Tayinloan Burn. The surveys were carried out in early June 2024.

The upper reaches of the Killean Burn (Fig. 1.1) flow from north-east to south-west that drains the western side of Cruach a' Bhodaidh (336m) and Cnoc nan Craobl (320m) and the headwaters of the Tayinlaon Burn drain the eastern side of these high points via a tributary: Allt Chaltuinn. Loch Dirigidale sites between the two catchments.

Fig. 1.1 Location of Killean wind Farm area

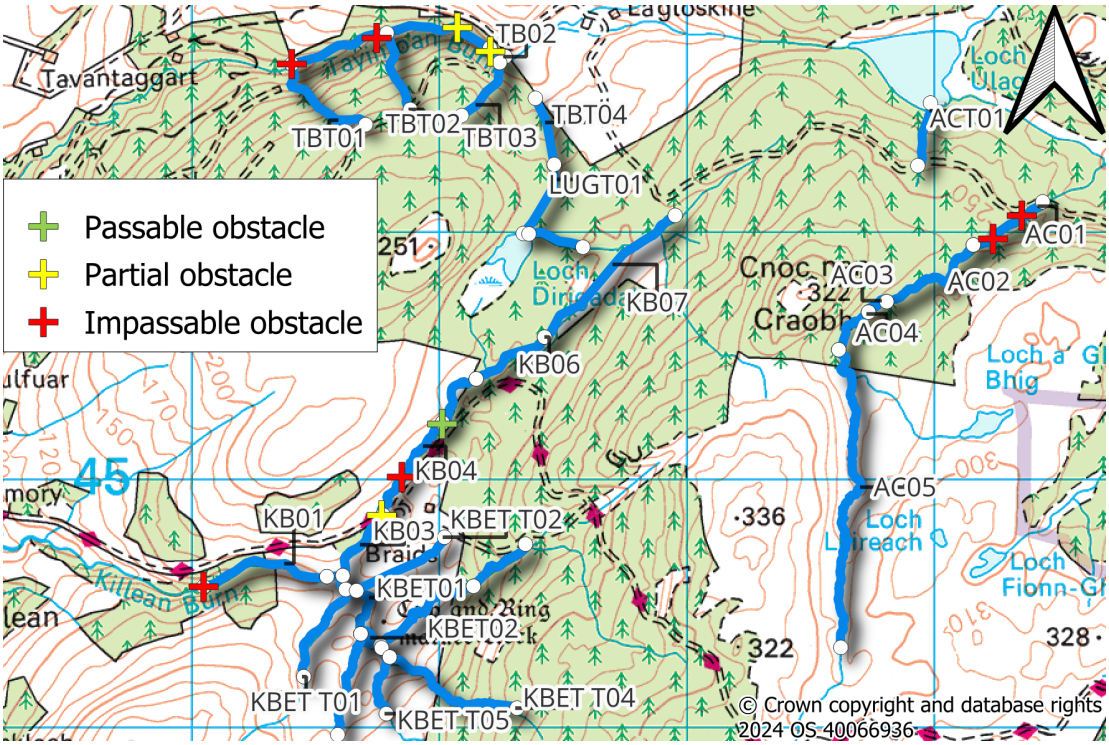


Land use within the proposed wind farm area is predominantly commercial forestry and farming of livestock on rough grassland. Active forestry operations influence much of the ground adjacent to headwaters, while rough grazing is present on much of the unnamed eastern tributary of the

Killean Burn and there are also established broadleaf woodland present along the main channel of the Killean Burn and the Tayinloan Burn within and downstream of the site.

Fisheries for migratory salmonid fish in the area are administered by the Argyll District Salmon Fishery Board. There are no known active fisheries operating in the Killean Burn or Tayinloan Burn catchment areas. The river reaches surveyed in the two catchments and the main obstacles to fish passage are shown in Figure 1.2.

Fig. 1.2 Survey reaches and main obstacles to fish passage



2. METHODS

The survey of fish habitat was focused on the stream channels adjacent to the existing forest road network and where new roads may be constructed. The methodology used to survey fish populations and fish habitat 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 12 survey sections are given in Appendix II.

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

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

2.2.2 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 2.2 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. Unstable or compacted substrates. Bankside cover for fish generally not present.
Less suitable		Low-to-Moderate gradient. Unstable or compacted substrates. Bankside cover for fish generally not present.
Unsuitable		High gradient. Bedrock substrate. 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).

Habitat that was potentially suitable for freshwater pearl mussels was also assessed according to those characteristics described by Nature.scot.

3 RESULTS

Results of the surveys are given separately for Killean Burn (section 3.1) and Tayinloan Burn (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 the text.

The habitat survey was undertaken on 30 sections of stream channel in two catchments (Table 3.0.1) totalling 0.283 Hectares area along 11.77 Km of stream length. The habitat survey of the Killean Burn was divided into three sections: the main channel of the Killean Burn (KB01-07), two small tributaries of Loch Dirigidale (LDG01-02) and an unnamed tributary (KBET01-04) and sub-tributaries (KBET T01-05) according to channel type and confluences of significant tributary streams. The three reaches totalled 6.799 Km stream length which covered 0.823 Hectares of habitat (61.5 % of all habitats surveyed). The survey of the Tayinloan Burn was divided into three reaches: The main channel of Tayinloan Burn (TB01-02), its tributaries (TBT01-04) and the major tributary of Allt Chaltuinn (AC01-05) and a small tributary of Loch Ulagadale (ACT01) along 4.996 Km stream length which covered 0.515 Hectares of habitat (38.5 % of habitats surveyed).

Table 3.0.1 Summary of habitat survey sections, length (Km) and area (Ha)

Watercourse	Section ID	No. Sections	Length (Km)	Area (ha)	Area (%)
Killean Burn	KB, LDG, KBET	18	6.799	0.823	61.5
Tayinloan Burn	TB, AC	12	4.966	0.515	38.5
Total		30	11.765	1.338	100
Favourable Habitat		7	1.898	0.283	35.2

The Strahler stream order of habitats surveyed in the Killean Burn catchment (Table 3.0.2) consisted of seven 1st order channel sections along 2.71 Km of stream length (18.6 % of habitat area), nine sections of 2nd order channels along 3.47 Km (54.5 % of habitat area) and two 3rd order channel sections along 0.62 Km of stream length (26.9 % of habitat area). In the Tayinloan Burn catchment, the Strahler stream order of habitats surveyed consisted of five 1st order channel sections along 1.52 Km of stream length (11.8 % of habitat area), five sections of 2nd order channels along 2.47 Km (39.8 % of habitat area) and two 3rd order channel sections along 0.97 Km of stream length (48.5 % of habitat area).

Table 3.0.2 Summary of Strahler stream order length (Km) and area (Ha)

Killean Burn					Tayinloan Burn				
Stream Order	No. Sections	Length (Km)	Area (Ha)	Area (%)	Stream Order	No. Sections	Length (Km)	Area (Ha)	Area (%)
1	7	2.707	0.153	18.60	1	5	1.521	0.069	11.79
2	9	3.472	0.449	54.53	2	5	2.473	0.231	39.75
3	2	0.620	0.221	26.86	3	2	0.972	0.282	48.46
4	0	0.000	0.000	0.00	4	0	0.000	0.000	0.00
Total	18	6.799	0.823	100	Total	12	4.966	0.582	100

3.1 Killean Burn

The results of the habitat survey coverage are summarised below for the main channel and tributaries of the Killean Burn in terms of the stream channel characteristics (section 3.1.1) and suitability of the habitat for salmonid fish (section 3.1.2).

3.1.1 Stream channel characteristics

Stream channel width in main channel of the Killean Burn was 0.7 meters (section KB07) in small 1st order streams channels, between 1.0 and 2.0 meters in 2nd order stream channels (sections KB03 to KB06) and between 3.5 m and 4.0 m in larger 3rd order stream channels (KB01 and KB02).

The type of river channel found (Table 3.1.1 and Figure 3.1.1) in the main channel of the Killean Burn consisted mostly of higher gradient habitat (34.4 % of habitat area) that was generally resilient to change (type A). Riverbed substrates in sections AB01 (Figure 3.1.1.1) and AB04 (Fig. 3.1.1.2) consisted mostly of bedrock and boulder and turbulent flows.

Table 3.1.1 Killean Burn channel sensitivity class, channel type, length (Km) area (Ha) and stream order

Section ID (stream order)	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Gradient (m/100 m)
KB01 (3)	Bedrock / Step-pool	A/B	0.540	3.5	3.5	0.189	22.97	4.26
KB02 (3)	Plane-riffle	C	0.080	4.0	4.0	0.032	3.89	1.25
KB03 (2)	Step-pool	B	0.352	2.0	2.0	0.070	8.56	3.13
KB04 (2)	Bedrock / Step-pool	A	0.471	2.0	2.0	0.094	11.45	3.82
KB05 (2)	Peat (mod)	F	0.269	1.5	1.5	0.040	4.90	1.12
KB06 (2)	Plane-riffle (mod)	C	0.344	1.0	1.0	0.034	4.18	2.03
KB07 (2)	Peat (mod)	F	0.734	0.7	0.7	0.051	6.25	0.82
LDG01 (1)	Peat / Step-pool	F/B	0.286	0.4	0.4	0.011	1.39	5.24
LDG02 (1)	Peat / passive meander	F	0.190	0.3	0.3	0.006	0.69	1.58
KBET01 (2)	Plane-riffle / step-pool	C/B	0.346	1.8	1.8	0.062	7.57	0.87
KBET02 (2)	Step-pool	B	0.148	1.4	1.4	0.021	2.52	2.70
KBET03 (2)	Step-pool / bedrock	B/A	0.514	1.0	1.0	0.051	6.25	3.31
KBET04 (2)	Bedrock / Step-pool	A/B	0.294	0.8	0.8	0.024	2.86	9.52
KBET T01 (1)	Peat / Step-pool	F/B	0.414	0.6	0.6	0.025	3.02	2.90
KBET T02 (1)	Peat / Step-pool	F/B	0.429	0.5	0.5	0.021	2.61	5.13
KBET T03 (1)	Peat / Step-pool	F/B	0.463	0.7	0.7	0.032	3.94	2.59
KBET T04 (1)	Peat / Step-pool	F/B	0.674	0.7	0.7	0.047	5.73	11.42
KBET T05 (1)	Peat / Step-pool	F/B	0.251	0.4	0.4	0.010	1.22	8.76
Killean Burn			6.799			0.823	100.000	
Favourable habitat			1.784			0.271	32.964	

Fig. 3.1.1 *Killean Burn stream channel sensitivity classification*

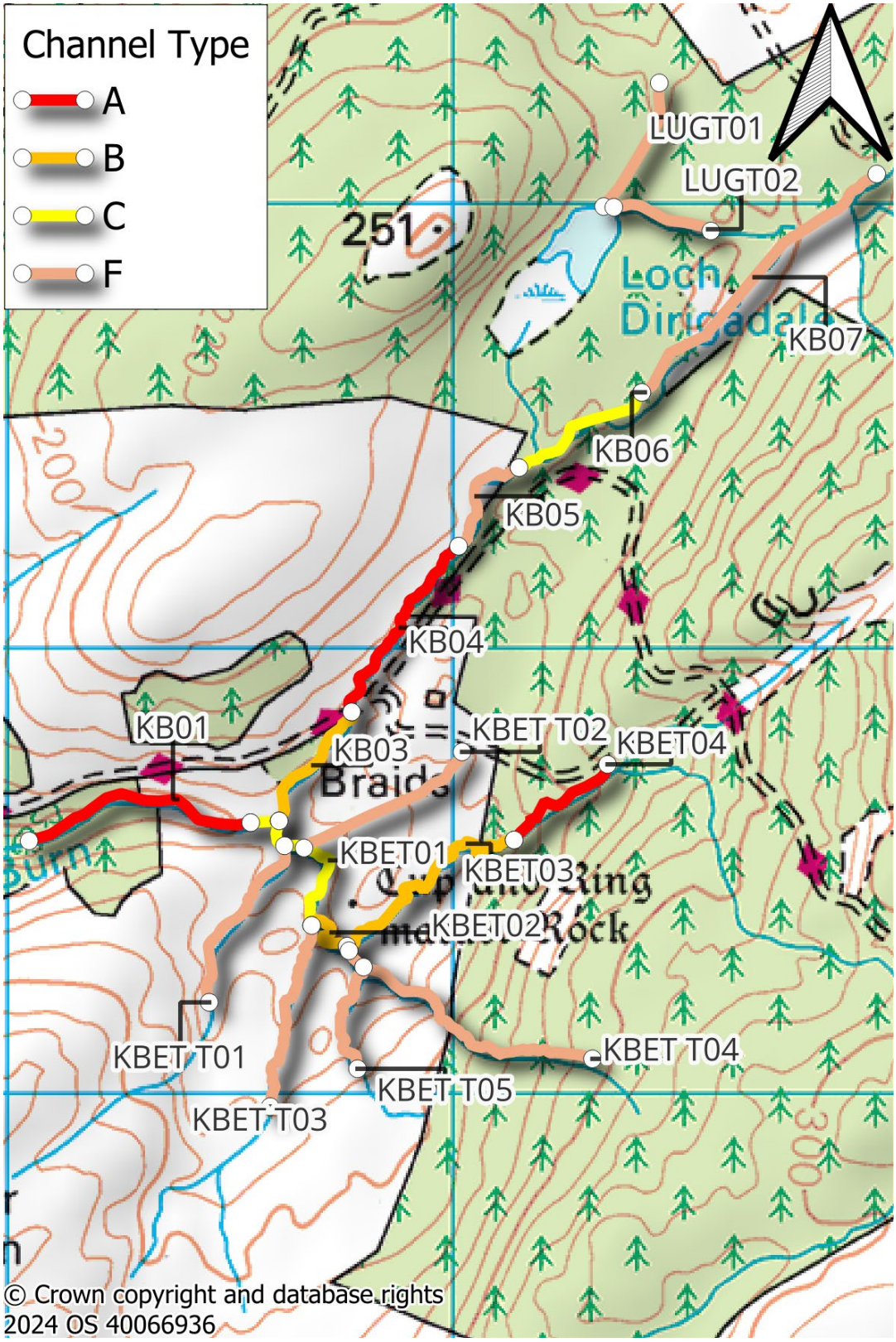


Fig.3.1.1.1 KB01 Bedrock / Step-pool channel

Fig.3.1.1.2 KB04 Bedrock / Step-pool channel

A mix of modified (straightened and dredged) low gradient passive peat river channels (type F) which are less sensitive to disturbance (11.5 % of habitat area) was found in two sections: KB05 (Figure 3.1.1.3) and KB07 (Figure 3.1.1.4).

Fig.3.1.1.3 KB05 Passive peat river channel (modified)

Fig.3.1.1.4 KB07 Passive peat channel (modified)

A smaller proportion of moderate gradient step-pool channel (type B) form 8.6 % of the habitats in one section (KB03, Figure 3.1.1.5) that are resilient to disturbance. Less resilient lower gradient plane-riffle channels (type C) were found in two survey sections (KB02 and KB06) forming 8.1 % of habitat in (Figure 3.1.1.6).

Fig.3.1.1.5 KB03 Step-pool channel

Fig.3.1.1.6 KB02 Plane-riffle channel

The type of river channel found in the unnamed major tributary to the Killean Burn consisted mostly of low-to-moderate gradient peat channels (five sections: KBET T-01 to T05) with patches of step-pool type channels where gradient increased (16.5 % of habitat area) which are generally resilient to disturbance (Figures 3.1.1.7 to 3.1.1.10).

Fig.3.1.1.7 KBET-T01 Peat / Step-pool channel

Fig.3.1.1.8 KBET-T02 Peat / Step-pool channel

Fig.3.1.1.9 KBET-T03 Peat / Step-pool channel

Fig.3.1.1.10 KBET-T04 Peat / Step-pool channel

In the main channel of the tributary, a mix of channel types were found, including less resilient plane-riffle channel (type C) in section KBET01 (Figure 3.1.1.11, 7.6 % habitat area), and more resilient step-pool channel (type B) in section KBET02 (Figure 3.1.1.12, 2.5 % of the habitat area), step-pool and bedrock channel (type B/A) in section KBET03 (Figure 3.1.1.13, 6.3 % of habitat area) and bedrock channel in section KBET04 (Figure 3.1.1.14, 2.9 % habitat area).

Fig.3.1.1.11 KBET01 Plane-riffle channel

Fig.3.1.1.12 KBET02 Step-pool channel

Fig.3.1.1.13 KBET03 Step-pool / bedrock channel

Fig.3.1.1.14 KBET04 Bedrock / step-pool channel

In the two tributaries to Loch Dirigidale (Figure 3.1.1.15), the channel type consisted of step-pool (LDG01, type F/B, Figure 3.1.1.6) in 1.4 % of all habitat and Peat channel (LDG02, type F) in 0.7 % of the habitat.

Fig.3.1.1.15 Loch Dirigidalel

Fig.3.1.1.16 LDG01 Step-pool channel

3.1.2 Suitability of fish habitat

The survey of the Killean Burn found six survey sections (34.9 % of habitat area) that were assessed as being suitable for juvenile salmonid fish in type C and type B channels (shaded orange and yellow) in Table 3.1.2.1 and Figure 3.1.2.1). The habitat that is less suitable for salmonid fish was found in nine survey sections (28.9 % of habitat) including type F channels (shaded beige) and three sections of unsuitable habitat (36.2 % of habitat) in type A channels.

Channel Type	No. Sect.	Length (Km)	Area (Ha)	Area (%)
A	3	1.305	0.307	36.20
B	3	1.014	0.167	19.72
C	3	0.770	0.129	15.19
D	0	0.000	0.000	0.00
F	9	3.710	0.245	28.89
Total	18	6.799	0.847	100
Suitable	6	1.78	0.296	34.91

Table.3.1.2.1 Proportion of suitable habitat for salmonid fish

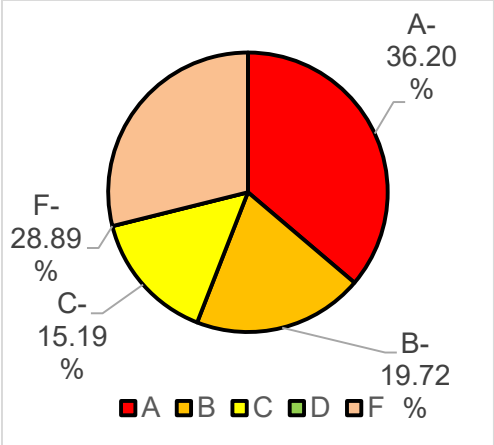


Fig.3.1.2.1 Suitability of fish habitat (% of area)

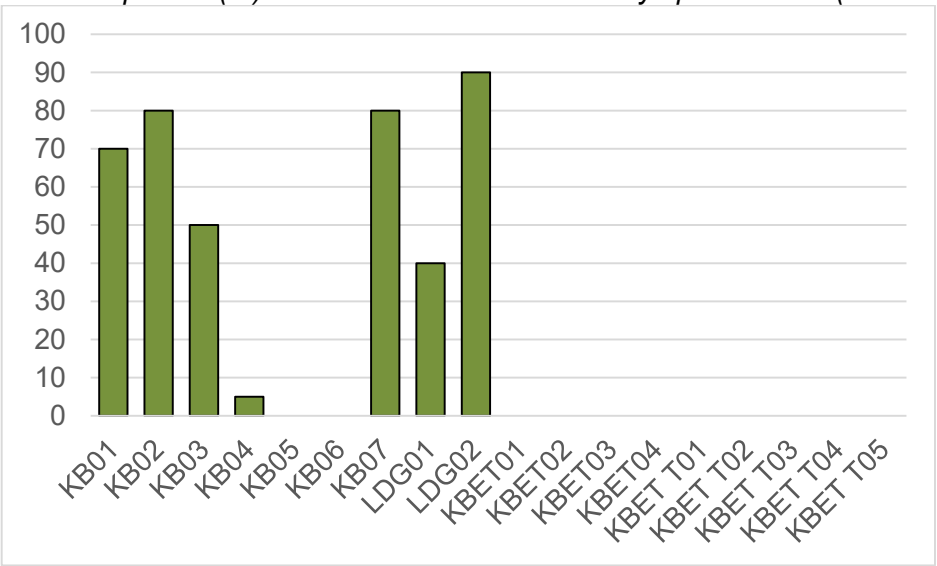
The less suitable habitat for fish in step-pool channel sections (type B) in the main river (KB03) and the main tributary (KBET02 and KBET03) consisted mostly of patches of mixed streambed substrates between boulder and bedrock steps that form a mix of deeper pools and shallower runs. The suitable habitat for fish in plane riffle channel sections (type C) in the main river (KB02 and KB06) and the main tributary (KBET01) consisted mostly of shallow pools and riffles with mixed streambed substrates with patches of spawning habitat (Figure 3.1.2.2). Some of this suitable habitat (KB06) had been modified (straightened) in the past and the riverbed substrates placed on the riverbank top to form an embankment (Figure 3.1.2.3).

The riparian (bankside) habitat for fish in the Killean Burn was mostly limited to bare bank faces in peat and bedrock channels (type F, type A and modified type C channels) with little or no cover provided for fish. The vegetation on the riverbanks mostly consisted of grasses and a few shrubs except for sections KB01 to KB04 on the main channel where some mature broadleaf trees are present (range 5 to 80 % of the channel) and section KB07, LDG01 and LDG02 where shade is provided by mature conifer trees (range 40 to 90 % of the channel).

Fig.3.1.2.2 KBET01 Mixed juvenile habitat

Fig.3.1.2.3 KB06 spawning site

Fig. 3.1.2.4 Proportion (%) of the river channel shaded by riparian trees (Killean Burn)



In addition to the known obstacles to migratory fish found downstream of the survey site, a total of four obstacles to upstream passage of brown trout were identified in the habitat suitable for fish which fragment the habitat between section KB03 and KB06 in the main channel.

A board (dam) placed across the stream at the upstream end of the culvert in section KB03 (Figure 3.1.2.5) and a waterfall and cascade in section KB04 (Figure 3.1.2.6) are likely to prevent the upstream passage of fish.

Fig. 3.1.2.5 Impassable obstacle KB03-01 (dam at upstream end of track culvert)

Fig. 3.1.2.6 Impassable obstacle KB04-01 (waterfall and cascade obstacle)

Obstacles to fish migration are more frequent in the tributaries (KBET T01 – T05 and LDG01 – 02) where fish habitat is less suitable and therefore less likely to affect any fish present in the larger stream channels.

3.2 Tayinloan Burn

The results of the habitat survey coverage are summarised below for the main channel and tributaries of the Tayinloan Burn in terms of the stream channel characteristics (section 3.2.1) and suitability of the habitat for salmonid fish (section 3.2.2).

3.1.1 Stream channel characteristics

The type of river channel found (Table 3.2.1 and Figure 3.2.1) in the main channel of the Tayinloan Burn consisted mostly of higher gradient habitat (68.5.4 % of habitat area) in seven of the 12 survey sections that was generally resilient to change (type A) including sections TB01 (Figure 3.2.1.1) and AC01 (Fig. 3.2.1.2) where bedrock and boulder substrates and turbulent flows are most common.

Table 3.2.1 Tayinloan Burn channel sensitivity class, channel type, length (Km) area (Ha) and stream order

Section ID (stream order)	Channel Type	Class	Length (Km)	Wet width (m)	Bed width (m)	Area (ha)	Area (%)	Gradient (m/100 m)
TB01 (3)	Bedrock / Cascade	A	0.876	3.0	5.0	0.263	50.99	5.71
TB02 (3)	Peat / passive meander	F	0.096	2.0	2.0	0.019	3.73	1.04
TBT01 (1)	Bedrock / Cascade	A	0.373	0.5	0.7	0.019	3.62	20.11
TBT02 (1)	Bedrock / Cascade	A	0.334	0.5	0.6	0.017	3.24	16.47
TBT03 (1)	Cascade / step-pool	A/B	0.262	0.3	0.3	0.008	1.52	19.85
TBT04 (1)	Cascade / step-pool	A/B	0.294	0.6	0.6	0.018	3.42	11.22
ACT01 (1)	Cascade / step-pool	A/B	0.258	0.3	0.3	0.008	1.50	12.40
AC01 (2)	Bedrock / cascade	A	0.337	2.0	4.0	0.067	13.08	8.90
AC02 (2)	Peat / step-pool	F/B	0.494	1.5	1.5	0.074	14.38	1.01
AC03 (2)	Step-pool	B	0.114	1.0	1.0	0.011	2.21	4.39
AC04 (2)	Peat	F	0.199	0.6	0.6	0.012	2.32	1.01
AC05 (2)	Peat / step-pool	F/B	1.329	0.5	0.5	0.066	12.89	1.73
Tayinloan Burn			4.966			0.515	100	
Favourable habitat			0.114			0.011	2.212	

Fig. 3.2.1 Tayinloan Burn stream channel sensitivity classification

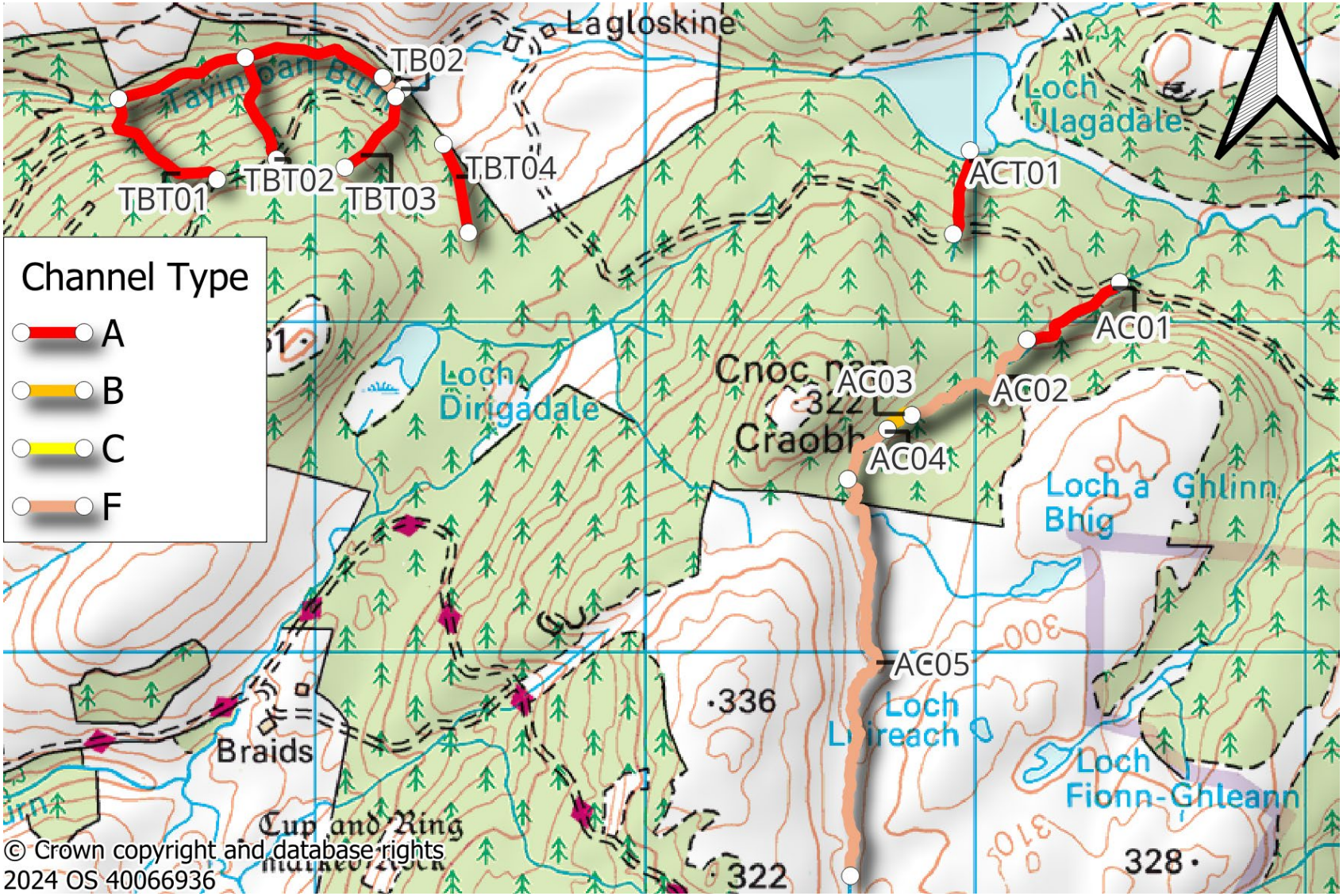


Fig.3.2.1.1 TB01 Bedrock / Step-pool channel

Fig.3.2.1.2 AC01 Bedrock / Step-pool channel

There were no accessible fish habitats in the smaller 1st order tributary channels that were also of higher gradient (type A): TBT01, TBT02, TBT03, TBT04 and ACT01. A mix of low gradient passive channels that are entrenched into peatland (type F) which are also less sensitive to disturbance (29.5 % of habitat area) in four sections including TB02 (Figure 3.2.1.3) and AC02 (Figure 3.2.1.4), AC04 (Figure 3.2.1.5), and AC05.

Fig.3.2.1.3 TB02 Passive meander peat channel

Fig.3.2.1.4 AC02 Passive entrenched peat channel

A smaller proportion of moderate gradient step-pool channel (type B) form 2.0 % of the habitats in one section (AC03, Figure 3.2.1.6) that are resilient to disturbance. Less resilient lower gradient channels (class C and D) were not found in the Tayinloan Burn survey area.

Fig.3.2.1.5 AC04 entrenched peat channel

Fig.3.2.1.6 AC02 Step-pool channel

Stream channel width in the Tayinloan Burn was 0.3 to 0.6 meters in small 1st order channels, between 1.5 and 2.0 meters in 2nd order channels (sections AC01 to AC02) and between 2.0 m and 5.0 m in larger 3rd order channels (TB01 and TB02).

3.2.2 Suitability of fish habitat

The survey of the Tayinloan Burn found one survey section (2.0 % of habitat area) that were assessed as being suitable for juvenile salmonid fish (type B, shaded orange in Table 3.2.2.1 and Figure 3.2.2.1). The habitat that is also less suitable for salmonid fish included four survey sections (29.5 % of habitat) in type F channels (shaded beige). There were also seven sections of unsuitable habitat (68.5 % of habitat) in type A channels. The less suitable habitat for fish in the step-pool channel section (type B) in Allt Chaltuinn (AC02) consisted mostly of patches of mixed streambed substrates between boulder and bedrock steps that form a mix of deeper pools and shallower runs.

Channel type	No. Sect.	Length (Km)	Area (Ha)	Area (%)
A	7	2.734	0.399	68.53
B	1	0.114	0.011	1.96
C	0	0.000	0.000	0.00
D	0	0.000	0.000	0.00
F	4	2.118	0.172	29.51
Total	12	4.966	0.582	100

Table.3.2.2.1 Suitability of habitat for salmonid fish

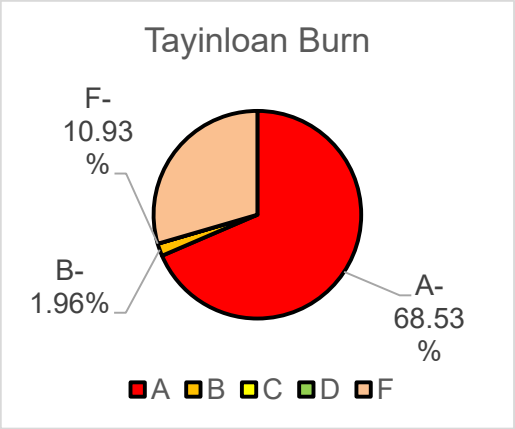


Fig.3.2.2.1 Suitability of fish habitat (% of area)

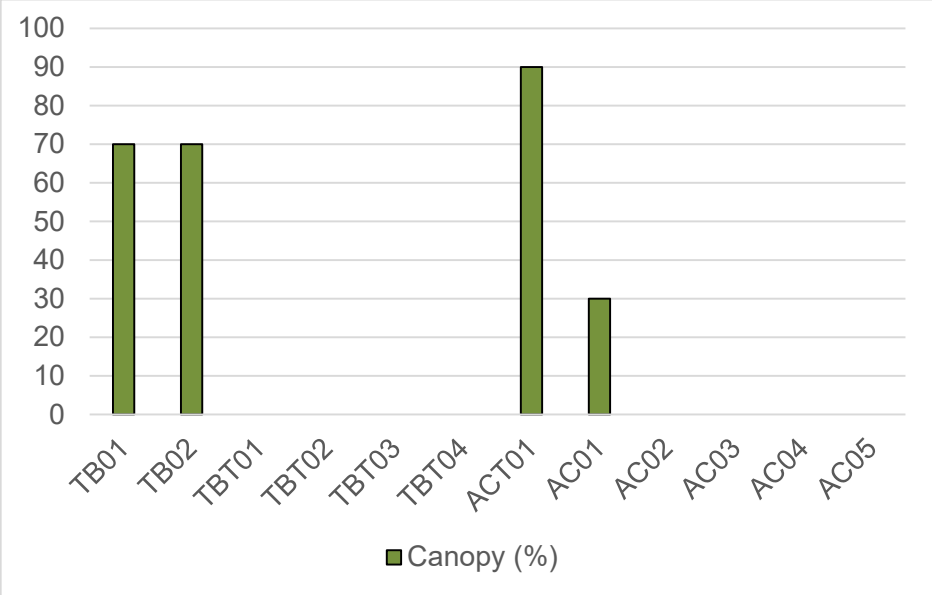
The less suitable habitat for fish in peat channel sections (type F) in the main river (TB02) and Allt Chaltuinn (AC02, and AC04 to AC05) consisted mostly of long deep glides within entrenched channels with short boulder steps and streambed substrates consisted of mixed smaller substrates, fine sediments (peat) and vegetation (Figure 3.2.2.2).

The riparian (bankside) habitat for fish in the Tayinloan Burn was mostly limited to bare bank faces in peat channels (type F), with little or no cover provided for fish. The vegetation on the riverbanks mostly consisted of grasses and a few shrubs except for sections TB01 and AC01 where some mature broadleaf trees are present (range 30 to 70 % of the channel). The riparian habitat in the tributaries consisted of clear-felled conifer plantation in sections TBT01, TBT02, TBT03 and TBT04 (Figure 3.2.2.2) or mature conifer trees in section ACT01 (Figure 3.2.2.3).

Fig.3.2.2.2 Standing and clear-fell forestry (TB01 and TBT01-03)

Fig.3.2.2.3 Mature forest plantations in the Tayinloan catchment

Fig. 3.2.2.4 Proportion (%) of the river channel shaded by riparian trees (Tayinloan Burn)



In addition to the known obstacles to migratory fish found downstream of the survey site, a total of four obstacles to upstream passage of brown trout were identified in the habitat suitable for fish which fragment the habitat in sections TB01 (Figure 3.2.2.5) and AC01 (Figure 3.2.2.6).

Fig. 3.2.2.5 Impassable obstacle TB01-01 (Bedrock waterfall)

Fig. 3.2.2.6 Impassable obstacle AC01-03 (waterfall obstacle)

4. DISCUSSION

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

4.1 Morphological characteristics and stream channel resilience

The variation in morphological channel types found by the survey found that some of the habitats surveyed may be susceptible to change in relation to infrastructure development and the use of water and land use.

The most resilient river channels (type A) were found in three survey sections of the 2nd and 3rd order stream channels in the Killean Burn and seven survey sections of the Tayinloan Burn in 1st, 2nd and 3rd order stream channels which make up a large proportion of the fish habitat (36.2 and 68.5 % of habitat area respectively).

Resilient Peat and passive meander channels (type F) were found in nine survey sections of the 1st and 2nd order stream channels in the Killean Burn and four survey sections of the Tayinloan Burn in 2nd and 3rd order stream channels which make up nearly a third of the fish habitat (28.9 and 29.5 % of habitat area respectively).

The moderately resilient stream channels (type B) were found in three sections of the Killean Burn and one section of the Tayinloan Burn in 2nd order stream channels which make up a smaller proportion of fish habitat (19.7 and 2.0 % respectively.

The lower gradient stream channels which are less resilient to disturbance (class C) were found in three sections of the 2nd and 3rd order stream channels of the Killean Burn which make up the smallest proportion of the habitats surveyed (15.2 %).

Activities associated with wind farm development are likely to consist of the upgrading of existing roads, the construction of new roads, stream crossings and other excavation works, and associated drainage network. Such works have potential to affect both the resilience and condition of stream banks and the riverbed.in the two catchments. The survey results suggest that most of the habitat surveyed is resilient to change (class A and class F) in the Killean Burn (67.0 %) and the Tayinloan Burn (98.0 %) in the bedrock and peat channels. The survey results suggest that

the most susceptible channels in terms of fish habitat and channel resilience are situated close to the existing forest road network in the main channel and lower part of the eastern tributary of the Killean Burn and therefore further development need to consider potential effects on fish habitats. The survey found that, in places, these favourable habitats for fish have undergone some morphological changes in the past. Channel straightening, removal of stream bed substrates (dredging) which now form raised embankments in the upper reach of the Killean Burn (KB05-KB07) are likely to have degraded the quality and productivity of the habitat for fish (if present), although there are some signs of recovery in one section (KB06) where riverbed substrates appear to be accumulating to form natural riffle and glide flow sequences.

4.2 Fish habitat suitability and condition

In general, the 1st order stream channels surveyed in both catchments consisted of a mix of peat (type F) and bedrock or cascade river channels (type A) that are less suitable for fish. Typically, the stream bed substrates found in small type F channels mostly consisted of smaller fine sediment or gravel substrates suggesting that there is little or no supply of coarse substrate into the channel. Additionally, these channels mostly erode their bed material and have heavily undercut banks which limit the access of flood flows onto the floodplain, which may reduce potential cover for fish in high flow events. The bedrock substrate and or torrential flows associated with type A channels also limit the cover for fish except where deep pools are formed or where patches of coarse substrates can accumulate. Additionally, 1st order stream channels are also likely to become dry during drought conditions, making the permanent presence of fish more unlikely when compared to larger 2nd and 3rd order stream channels.

The type B and C channels found in 2nd and 3rd order streams generally form more favourable habitat for salmonid fish which have sufficient coarse riverbed substrates and have sufficient water discharge and habitat complexity to support different age classes of trout. The composition of the substrates in these channels is better suited to spawning, incubation of eggs and provide cover for the larger juvenile life-stages (fry and parr). The less favourable habitat for fish found in type F channels in the 3rd order channel (such as KB05, KBET T01, TB02 and AC02) may have sufficient resources to support resident brown trout as some small coarse substrates were present. However, these potentially favourable habitats may be disconnected into smaller patches where obstacles to fish migration are frequent, which may reduce potential for populations of trout to be maintained.

4.3 Fish habitat connectivity and likely fish distribution

The obstacles to fish migration found by the survey suggest the habitat surveyed is isolated by significant obstacles to fish migration in sections KB01 and TB01 and migratory salmonids (Atlantic salmon ad sea-run brown trout) will not be present. However, European eel may by-pass such obstacles overland and therefore may potentially be present upstream of these obstacles.

Within the survey area, a man-made obstacle found at the upstream end of the track culvert (in section KB03) and natural obstacles further upstream (in section KB04) may limit access of resident brown trout into more favourable habitat (in section KB06). Similarly, natural obstacles in sections AC01 may isolate any trout populations present downstream and upstream of the obstacles found in this section of the Tayinloan Burn.

4.4 Freshwater Pearl mussels

The types of stream channel found in most survey sections by the survey have little potential to support populations of freshwater pearl mussel. The compacted substrate found in most peat channels and few stable substrates found in bedrock channels, suggest that they are unsuitable for mussels. The searches conducted in smaller patches of potentially favourable substrate in plane riffle and step pool channel types did not find any mussels which suggest that there is limited potential for these habitats to support freshwater pearl mussels. Additionally, the modifications (channel straightening, dredging and embankment) are likely to have reduced the likelihood of pearl mussels being present within these channels.

5. CONCLUSIONS

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

- The location of likely obstacles to fish migration at the downstream end of the survey site indicate that any fish population present is likely to be limited to resident brown trout and European eels. Obstacles to fish migration found within the survey area are likely to fragment or limit the distribution of trout.

- Suitable habitat for brown trout is likely to be limited to 2nd and 3rd order stream channels where there are suitable riverbed substrates. Most of the habitat within 1st order streams are less likely to support populations of brown trout.

- The condition of the likely habitat for trout found by the survey may be affected by existing land use (Forestry and livestock grazing) and some habitat has been modified (straightened and dredged) to improve land drainage.

- Channel type and the riverbed substrates found by the survey are likely to reduce the suitability of the habitat for freshwater pearl mussel.

- The suitable habitat where trout were found is mostly adjacent to the existing forest road network. Any development of the infrastructure and land use should consider the prevention of disturbance of stream habitats, the riparian vegetation and ensure stream crossings allow for the passage of fish in both upstream and downstream directions.

6. REFERENCES

Armstrong, J., Kemp, P.S., Kennedy, G.J.A., Ladle, M. and Milner, N.J. (2003) Habitat requirements of Atlantic salmon and brown trout in rivers and streams. *Fisheries Research*, 62, (2), 143-170. (doi:10.1016/S0165-7836(02)00160-1).

Hastie, C. L., Boon, P.J. and Young, M.R. (2000). Physical microhabitat requirements of freshwater pearl mussels (*Margaritifera margaritifera*). Hydrobiologia. **429**. 59-71.

Maitland, P. and Campbell, N. (1992). Freshwater Fishes of the British Isles. Harper Collins.
Scottish Fisheries Coordination Centre (2007). Electrofishing survey training course manual. FRS, Pitlochry, pp 1-64.

Malcolm IA, Millidine KJ, Glover RS, Jackson FL, Millar CP, Fryer RJ. 2019a. Development of a large-scale juvenile density model to inform the assessment and management of Atlantic salmon (Salmo salar) populations in Scotland. Ecological Indicators 96: 303–316 DOI: 10.1016/J.ECOLIND.2018.09.005

Malcolm IA, Millidine KJ, Jackson FL, Glover RS, Fryer RJ. 2019b Assessing the status of Atlantic salmon (Salmo salar) from juvenile electrofishing data collected under the National Electrofishing Programme for Scotland (NEPS) Scottish Marine and Freshwater Science Vol 10 No 2.

Scottish Fisheries Coordination Centre (2007b). Habitat survey training course manual. MSS, Pitlochry, pp 1-64

Scottish Natural Heritage (2010), Freshwater Pearl Mussel Survey Protocol, SNH www.snh.gov.uk/docs/A372955.pdf

SNIFFER (2006). A new impact assessment tool to support river engineering regulatory decisions. WFD49 (Rivers) Final Technical Report.

Strahler, A. N. (1952), "Hypsometric (area-altitude) analysis of erosional topology", Geological Society of America Bulletin, **63** (11): 1117–1142, doi:10.1130/0016-7606(1952)63[1117:HAAOET]2.0.CO;2.

Appendix I – Geomorphic Summary of river channel type (SNIFFER, 2006)

Channel type	Geomorphic Description	Sensitivity Class
Bedrock channels	Most commonly found in upland areas, though bedrock lined reaches can occur in certain lowland environments. They generally contain little, if any, bed sediment and have limited hydraulic connection with the riparian zone. Channel gradients tend to be high, resulting in a high transport capacity but limited sediment supply. These factors, together with the high degree of bank strength, result in quite stable channels.	A
Cascades	Are restricted to upland areas with steep slopes and are characterised by disorganised bed material typically consisting of cobbles and boulders constrained by confining valley walls. The riparian zone is usually extremely small in extent and interactions with the channel are limited. The large size of bed and bank material, together with high levels of energy dissipation due to the bed roughness, dictates that the largest bed load only becomes mobile in extreme floods (ca. >25 year return interval). Bedrock outcrops are common, and small pools may be present among the boulders.	A
Step-pool channels:	Has a steep gradient and consists of large boulder clasts which form discrete sediment accumulations across the channel, forming a series of “steps” which are separated by intervening pools containing finer sediment (typical spacing 1-4 channel widths). The stepped channel morphology results in zones of turbulence interspersed by more tranquil flows. As with cascade reaches, the high degree of channel roughness, and large sediment on the channel bed and banks results in stable channels that respond only in very large flood events. The stream is generally confined by the valley sides, and there is little/limited development of terraces or floodplain.	B
Plane bed channels:	Generally moderate gradient streams with relatively featureless gravel/cobble beds, but include units ranging from glides, riffles and rapids. Sediment size and channel gradients are smaller than step-pool channels and deeper pool sections tend to be lacking. The river bed is generally armoured and, thus, mobilized in larger floods. Although channels are typically stable, they are more prone to channel change than any of the preceding channel types. Thus, with relatively more frequent bedload movement, they represent transitional channels between the more stable types listed above and the following more dynamic types of channel. Channels are generally straight and may be confined or unconfined by the valley sides. However, the banks- which generally comprise material resistant to lateral migration- constrain the channel from migrating laterally and developing alternate bars/riffles.	B
Pool-riffle and Plane-riffle channels:	Meandering and unconfined channel that, during low flow, are characterised by lateral oscillating sequences of bars, pools and riffles, resulting from oscillations in hydraulic conditions from convergent (erosive) to divergent (depositional) flow environments (typical spacing 5-15 channel widths). The gradient of such channels is low-moderate and the width depth ratio high. The bed is predominatly gravel, with occasional patches of cobbles and sand. Accumulation of sediments in gravel bars indicates increasingly transport-limited conditions, though most large floods will produce some bedload movement on an annual basis, thus reducing the stability of the channel. In such channels, interactions between the stream and the riparian zone become more obvious with extensive over bank flood flows and wetland areas often characterising the riparian zone. The banks are typically resistant to erosion, and lateral migration of the channel is limited, resulting in relatively narrow and intermittently deep channels. Plane-riffle channels Plane-riffle channels form an intermediate channel form between plane-bed and pool riffle channels. The retain many of the attributes of pool-riffle channels, however, they generally have less defined pools, coarser (armounred) substrate and less extensive bar features. They are a common channel form in UK, although it is unclear whether their presence is natural or whether they represent a degraded form of the pool-riffle channel. For management purposes, it is suggested that they are treated as a pool-riffle channel type.	C
Braided channels:	Braided reaches can occur in a variety of settings. They are characterised by relatively high gradients (but ones that are less than upstream reaches) and/or abundant bedload. Sediment transport is usually limited under most conditions and the channel splits into a number of threads around instream bars. Nevertheless, poor bank strength renders them highly dynamic and channels will generally change even in relatively small flood events.	C

Appendix I – Geomorphic Summary of river channel type (SNIFFER, 2006)

Wandering channel:	These reaches exhibit characteristics of braided and meandring channels simultaneously, or, if studies over a number of years, display a switching between divided and undivided channel types. Wandering channels may also be susceptable to channel avulsions during high flow events, where the channel switches to a historical planform. Wandering channels typically occur where a reduction of bed material size and channel slope is combined with a widening of the valley floor. In sediment transport terms such reaches are bedload channels, but the number of competent transport events in any year will vary greatly according to bed material size and the associated entrainment function. Generally, they can be viewed as a transition chennal type between braided and lowland meandering channels.	C
Low gradient actively meandering:	Are unconfined low-gradient meandering channels with a bedload dominated by sand and fine gravel. Hence, the channel bed has marked fine sediment accumulations that are mobile in most flood events. These occur in higher order (ie typically lowland) channels exhibiting more laminar flow hydraulics, with turbulent flows being uncommon. The fine bed sediment erodible banks and unconfined settings means that such channels are dynamic and prone to change, they also often have extensive riparian zones and floodplains which are linked to the channel. Bars and pools may be present, and are associated with bends and crossing of the meander pattern.	D
Groundwater dominated channels:	Groundwater-dominated rivers low gradient channels and are characterised by a stable flow regime; although limestone rivers with cave systems may display hydrological characteristics similar to freshet rivers (Sear et al., 1999). This stable regime is a product of the pervious catchment geology, and consequent reduction in overland flow that characterises groundwater-dominated streams (Burt 1992; Sear et al., 1999). Bed movement is infrequent and sediments are predominantly transported in suspension (Sear et al., 1999; Walling and Amos 1999). Typically, sediments are derived from catchment sources, although large macrophyte beds provide a source of in-stream organic detritus (Burt 1992; Sear et al., 1999). As bed disturbance is infrequent, deposited sediments may remain in the gravel for extended periods, promoting the accumulation of large quantities of fine sediment. Substrate generally comprises gravels. pebbles and sands, and glides and runs are the dominant flow types (or morphological units. Localised areas of riffle may be present, particularly where woody debris is available.	E
Low gradient passively meandering:	These channels are typically found at lower extremities of the channel system. Generally they flow through high resistant materials, for instance clays and carse deposits. They are generally sinuous, however, as the banks comprise materials that are resistant to erosion, they are typically ‘fixed’ in there planform geometry. Thus, these channels are often incised and display low width depth ratios. The beds typically comprise fine sedimentary materials (sands and silts), although pockets of gravel can be present, particularly in poorly formed bar deposits. These channels are typically deep and flows are dominated by glides, although runs may be associated with meander bends. Riparian vegetation is influenced by the clay soils and is often more sparse than in other channel types, fairly comprising grasses shrubbery and smaller pockets of woody growth. Primary production is strong in these channels and, coupled with stable beds, allows extensive growth of macrophyte vegetation. Table 5 Geomorphic summary of typical channels used to aid development of the typology.	F
Peat rivers:	These channels are typically found at upper and lower extremities of the channel system. Generally they flow through high resistant peat materials. They are generally sinuous, but may be straightened to aid land drainage. banks comprise materials that are resistant to erosion, they are typically ‘fixed’ in there planform geometry. Thus, these channels are often incised and display low width depth ratios. The beds typically comprise fine sedimentary materials (sands and silts), although pockets of gravel can be present, particularly in poorly formed bar deposits. These channels are typically deep and flows are dominated by glides, although runs may be associated with meander bends. Riparian vegetation is often more sparse than in other channel types, fairly comprising grasses shrubbery. The stable beds, allows extensive growth of macrophyte vegetation. Table 5 Geomorphic summary of typical channels used to aid development of the typology.	F

APPENDIX II – Habitat Survey site locations

Killean Burn - Location of habitat survey sections

Section ID	D/S Easting	D/S Northing	U/S Easting	U/S Northing
KB01	171049	644566	171547	644607
KB02	171547	644607	171611	644611
KB03	171611	644611	171768	644854
KB04	171768	644854	172013	645223
KB05	172013	645223	172150	645405
KB06	172150	645405	172426	645574
KB07	172426	645574	172948	646070
LUGT01	172340	645992	172462	646259
LUGT02	172350	645990	172581	645937
KBET01	171611	644611	171684	644376
KBET02	171684	644376	171768	644319
KBET03	171768	644319	172139	644568
KBET04	172139	644568	172349	644738
KBET T01	171617	644553	171446	644202
KBET T02	171662	644546	172022	644766
KBET T03	171684	644376	171592	643964
KBET T04	171768	644319	172315	644076
KBET T05	171797	644272	171785	644052

Tayinloan Burn - Location of habitat survey sections

Section ID	D/S Easting	D/S Northing	U/S Easting	U/S Northing
TB01	171405	646676	172202	646727
TB02	172202	646727	172267	646706
TBT01	171405	646676	171680	646443
TBT02	171790	646798	171876	646492
TBT03	172236	646679	172091	646468
TBT04	172389	646538	172462	646259
ACT01	173984	646511	173934	646266
AC01	174429	646119	174158	645946
AC02	174158	645946	173808	645717
AC03	173808	645717	173727	645676
AC04	173727	645676	173609	645524
AC05	173609	645524	173615	644317

Obstacles to fish migration (upstream direction)

ID	Easting	Northing	Type	Height (m)	Length (m)	yes (S/F)	Unsure	No (u/s)
KB01-01	171049	644566	CSCD/WF					1
KB03-01	171768	644854	CU	1	12		1	
KB04-01	171850	645009	CSCD	2	2			1
KB04-02	172013	645223	CU	0.3	12	1		
TB01-01	171405	646676	CSCD/WF					1
TB01-02	171748	646781	WF	10	15			1
TB01-03	172074	646823	CSCD	3			1	
TB01-04	172207	646727	CU	0.5	8		1	
AC01-01	174354	646064	WF	5	1			1
AC01-02	174238	645970	CSCD	10	10			1