Beaw Field Wind Farm, Yell, Shetland Isles:
Fish Habitat and Electric Fish Survey Report

Commissioned Report

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COMMISSIONED REPORT

Beaw Field Wind Farm, Yell, Shetland Isles: Assessment of fish habitats and populations

Contractor: Waterside Ecology

Summary

Background

A proposal for a wind farm development has been made by the Applicant for Beaw Field Wind Farm, in Yell, Shetland. The Site is centred on the Burn of Hamnavoe at grid reference HU 50461 82092. The Site drains into a number of stream catchments and there are several standing water bodies around the Site's periphery. Waterside Ecology was commissioned to conduct surveys of fish in streams within and downstream of the Planning Application boundary area. Specific objectives were to:

- Describe stream habitats in the watercourses within and draining the Site. In particular, to describe their suitability for fish species potentially present.
- Carry out electric fishing surveys to determine fish species present, both within the Site and in watercourses receiving runoff from the Site.
- Identify key issues in relation to the potential impact of the Proposed Development on fish communities.

Walkover habitat surveys of streams potentially affected by the Proposed Development were carried out during August 2015. These surveys were followed by electric fishing to determine fish species presence and abundance.

Main Findings

- Most of the streams in the Study Area were found to provide suitable habitats for trout.
- Productive trout habitats were most abundant in the Burn of Hamnavoe and the Burn of Arisdale. Suitable habitats were also identified in Green Burn and in the Loch of Kettlester outflow streams. Many of these habitats are accessible to sea trout and trout populations are likely to include a migratory component.
- Electric fishing found juvenile trout in varying densities in Burn of Arisdale, Burn of Hamnavoe, the Loch of Kettlester outflow and Green Burn. No trout were found at survey sites in Burn of Horsewater or Burn of Evrawater, but they may be present in the lower reaches of these watercourses, outside the Study Area.
- No salmon were found in the Study Area.
- Eels were widespread and were found in all streams where electric fishing took place.
- Three-spined sticklebacks were found only in the Loch of Kettlester outflow stream.
- Larval lamprey habitats were found only in Burn of Arisdale but spot checks found no larvae, consistent with a previous survey of this stream during 2004.

The implications of the Proposed Development for fish habitats and populations are discussed and sensitivities identified. These relate primarily to the potential for changes to water quality including changes in levels of silt and suspended solids.

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1 INTRODUCTION

1.1 Background

The aim of this study was to assess fish habitats and populations in and around the site of the proposed Beaw Field Wind Farm on Yell, in the Shetland Isles. The Site is centred on the Burn of Hamnavoe at grid reference HU 50461 82092. The Site drains into a number of stream catchments and there are several standing water bodies around the Site's periphery.

1.2 Fish population conservation status

Based on available distribution maps (Davies *et al*. 2004; Maitland 2007) freshwater fish populations potentially present on Yell include brown trout *Salmo trutta*, salmon *S. salar*, three-spined stickleback *Gasterosteus aculeatus* and European eels *Anguilla anguilla*. Lampreys *Lampetra sp*. and *Petromyzon marinus* are not known from the Shetland Isles (Watt & Ravenscroft 2005). Arctic charr are known from a single loch on Mainland Shetland, but have not been recorded elsewhere on the islands.

Atlantic salmon are listed on Annex II of the Habitats and Species Directive. Atlantic salmon, brown trout and eels are all listed as priority species on the UK and Scottish Biodiversity Action Plans. Due to recent declines, eels are of increasing conservation interest and are protected by European (EC No 1100/2007) and Scottish (Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008) legislation. Eels were recently listed as endangered on the IUCN Red List.

1.3 Habitat requirements

1.3.1 Salmon and trout

The physical habitat requirements of juvenile salmonids have been subject to a considerable amount of detailed study (for reviews see e.g. Crisp 1993; Hendry & Cragg-Hine 2003; Klemetsen *et al*. 2003; Summers *et al*. 1996; Youngson & Hay 1996). Trout and salmon spawn in late autumn and early winter, depositing their eggs in redds which they excavate in gravel and pebble substrates. Eggs are often deposited in areas of accelerating flow, such as the tails of pools and glides, upstream from riffles. However, in upland streams eggs may be deposited in any areas of gravel that can be physically moved. A good supply of oxygen is essential for eggs to develop and this is facilitated by a flow of water through the gravel. Clogging with fine sediment such as silt and fine sand reduces water flow resulting in egg mortality due to lack of oxygen. Egg survival is also affected by redd 'washouts' during winter spates – the direct, physical, scouring out of eggs from the gravel. Substrate stability, the dynamics of water flow and the weather all determine the extent of siltation and washouts.

After hatching the young fry remain in the gravel, absorbing nutrient from the remaining yolk sac. On emergence, usually between March and early May, the young fry disperse and set up territories which they defend aggressively. Salmon fry prefer fast flows (>30 cm/s) and favour areas with surface turbulence (riffle habitat). They require a rough bed of pebble, cobble and gravel. Trout fry prefer areas of relatively low velocity water near the streambed. Cover from stones, plants or debris is required and good cover is essential for maintaining high fry densities. Salmon that have survived their first winter (parr) prefer deeper water than fry (typically 15-40 cm) and a coarser substrate of pebbles, cobbles and boulders. Trout parr generally favour areas of relatively low current speed where cover is available. Juvenile trout are often to be found in cover alongside the banks, in undercuts, among tree roots or in marginal vegetation. Cover remains important for adult trout and salmon particularly in smaller streams. In larger rivers and lochs this may be less important, as deep water provides refuge.

1.3.2 Eels

Eel habitat requirements have received less attention than those of salmonid fish. Tesch (1977) suggests that so long as temperature and oxygen requirements are met, there are few stretches of water that are not suitable for eels. The main requirement for eels is cover, as they are averse to light and require suitable refuges during daylight hours. Eels of different size show different substrate

preferences. Larger eels require large hollows, crevices or weed beds whereas small eels are sometimes abundant in cobble substrates, where they can burrow between the stones. Tree stumps, roots and other large structures provide ideal cover for eels. Eel diet is diverse, but the majority of diet consists of benthic species (Moriarty 1978; Kottelat & Freyhof 2007).

1.3.3 Three-spined stickleback

Three spined sticklebacks inhabit a huge array of habitat types in both coastal and freshwaters. In the UK, they are widely distributed in all types of freshwater, from weed-choked ditches to high altitude lakes (Maitland and Campbell 1992). They hunt by sight, feeding on an array of invertebrate prey. Spawning usually takes place in spring and summer, when the males set up territories and create nests where the female deposits her eggs. The male then tends the eggs until the fry hatch and move away from the natal territory. Sticklebacks are very tolerant of pollution and may be one of the last species to be extirpated from highly polluted streams.

2 STUDY AREA AND OBJECTIVES

Typical concerns in relation to wind farm developments and fish include the potential for siltation or other changes to water quality that may affect aquatic habitats and species. Point source impacts on habitats e.g. at watercourse crossings can also occur. Since changes to water quality can extend well downstream of their source, the current assessments included stream reaches outside as well as within the Site. The Study Area is defined in Table 1 and the proposed scheme layout is shown on Figure 1.

Table 1 Study Area - stream reaches selected for habitat and/or electric fishing surveys

Watercourses	Survey extent
Burn of Arisdale	Tidal limit at HU 4859 8092 to HU 4839 8200.
Burn of Hamnavoe	Tidal limit at HU 4929 8043 to HU 5015 8370. Survey also included an unnamed tributary upstream of HU 4990 8256.
Burn of Evrawater	HU 5003 8076 to HU 5048 8149.
Loch of Kettlester inflow and outflow streams	HU 5133 8105 to HU 5119 8112 and HU 5141 5129 to HU 5129 8115. Also outflow stream at HU 5161 8083.
Burn of Horsewater and Horsewater inflow streams	HU 5310 8189 to HU 5262 8172. Inflow streams at HU 5239 8156 and HU 5238 8148.
Green Burn	HU 5201 8318 to HU 5162 8241.

Specific objectives of the current surveys were to:

- Describe stream habitats in the watercourses within and draining the Site. In particular, to describe their suitability for fish species potentially present.
- Carry out electric fishing surveys to determine fish species present, both within the Site and in watercourses receiving runoff from the Site.
- Identify key issues in relation to the potential impact of the Proposed Development on fish communities.

3 METHODS

3.1 Habitat survey

Surveys included both quantitative and non-quantitative walkovers. Both were based on protocols described by Hendry and Cragg-Hine (1997), Summers *et al*. (1996) and SEPA (2010a). These characterise in-stream habitats according to depth, substrate, flow and thus suitability for different age classes of salmonid fish (Table 2). Surveys were based on contiguous sections of varying length.

Figure 1 Beaw Field Wind Farm: proposed layout at time of survey

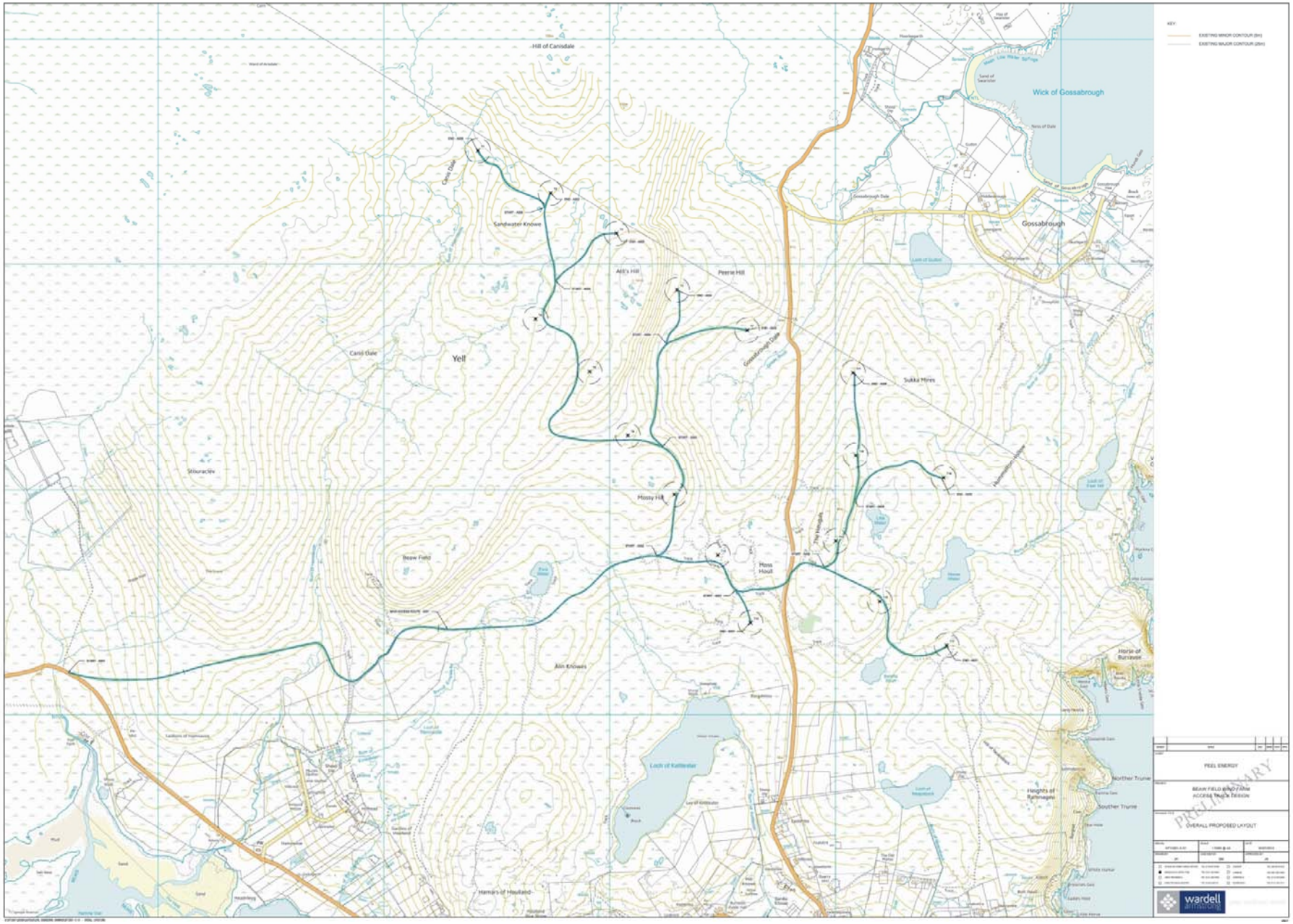


Table 2 Habitat categories used for walkover survey

Habitat category	Description
Productive juvenile salmonid habitat	Habitats with mixed depth and coarse substrates including cobble, boulder and pebble that provide cover for salmonid fry and parr.
Deep pool	Over 60 cm deep. Slow or eddying current. Suitable for adult salmonids if cover is present. If >1 m deep cover may be less important, as depth can provide refuge.
Glide	Low or moderate gradient channel with small substrates. Lacking cover for fish. Productive only if instream macrophytes or bankside cover are present.
Spawning	Ideally well oxygenated, stable & not compacted. Typically comprising gravel and pebble. Fines (sand & fine gravel <2 mm) less than 20%. Not silted.
Bedrock	Sheet bedrock. No cover for fish. Unproductive habitat.
Narrow embedded	Small incised channels with non-mobile bed material. Very poor habitat but may support fry or small parr if spawning present nearby.
Peat channel	Small channels incised through peat and lacking hard substrates. Unsuitable for fish.

Quantitative habitat surveys were conducted where streams were judged largely suitable for production of salmonid fish. During these surveys data were collected on substrate composition, flow types and depths. Areas of each habitat category (Table 2) were marked on 1:10,000 maps of the river in the field, using colour codes. One or more photograph was taken in each survey section showing representative habitats or features of particular relevance.

Qualitative surveys were conducted in small first order streams where these were clearly wholly or largely unsuitable for production of salmonid fish. These streams were inspected and target notes and photographs were taken.

Obstacles to migration were recorded and photographed. Their likely passability for adult salmonids was assessed based on published guidance (SEPA 2010a, SNIFFER 2010). Where possible, the height (lip to plunge pool) and length (upstream to downstream) of obstacles was measured using a tape and bob weight. Salmon and trout are considered capable of leaping 3.7 and 1.8 vertical metres respectively (SEPA 2010a). These figures are maxima attained under ideal conditions. Obstacles that were higher than these figures and passable only by jumping were classified as impassable unless it was apparent that height would decrease significantly at high flow due e.g. to downstream constrictions.

Areas of suitable spawning substrate were recorded. Other variables recorded in each survey section were: (i) up and downstream grid reference, (ii) wet width, (iii), stability of substrate and compaction of substrate. The availability of cover for fish alongside banks was recorded as this can be an important factor in determining trout density, particularly in habitats where cover on the streambed is lacking. The surveyors also made a subjective assessment of typical habitat quality for juvenile salmon and trout in each section, based on published habitat requirements and many years' experience of electric fishing in streams throughout Scotland.

There are no recognised methods for assessing habitat suitability for European eels or three-spined sticklebacks. Both have very broad habitat niches. The main requirement of eels, other than a food source, is cover. This may take the form of stones, roots or vegetation but eels also have the ability to bury themselves in soft streambeds. Target notes were maintained on the availability of cover.

3.2 Electric fishing survey

3.2.1 Field survey

Fish populations were surveyed by electric fishing between 18th and 20th August 2015. The survey was conducted under Scottish Government License CSM-15-138 and with authorisation from landowners. The distribution and location of electric fishing sites (Table 3, Annex 1) was guided by the results of

habitat surveys, which were completed before electric fishing commenced. Sites were placed in areas where suitable habitats for salmonid fish, the species most likely to be encouneterd, were present.

Surveys were conducted using fully and semi-quantitative methods as described by Scottish Fisheries Co-ordination Centre (SFCC 2007). Three electric fishing runs were carried out through each fully quantitative site. This permits total fish density to be established based on the depletion in fish numbers during consecutive runs (SFCC 2007). A single electric fishing run was conducted at semi-quantitative survey sites. Stop nets were established at fully quantitative sites immediately prior to survey.

In addition to the quantitative surveys, a number of qualitative (non-area delimited) surveys were carried out in the smaller streams to establish fish presence and distribution. In most of these the channel was too narrow to permit quantitative survey or habitat was of such poor quality that long reaches had to be rapidly searched in order to establish fish presence.

All survey sites (Table 3) covered the full stream width and incorporated a representative range of habitat types. Full and detailed habitat descriptions (Annex 2) were made at all quantitative survey sites using the SFCC (2007) protocol.

Table 3 Locations of fully quantitative electric fishing sites

Site code	Watercourse	NGR	Survey type
A1	Burn of Arisdale	HU 48536 81142	Semi-quantitative
A2	Burn of Arisdale	HU 48382 81662	Semi-quantitative
A3	Burn of Arisdale	HU 48420 81778	Semi-quantitative
HV1	Burn of Hamnavoe	HU 49614 80070	Fully quantitative
HV2	Burn of Hamnavoe	HU 49739 82088	Semi-quantitative
HV3	Burn of Hamnavoe	HU 50269 83061	Semi-quantitative
HW1	Burn of Horsewater	HU 53054 81848	Qualitative
E1	Burn of Evrawater	HU 50353 81245	Qualitative
K1	Loch of Kettlester outflow	HU 51612 80829	Semi-quantitative
G1	Green Burn	HU 52049 83276	Semi-quantitative
G2	Green Burn	HU 51913 82846	Fully quantitative
G3	Green Burn	HU 51658 82527	Semi-quantitative

Fish were captured in hand-held dip nets then placed in bins of clean water where they were held until ready for processing. Fish were anaesthetised for handling and were identified to species. Salmonid fork length was measured to the nearest millimetre as was eel total length. Scales were collected from salmonids to assist with age determination. All fish were allowed to recover fully in clean water before being released back into the survey reaches.

3.2.2 Analyses

All fish densities are expressed as fish per 100 square metres of wetted stream area (fish.100m^{-2}). Salmonid densities are presented separately for fish aged 0+ years old i.e. young of the year and for fish aged 1 year or older. Throughout the report 0+ salmonids are referred to as fry and older juveniles as parr.

Depletion estimates for fully quantitative sites were calculated using the *Removal Sampling 2* software (Pisces Conservation Ltd., 2007). The estimator used was Maximum weighted likelihood more commonly referred to as the Carle and Strub (1978) estimate. Where it was possible to calculate depletion estimates, upper and lower 95% confidence intervals are provided for densities in the data tables. Some confidence limits were asymmetrical since, logically, the lower 95% confidence limit cannot be less than the actual number of fish caught.

The classification provided by Godfrey (2006) is used to describe fish abundance in a national context. The classifications are based on large data sets held by Scottish Fisheries Co-ordination Centre

(SFCC). The quintile ranges of salmon and trout densities (Annex 3) allow for comparison of fishery performance against nationally based reference points. The classification system is based on semi-quantitative fishing i.e. density based on number of fish captured during a single electric fishing run through an undisturbed site. Different classifications are provided for stream of various widths. No fish density data from the northern isles were used in the development of the classifications and, as a result, their applicability to Shetland is uncertain. Nevertheless, Godfrey's tables are widely used and provide a helpful means of describing abundance in an objective and clearly defined manner

4 RESULTS

4.1 Burn of Arisdale

4.1.1 Stream habitats

The habitat survey of Burn of Arisdale extended from the normal tidal limit (NTL) at HU 4859 8092 upstream to HU 4839 8200, a distance of approximately 1.2 km as measured along the watercourse. The survey was conducted in five contiguous sections, AR1 to AR5, numbered from downstream. Details of each section are included in Appendices 4 and 5 and photographs are in Annex 7.1.

The lower reaches of Burn of Arisdale are typically between 5 m and 7 m in wet width. The gradient is low to moderate and flow types are varied, with runs and riffles as well as more gently flowing glides and pools. Sections AR1 to AR3 provide long reaches of stable boulder and cobble habitat that appear well suited to the production of juvenile salmonids. Depth is typically between 10 and 40 cm and cover on the streambed is plentiful, both from boulders and from macrophytes. In most places the wetted channel abuts one or more bank and some additional overhead fish cover is available from undercut turf. Some deep pool habitat is available that would provide resting areas for adult salmon or trout. This includes a large pool impounded behind the weir in section AR2.

Gradient eases further at the upstream end of AR3 and through AR4 where the stream is meandering with pool, glide and riffle sequences. Some good quality spawning habitats suited to trout and salmon are present in these reaches. Stream gradient is higher through AR5 and substrates in this section are predominantly stable mossy boulders and cobbles.

Some 6435 m^2 of productive juvenile salmonid habitats were estimated to be present in the survey reaches (Table 4) representing an estimated 84% of the wetted area. All of this was judged to be of good quality for salmonid fry and/or parr. Most of the remainder is deep pool habitat. Some 30 m^2 of spawning habitat was recorded, spread over four locations in AR3 and AR4 (see Annex 6 for locations of individual patches of spawning habitat).

Table 4 Summary of habitat availability in streams within the Study Area

Watercourse	Length of survey reach (m)	Wetted area of survey reach (m^2)	Wetted area (m^2)						
			Productive juvenile	Glide	Deep pool	Bedrock	Narrow embedded	Peat channel	Spawning
B. Arisdale	1190	7695	6435	120	1140	0	0	0	30.0
B. of Hamnavoe	5030	10825	9581	210	250	728	28	28	33.0
Horsewater streams	640	492	0	0	0	0	360	132	0.0
Green Burn	1060	1525	602	428	105	75	0	315	2.0

Suitable habitat for eels is distributed throughout the survey reaches with abundant cover among boulders and macrophytes. A numbers of small patches of stable sand in sections AR3 and AR4 appeared potentially suitable for larval lampreys.

In most sections the stream banks are stable, although some erosion and undercutting was apparent on the outside of bends in section 4 (Figure 3). This erosion is not viewed as detrimental as it provides a source of some spawning calibre material to the watercourse.

Figure 2 Section AR2

Figure 3 Section AR4

The bridge apron at HU 4854 8121 was inspected. Water flow over the apron is concentrated and permits sufficient depth for fish passage. It does not form a significant obstacle to migration of salmonids or eels. The weir at HU 4858 8130 forms a more significant obstacle. The weir (Figures 4 and 5) spans the full stream width. The weir face is approximately 0.7 m high. Its ascent is complicated by the presence of shallow sill below the weir face, which does not provide sufficient depth for fish to jump. Flow over the weir is concentrated through a notch below which there is a structure that may have been a fish pass. However, the walls of this structure appear to have collapsed and it no longer provides sufficient depth for fish jumping at the weir face. The weir may be passable for salmonids at some water levels. Nevertheless, this is uncertain and it seems to represent a significant barrier that would impede upstream passage at some water levels. The weir face has a dense growth of bryophyte and this provides suitable climbing substrate for glass eels (juvenile upstream migrants).

Figure 4 Weir at HU 4854 8121

Figure 5 Weir at HU 4854 8121

4.1.2 Fish populations

Three electric fishing sites were established on Burn of Arisdale. Trout fry and parr were present at all sites as were eels (Table 5), but salmon were absent.

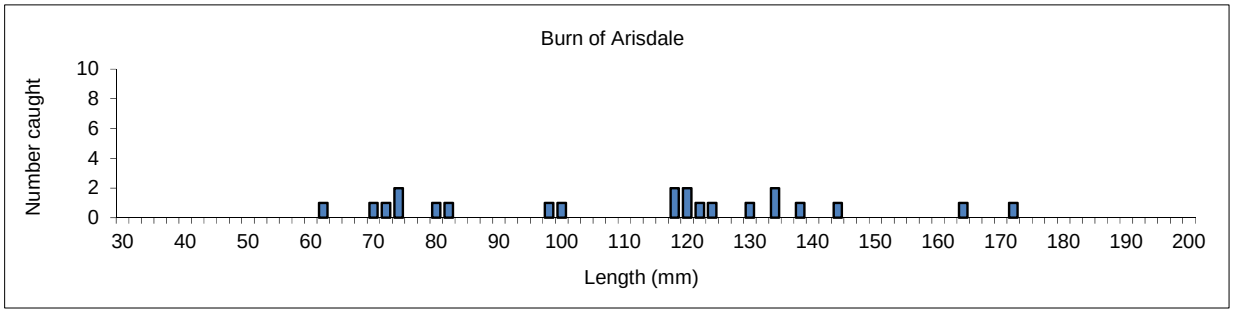
Trout fry densities at sites A1 and A3 would be classified as very poor in a national context while A2 would be classified as poor. Trout parr densities were more variable and would be classified as very poor, excellent and moderate at A1, A2 and A3 respectively.

Table 5 Burn of Arisdale electric fishing results

Site	Trout per 100m² (single run density)		Trout per 100m² (Carle & Strub estimate)		Eels (n)
	Fry (0+)	Parr (1++)	Fry (0+)	Parr (1++)	
A1	1.7	1.7	NA	NA	6
A2	5.4	10.9	NA	NA	7
A3	0.7	3.6	NA	NA	10

Trout fry varied in length from 63 mm to 82 mm (Figure 3) with a mean of 73.9 mm (± 6.4 s.d.). There was no overlap in length with the 1+ parr year class, which ranged from 98 to 145 mm in length. Small numbers of 2+ trout were also present.

Figure 6 Trout length distribution at Burn of Arisdale survey sites



Eels at sites A1 to A3 ranged in length from 90 mm to 390 mm. Eels cannot accurately be aged on scale annuli so scales were not taken. The smallest eels are likely to have entered the stream during 2014 or 2015 while the largest may have been many years old.

Spot checks for larval lampreys in apparently suitable habitats found no larvae.

4.2 Burn of Hamnavoe

4.2.1 Stream habitats

Burn of Hamnavoe was surveyed from the NTL upstream to HU 5015 8370, a distance of approximately 4.3 km. The lower 0.7 km of the unnamed tributary joining Burn of Hamnavoe at HU 4990 8256 was also surveyed.

The three most downstream survey sections, HA1 to HA3, flow mainly through improved grassland. These sections have a moderate gradient with riffle, run and glide flow types. Wet width is typically between 3 and 4 m. Instream substrates are primarily cobble and boulder. The streambed is partly unstable as are the heavily grazed banks. The gradient increases near the upstream end of section HA3 where the stream passes over a number of bedrock slabs and steps. These would impede upstream migrating salmonids on lower flows but are likely to passable during periods of higher discharge.

The next four survey sections to HU 417 819 have a moderate to steep gradient. There is some stable boulder habitat but smaller substrates appear mobile and spawning habitat is lacking. Large depositional bars are present on bends through sections HA4 to HA6 (Figure 8). Depth is typically

between 15 and 40 cm and flow types are dominated by runs and riffles with occasional shallow pools. The latter provide some good quality habitat for trout parr.

Figure 7 Rock steps in section HA3

Figure 8 Section HA6

Stream habitats change abruptly at HU 417 819, part way up HA7. Upstream of this point (which coincides with a change in underlying geology) the stream is narrower and flows mainly between steep, incised bank faces. The gradient is lower than in the reaches downstream and the channel is more sinuous. Substrates through HA8 to HA11 are mainly stable, mossy cobble and boulder with varying amounts of pebble, sand and gravel. Wet width is typically between 1.5 and 2.5 m and equals bank width. Overhead cover from undercuts is abundant. These habitats are well suited to trout production and patches of spawning habitat are widespread.

A sloping rock ramp at HU 5009 8273 in section HA11 presents a potential obstacle to upstream migrating salmonids. It is approximately 1.4 m high and 1.8 m long and water flow over the face is very shallow. At the time of survey it was clearly impassable. However, it is possible that the plunge pool at its base may fill on a higher flow, which combined with increased depth over the face of the ramp, might allow fish to ascend by burst swimming.

Figure 9 Deep glide in section HA9

Figure 10 Spawning substrates in section HA14

Sections HA12 to HA15 are very sinuous with a low gradient and much pool and glide habitat interspersed with runs. Spawning habitat suitable for trout is widespread in accelerating flows at the tails of glides and pools and trout fry were seen at many locations. The stream banks are incised peat and in many places provide good overhead cover.

The unnamed tributary stream at HU 4990 8256 is typically between 0.5 m and 1 m wet width. It flows through peat hags and there is some braiding of the channel. In general, trout habitat quality is poor or moderate as much the stream is shallow and cover on the streambed is lacking. Nonetheless, trout

were seen in all three survey sections (HA16 to HA18). Spawning habitat is scarce in this stream and only one patch of 0.5 m^2 was recorded.

Figure 11 Section HA16

Figure 12 Section HA18

An estimated 9581 m^2 of productive juvenile salmonid habitats were recorded in the survey reaches of Burn of Hamnavoe representing an estimated 89% of the wetted area (Table 4). With the exception of the unnamed tributary, all of this was judged to be of moderate or good quality for juvenile trout. Most of the remainder of the habitat was recorded as bedrock (7%), deep pool or glide habitat. Some 33 m^2 of spawning habitat was recorded. Of this, 28.9 m was in sections HA8 to HA18 (see Annex 6 for locations of individual patches of spawning habitat).

4.2.2 Fish populations

Electric fishing sites H1, H2 and H3 were located in habitat survey sections HA4, HA8 and HA13 respectively. Trout fry and parr were present at all three sites (Table 6). A single eel of 140 mm was caught at H1 but none were taken at the two more upstream sites. No other fish species were encountered.

Trout fry density ranged from 4.0 fish.100 m^2 at H2 to 14.1 fish.100 m^2 at H3 (Table 6). These densities reflect the distribution of spawning habitat, which was most abundant in the upper survey reaches. Trout fry densities at H1, H2 and H3 would be classified as poor, very poor and moderate respectively by national standards. Trout parr density at all three sites exceeded fry density. Parr densities ranged from moderate at H1 to excellent at H3.

Site H1 was fished using fully quantitative techniques. The resulting Carle and Strub estimates suggest that approximately 50% of fish present were caught during the first run through the electric fishing site.

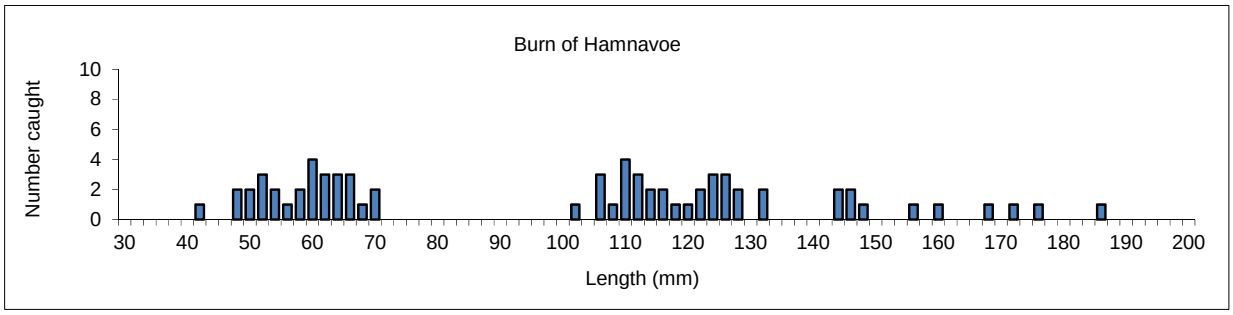
Table 6 Burn of Hamnavoe electric fishing results

Site	Trout per 100m^2 (single run density)		Trout per 100m^2 (Carle & Strub estimate)*		Eels (n)
	Fry (0+)	Parr (1++)	Fry (0+)	Parr (1++)	
H1	5.9	6.7	10.9 (10 – 13.4)	15.9 (14.2 – 19.5)	1
H2	4.0	10.0	NA	NA	0
H3	14.1	17.8	NA	NA	0

*Lower and upper 95% confidence limits given in parentheses

Trout fry varied in length from 43 mm to 70 mm (Figure 13) with a mean of 59.1 mm (± 7.1 s.d.). There was no overlap in length with the 1+ parr year class, which ranged from 103 to 133 mm in length. Moderate numbers of 2+ and 3+ trout were also present.

Figure 13 Trout length distribution at Burn of Hamnavoe survey sites



4.3 Burn of Evrawater

4.3.1 Stream habitats

Burn of Evrawater was surveyed non-quantitatively from the edge of Hamnavoe village (HU 5003 8076) upstream to HU 5048 8149. The lower reaches are in Loch of Hamnavoe, an area of marshy ground where the stream is dissipated among several braided channels, which frequently disappear beneath the turf. The streambed in this area is mainly mineral hardpan or peat. Further upstream the burn comprises a simple incised channel with runs and little pools. Depth is typically less than 10 cm and the streambed is peat or mineral hardpan. The burn was very turbid and much eroded peat is present in the pools. Habitat quality for is very poor and there is no spawning substrate.

4.3.2 Fish populations

A single qualitative site covering approximately 300 linear m of stream was surveyed. A single eel of 290 mm was the only fish seen or caught.

Figure 14 Section EV1 in Loch of Hamnavoe

Figure 15 Section EV2

4.4 Loch of Kettlester inflow and outflow streams

4.4.1 Stream habitat

Two small streams drain from the Site into Loch of Kettlester (Figure 1). Both are very small first order streams and both may dry during prolonged periods of dry weather.

The more westerly of the two streams enters Loch of Kettlester at HU 5133 8105. Wet width is typically less than 0.5 m and parts of the stream flow beneath turf. There are no movable substrates and the streambed is either eroded peat or mineral hardpan. Depth is mainly less than 5 cm although a few semi-stagnant pools to 15 cm deep were recorded (Figure 16). The watercourse is entirely unsuitable for salmonid fish and is unlikely to support eels in significant numbers, if at all.

The more easterly stream enters Loch of Kettlester at HU 5141 5129 via a 15 m long peat pipe, where the flow is below ground. The streambed in the lower 50 m of the watercourse is mineral hardpan with a little scattered pebble and gravel. Further upstream the burn is a poorly defined channel through peat hags with near-stagnant pools linked by tiny runs. It is totally unsuited to salmonid fish.

The western stream conveys no hard substrates. However a little loose pebble and gravel is present in the eastern steam and there is 5 m^2 of spawning calibre substrate in a gravel fan where the stream enters Loch of Kettlester. This might permit trout to spawn.

Figure 16 West inflow (section KeW)

Figure 17 East inflow (section KeE)

4.4.2 Fish populations

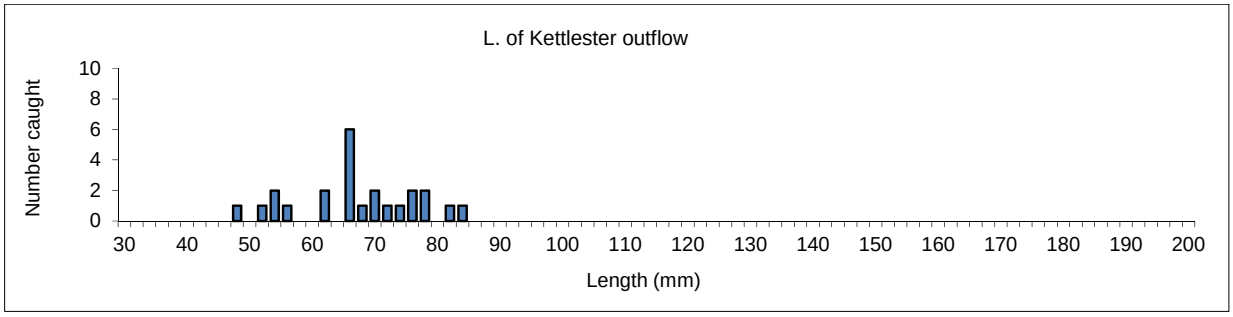
As habitats in the small inflow streams were clearly unsuited to fish production a single semi-quantitative electric fishing survey took place in the Loch of Kettlester outflow stream. Trout fry were present but parr were absent, suggesting that older trout might move up into the loch where growth opportunities are likely to be greater than in the shallow outflow stream. Suitable habitat for trout spawning was noted within the electric fishing site, which was immediately downstream of the sluice at the loch outflow. Trout fry density was 22.0 fish per 100m^2, which would be classified as moderate for a stream of this size (<4 m). Fry ranged in length from 48 to 84 mm (Figure 18).

Two eels were caught, measuring 205 mm and 330 mm. The nine three-spined sticklebacks that were caught ranged in length from 26 mm to 50 mm.

Table 7 Loch of Kettlester outflow stream electric fishing results

Site	Trout per 100m^2 (single run density)		Eels (n)	Three-spined sticklebacks (n)
	Fry (0+)	Parr (1++)		
K1	22.0	0.0	2	9

Figure 18 Trout length distribution at Loch of Kettlester outflow survey site



4.5 Burn of Horsewater and tributaries

4.5.1 Stream habitats

Burn of Horsewater flows between Horse Water (HU 524 816) and Loch of Mid Yell (HU 810 531). The Mill Burn carries water from Loch of Mid Yell to the sea at Bay of Whinnifirt. Mill Burn was fully inspected and no obstacles to upstream migration of salmonids or eels were recorded, suggesting that Burn of Horsewater is accessible to migratory fish.

Burn of Horsewater is a small, steep burn with a mean gradient of approximately 6%. Wet width is typically between 0.5 m and 0.8 m and the stream tumbles down the hillside in series of runs and small torrents. Parts of the stream have step-pool morphology but the lower reaches near Loch of Mid Yell have gentler gradient with some glides and runs. Substrates are mainly immobile with little bed transport. Substrate composition is predominantly boulder and cobble set into peat or mineral hardpan. No spawning habitat was recorded (Table 4) and habitat quality was judged to be poor, although some of the little pools appear capable of supporting small numbers of trout. In places the burn disappears underground for up to 15 m and it is uncertain if salmonid fish have access all the way up to Horse Water.

There are two inflow streams to Horse Water. The most northerly of these flows from Litla Water (HU 522 819). This tiny watercourse is a simple channel incised in peat which in some places dissipates into wet flush habitat with a poorly defined channel. It is entirely unsuited to salmonid fish.

The more southerly inflow arises in Swarta Shun. Much of this little watercourse flows beneath the turf. Visible streambed substrate is almost entirely peat and the channel was judged to be unsuited to salmonid fish (see Annex 6 for photographs).

Figure 19 Section HO1

Figure 20 Section HO2

4.5.2 Fish populations

A single qualitative electric fishing survey covered most surveyable reaches between Loch of Mid Yell and Horse Water. A single eel of 140 mm was captured but no other fish were seen or caught.

4.6 Green Burn

4.6.1 Stream habitats

Green Burn flows into the sea at Wick of Gossabrough (HU 525 837). The lower reaches were inspected down to the NTL and no barriers were recorded, suggesting that migratory salmonids have access to the Study Area. The habitat survey extended from HU 5201 8318 (approximately 0.7 km upstream of the NTL) to HU 5162 8241, a distance of approximately 1.1 km as measured along the stream channel. The four contiguous survey sections were coded GR1 to GR4 starting downstream (see Appendices 4 and 5).

The lower reaches of survey section GR1 are 1.8 m to 2 m wide with unstable substrates angular cobble, boulder and pebble. Gradient is moderate or steep and downstream of the Gossabrough road bridge the stream is entrenched between bedrock bank faces. The gradient eases approximately 80 m upstream of the bridge and in the upper parts of GR1 the stream is 30 to 80 cm deep with glide and pool flow types linked by short runs. Substrate in these reaches is stable partly-embedded boulder and cobble with some granule. Similar habitat extends through most of GR2, where the channel is incised between steep peat bank faces and the gradient is low. In the top 30 m of GR2 the stream is steeper and shallower with substrates of cobble, pebble and boulder.

The downstream end of GR3 has stable substrates of cobble and boulder but further upstream the channel is deeply entrenched between peat banks and substrate is mainly sand and gravel lying in a thin layer over peat. Small patches of spawning substrate were present at various locations through the section. Section GR3 ends at the B9081 road. Upstream of the road in section GR4 the stream flows between incised peat banks in an area of pear hags (Figure 22). Broad pools are linked by narrow runs. Substrate is almost entirely peat with a few areas where coarse sand and gravel form a thin layer on top. Stream depth through GR4 is typically 30 cm to 1 m and habitat quality habitat for trout or eels is poor.

An estimated 602 m^2 of productive juvenile salmonid habitats were recorded in the survey reaches of Green Burn representing an estimated 39% of the wetted area (Table 4). A further 35% was recorded as glide or pool, both of which would be expected to support trout since overhead cover was plentiful.

Figure 21 Section GR1

Figure 22 Section GR4

The stream flows through culverts beneath the Gossabrough road (HU 5201 8318) and the B9081 road (HU 5180 8264). The Gossabrough road culvert has a shallow, flat downstream sill and is likely to hinder upstream movement of salmonid fish on low and moderate flows due to lack of depth. It is likely to be passable on a higher flow, although in full spate conditions stream velocity through the sloped culvert may be a concern.

The downstream end of the culvert at the B9081 is perched at approximately 0.75 m above the stream surface. An apron of large boulders extends downstream of the culvert, resulting in very poor conditions for fish to attempt to jump into the culvert. It is uncertain whether this obstacle is passable to salmonids. However, given the very poor quality and limited extent of stream habitat upstream of the road an obstacle at this location can have little impact on fish abundance in the stream. Photographs of both culverts are provided in Annex 7.7.

4.6.2 Fish populations

Trout and eels were present at all three electric fishing sites on Green Burn (Table 8). Fry density at G1 and G2 would be classified as poor and good respectively by national standards for a stream of this size. Parr densities at both sites were moderate. Site G3, which is upstream of the B9081 road,

consisted of runs and peat pools largely without hard substrates. Approximately 150 m of watercourse were covered and two trout parr were caught, suggesting very low density. Trout fry were absent.

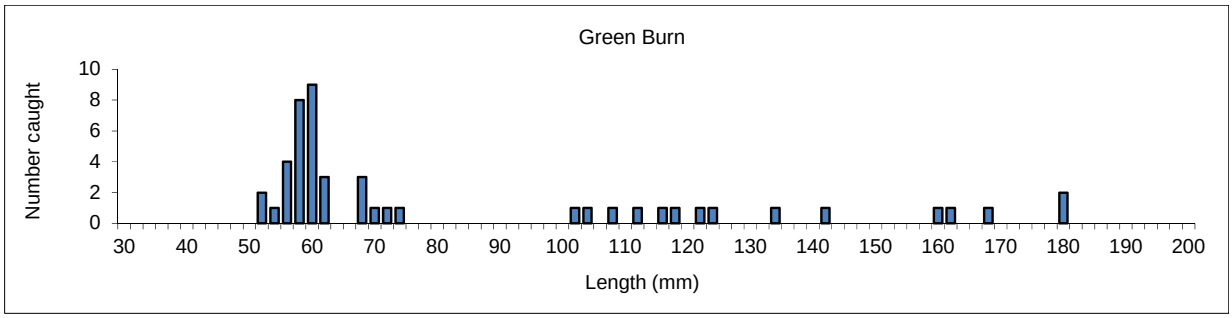
Table 8 Green Burn electric fishing results

Site	Trout per 100m² (single run density)		Trout per 100m² (Carle & Strub estimate)*		Eels (n)
	Fry (0+)	Parr (1++)	Fry (0+)	Parr (1++)	
G1	9.2	5.8	NA	NA	4
G2	23.5	5.9	30.5 (29.3 – 34.6)	10.6 (9.4 – 15.7)	2
G3	Absent	Present	NA	NA	2

*Lower and upper 95% confidence limits given in parentheses

Trout fry at Green Burn survey sites ranged in length from 56 mm to 75 mm (mean 60.8 mm ± 2.4 mm s.d.) and, as in other streams, showed no size overlap with the 1+ year class (Figure 23). Parr of 1+ and 2+ years of age were present. Eels ranged in length from 121 mm to 340 mm.

Figure 23 Trout length distribution at Green Burn survey sites



5 INTERPRETATION AND DISCUSSION

5.1 Status of fish populations

The two most widespread fish species in the Study Area were trout and eels. Salmon were absent at all survey sites and while survey intensity was not particularly high it seems probable that they are absent from the survey streams. Given the relatively small size of most of the streams this is unsurprising, as salmon populations tend to be found in larger watercourses with sea trout relatively more abundant in smaller catchments (Milner *et al*. 2006). Burn of Arisdale may be sufficiently large to support salmon; however none were found despite the presence of apparently suitable habitats for all life stages. One anecdotal record suggests that salmon may have been present in this watercourse in recent times[1] and the National Biodiversity Network lists a record of salmon at the mouth of the stream in 1990. However, the lack of salmon in the current survey suggests that the species may now be absent.

No impassable natural obstacles were identified in the Burn of Arisdale, Burn of Hamnavoe, Burn of Horsewater of Green Burn that would prevent salmonid fish from gaining access to the Study Area. It is probable therefore that trout populations in these streams (if present - none were found in Burn of Horewater) will include a sea trout component.

Given that trout populations in the study area are likely to have a migratory component; juvenile densities in the streams may be determined by factors impacting on marine survival as well as by elements of the freshwater environment. Sea trout numbers throughout much of Scotland have

[1] http://www.shetlandtimes.co.uk/2008/06/27/isles-views-3

declined in the past two decades (Marine Scotland Science 2015) and there is abundant anecdotal evidence that Shetland is not immune from this trend[2]. As a result, streams in the Study Area may not currently be stocked to capacity with young trout. Marine survival of salmon has also been low in recent years leading to widespread declines in the abundance of returning adults (Hansen *et al*. 2012). Any impact of man-made barriers, such as that on Burn of Arisdale, may therefore exacerbate any reduction in stocks associated with low survival at sea.

Trout densities in most study streams were variable and tended to reflect habitat quality and the distribution of spawning habitat. This was particularly clear in Burn of Hamnavoe where the highest densities of trout fry were spatially associated with the presence of good quality spawning habitat in the upper reaches. These fry are likely to disperse widely through the stream as they develop. High fry densities were also found at site G2 in Green Burn, also associated with a reach that provided spawning potential. Trout fry densities in Burn of Arisdale were lower than might be expected at all sites based on the apparent quality of habitat and the presence of spawning substrates. The extent to which access issues at the weir (HU 4858 8130) restrict upstream salmonid is uncertain but its impact may be significant.

The apparent absence of trout in Burn of Horsewater may simply reflect the lack of spawning opportunities in the burn, although it should be noted that trout may spawn over any movable material in streams where typical spawning habitats are unavailable (Maitland & Campbell 1992). While the small inflow stream to Horse Water are clearly unsuited to trout it is probably unsafe to assume that trout are entirely absent from this catchment, particularly as it is accessible from the sea.

The study area on Burn of Evrawater was clearly unsuited to trout and none were found during electric fishing. Visual checks from the public road near Hamnavoe suggest that the lower reaches of the stream might support trout, but this is unconfirmed.

Eels were very widespread at electric fishing sites and were the only fish species identified in the study reaches of Burn of Horsewater and Burn of Evrawater. Their wide distribution is unsurprising as eels are capable of occupying a great variety of habitats. In addition, they have tremendous powers of dispersal and can climb some obstacles that would be impassable to salmonids if suitable substrate such as wet vegetation is present. In some circumstances, they will leave the water and migrate overland through wet vegetation (Moriarty 1978; Maitland 2007). As a result, small numbers of eels can sometimes be found in waterbodies that are not linked to the sea, such ponds and isolated lochans.

Larval lamprey habitats were found only in the lower reaches of Burn of Arisdale. Spot checks found no lampreys. This stream was surveyed for lampreys as part of the SNH funded national survey in 2004 (Watt & Ravenscoft 2005). That survey found no lampreys, consistent with current data. As there are no records of any lamprey species from streams in the Shetland Isles, it may be assumed that these species are absent from the Study Area.

5.2 Implications of Proposed Development

Diffuse and point source impacts from construction works around watercourses clearly have potential to affect stream habitats and fish populations. Typical sensitivities around wind farm developments and salmonid fish relate mainly to the exposure of large quantities of soil and the potential for siltation. Inputs of silt and other fine material including peat can cause damage to fish habitats and direct mortality to fish and ova. Similar or greater impacts would be expected in the event of any major erosion event resulting from large scale developments. In some circumstances exposure of mineral soils due to removal of blanket peat has the potential to increase leaching of metals such as aluminium and zinc, both potentially toxic to aquatic fauna, into watercourses. Aluminium leaching may be a lower

[2] E.g. http://www.trout-salmon-fishing.com/seatroutfishing-scottishislands.htm

risk in streams draining peatland, since where levels of dissolved organic carbon are high it tends to form organic chelates, rendering it less toxic (Rosseland & Kroglund 2011).

Spawning habitats can be particularly at risk in the event of siltation since clogging of interstial space with fine material prevents oxygen reaching eggs and alevins. Spawning habitats were relatively scarce in most parts of the Study Area and may be limiting to fish populations in many stream reaches, including the lower reaches of Burn of Hamnavoe and Green Burn. Careful site management and regular inspections will be needed to avoid deterioration of water quality or impacts on spawning habitat through inputs of silt or other fine material.

Limited data on stream hydrochemistry are presented in the Scoping Report for the Beaw Field Wind Farm (Peel Wind Farms (Yell) Ltd 2015). Those data suggest that the streams have a circumneutral pH and levels of dissolved oxygen that are within the standards required by salmonid fish. No data are presented on turbidity or suspended solids. We would recommend that baseline data on these and other biologically significant hydrochemical parameters should be collected to form the basis for a water quality monitoring program to be implemented during the construction process.

At the time of survey two stream crossings in reaches potentially providing productive fish affect were included in the proposed layout, one on Burn of Hamnavoe near HU 4972 8130 and one on Burn of Evrawater near HU 5033 8136. The Burn of Evrawater location was found to be non-sensitive from a fisheries or fish ecology perspective, with little suitable habitat and an absence of trout. So long as standard mitigations are implemented to avoid significant downstream impact on water quality no impact on fish habitats would be expected from works at this location. Habitat at the proposed Burn of Hamnavoe crossing is suitable for juvenile trout. No spawning habitat was recorded at this location but spawning and productive juvenile habitats are present both up and downstream the proposed crossing site. Therefore crossing design must ensure that fish passage is maintained (see Scottish Government 2011). If substantial instream work is required or there is likely to be significant disturbance to the riverbed SEPA may require that works avoid periods when eggs are in the gravel or fry are emerging. This would typically cover the period between October and May (SEPA 2010b).

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Annex 1.1. Electric fishing survey sites and events

Site code	Site details						Event details				
	Watercourse	NGR*	Runs	Width (m)	Length (m)	Area (m^2)	Voltage	Conductivity ($\mu S.cm^{-1}$)	Temp. (°C)	Level	Clarity
A1	B. of Arisdale	HU 48536 81142	1	4.6	25.5	117.3	220	130	13.3	Low	Clear
A2	B. of Arisdale	HU 48382 81662	1	6.7	11	73.7	250	130	13.3	Low	Clear
A3	B. of Arisdale	HU 48420 81778	1	3.7	38	140.6	250	126	13.4	Moderate-low	Clear
HV1	B. of Hamnavoe	HU 49614 80070	3	2.6	46	119.6	220	102	16.2	Moderate-low	Some colour
HV2	B. of Hamnavoe	HU 49739 82088	1	2.5	20	50.0	200	104	15.0	Moderate-low	Some colour
HV3	B. of Hamnavoe	HU 50269 83061	1	1.5	71	106.5	190	100	12.7	Moderate-low	Some colour
HW1	B. of Horsewater	HU 53054 81848	1	NA	NA	NA	180	183	14.6	Moderate-low	Some colour
E1	B. of Evrawater	HU 50353 81245	1	NA	NA	NA	180	NR	NR	Low	Some colour
K1	L. of Kettlester outflow	HU 51612 80829	1	1.4	78	109.2	180	190	15	Medium	Some colour
G1	Green Burn	HU 52049 83276	1	1.7	51	86.7	200	125	15	Moderate-low	Coloured
G2	Green Burn	HU 51913 82816	3	1.2	71	85.2	200	120	15	Moderate-low	Coloured
G3	Green Burn	HU 51658 82527	1	NA	NA	NA	200	119	15.2	Moderate-low	Coloured
A1	B. of Arisdale	HU 48536 81142	1	4.6	25.5	117.3	220	130	13.3	Low	Clear

*Downstream end of site

Annex 1.2. Depletions in fish numbers attained during consecutive runs at fully quantitative electric fishing survey sites.

Site	Number 0+ salmon caught			Number 1++ salmon caught			Number 0+ trout caught			Number of 1++ trout caught		
	run 1	run 2	run 3	run 1	run 2	run 3	run 1	run 2	run 3	run 1	run 2	run 3
HV1	0	0	0	0	0	0	7	3	2	8	6	3
B2	0	0	0	0	0	0	20	3	2	5	2	1

Annex 2. Instream habitat at quantitative electric fishing sites

Site	Depth (cm)						Substrate (%)									Flow types (%)							
	<10	*11-20*	*21-30*	*31-40*	*41-50*	*>50*	*HO*	*SI*	*SA*	*GR*	*PE*	*CO*	*BO*	*BE*	*OB*	*SM*	*DP*	*SP*	*DG*	*SG*	*RU*	*RI*	*TO*
A1	5	20	50	10	10	5	0	0	0	0	10	50	35	5	0	5	10	10	10	0	45	20	0
A2	15	35	25	20	5	0	0	0	2	8	15	60	15	0	0	10	0	10	20	10	15	35	0
A3	5	25	45	20	5	0	0	0	5	10	10	45	30	0	0	0	10	0	25	0	45	20	0
HV1	5	15	30	30	15	5	0	0	2	5	13	30	50	0	0	5	20	0	20	10	30	15	0
HV2	0	20	10	20	30	20	10	0	2	5	18	55	20	0	0	5	20	0	55	0	10	10	0
HV3	5	20	25	30	15	50	20	0	5	35	15	20	5	0	0	0	10	10	25	0	45	10	0
KO1	25	35	35	5	0	0	0	0	3	15	27	50	5	0	0	5	0	0	0	10	60	25	0
G1	5	35	30	25	5	0	0	0	0	0	10	35	35	20	0	5	20	10	0	0	50	10	5
G2	5	20	25	30	20	0	10	0	2	8	20	55	5	0	0	5	5	0	15	10	45	10	0

Substrates: HO = high organic (peat); SI = silt; SA = sand; GR = gravel; PE = pebble; CO = cobble; BO = boulder; BE = bedrock; OB = obscured.
Flow types: SM = shallow marginal; DP = deep pool; SP = shallow pool; DG = deep glide; SG = shallow glide; RU = run; RI = riffle; TO = torrent.

Site	Cover left bank (% of bank length)				Cover right bank (% of bank length)				Cover in wider channel
	UC	DR	BA	MA	UC	DR	BA	MA	
A1	0	0	95	5	50	0	50	0	Good
A2	10	0	90	0	60	0	40	0	Moderate
A3	20	0	80	0	35	0	65	0	Good
HV1	20	0	80	0	20	0	80	0	Good
HV2	30	0	70	0	25	0	75	0	Good
HV3	40	0	65	0	45	0	55	0	Moderate
KO1	40	0	60	0	40	0	60	0	Moderate
G1	5	0	95	0	5	0	95	0	Moderate
G2	40	0	60	0	30	0	70	0	Moderate

Bankside fish cover: UC = undercut bank; DR = draped vegetation; BA = bare (no cover); MA = marginal vegetation (incl. tree roots).

Annex 3. Salmonid density classification system for Scotland (Godfrey 2006)

	Watercourse width class			
	<4 m	4 – 6 m	6 – 9 m	>9 m
Trout 0+				
0th percentile	0.6	0.5	0.5	0.2
20th percentile	4.5	3.3	2.2	1.1
40th percentile	11.0	6.9	4.0	1.8
60th percentile	22.9	13.7	5.7	3.3
80th percentile	49.9	32.2	12.9	7.1
100th percentile	415.7	221.4	160.8	100.5
Trout 1++				
0th percentile	0.7	0.4	0.5	0.2
20th percentile	4.5	2.0	1.3	0.7
40th percentile	5.0	3.4	2.1	1.0
60th percentile	8.3	6.4	3.6	1.8
80th percentile	15.3	10.3	6.2	2.7
100th percentile	174.2	67.4	204.4	10.1
Salmon 0+				
0th percentile	0.2	0.5	0.5	0.3
20th percentile	4.3	5.1	5.2	4.2
40th percentile	8.7	11.0	12.2	10.7
60th percentile	15.2	26.6	21.5	18.7
80th percentile	35.2	49.2	41.2	38.9
100th percentile	497.7	290.0	295.9	252.1
Salmon 1++				
0th percentile	0.7	0.4	0.4	0.3
20th percentile	2.5	2.8	3.2	2.3
40th percentile	5.1	5.1	6.2	4.1
60th percentile	8.3	9.6	10.6	8.2
80th percentile	15.8	16.8	16.8	14.2
100th percentile	79.0	51.4	119.1	50.4

Density in regional classification	Descriptive category used in text
Min to 20th percentile	Very poor
20th to 40th percentile	Poor
40th to 60th percentile	Moderate
60th to 80th percentile	Good
80th to 100th percentile	Excellent

The classification is based on data from 1638 survey sites, held by SFCC. The quintile densities allow for comparison of fishery performance against regionally based reference points. Classifications are based on single run minimum densities.

Annex 4. Habitat survey sections and habitat descriptions

Watercourse	Section Code	NGR		Instream habitat description	Banks and riparian habitat
		Downstream	Upstream		
Burn of Arisdale	AR1	HU 4859 8092	HU 4854 8121	Section starts at upstream end of sea pool. Stable juvenile salmonid habitat throughout reach. Moderate current speed with riffle, run and glide flow types. Depth 10 to 30 cm. Cobble and boulder dominated substrate with approximately 30% gravel and pebble. No well-defined spawning habitats but small patches of spawning calibre substrate widespread. Flow over bridge apron at upstream end is deep and easily passable.	Low stable grassy banks. Wet width mainly equals bed width so some undercuts available providing overhead cover.
Burn of Arisdale	AR2	HU 4854 8121	HU 4848 8139	Good productive juvenile habitats in lower 90 m. Weir back water up for approximately 70, creating deep pool habitat. Upstream of this the stream has stable mixed juvenile habitat.	Mainly stable and grassy with one short eroding reach on right bank.
Burn of Arisdale	AR3	HU 4848 8139	HU 4842 8156	Stable cobbles and boulders, mainly covered in bryophytes. Moderate current speed. Good cover for juvenile salmonids.	Mainly stable and grassy with a few undercuts providing cover alongside banks.
Burn of Arisdale	AR4	HU 4842 8156	HU 4842 8175	Varied reach with some broad shallow riffle and glide but also with deep pool habitat. Some good quality spawning habitats present. Stable with some bryophyte and patches of vascular vegetation. Depth typically 10 to 40 cm with one deep pool. Mixed substrates of cobble, pebble and boulder.	Some erosion on outside of bends. Point bars indicate deposition.
Burn of Arisdale	AR5	HU 4842 8175	HU 4839 8200	Narrower and higher gradient than section AR4. Substrate is 50% boulder providing good cover for salmonids and eels. Lack of spawning habitat.	Stable grassy banks with good overhead cover from undercuts.
Burn of Hamnavoe	HA1	HU 4929 8043	HU 4942 8061	Mixed juvenile salmonid habitat with moderate gradient and coarse substrates. A little unstable and substrates poorly sorted. Depth typically 10 to 40 cm.	Heavily grazed with some erosion on bends.
Burn of Hamnavoe	HA2	HU 4942 8061	HU 4946 8087	Mixed juvenile salmonid habitat with moderate gradient and coarse substrates. Unstable and substrates poorly sorted. Depth typically 10 to 40 cm.	Heavily grazed with rapid erosion on bends.
Burn of Hamnavoe	HA3	HU 4946 8087	HU 8954 8113	Mixed juvenile salmonid habitat interspersed with bedrock. Two pools would hold salmon in elevated flows only.	Rapid erosion of left bank at downstream end. More bedrock banks at upstream end.
Burn of Hamnavoe	HA4	HU 8954 8113	HU 4970 6112	Cobble, boulder and pebble substrates are a little unstable. Flow types are run, riffle and torrent at downstream end giving way to meandering riffle and glide at top of section. Pools to 1 m deep and patchy spawning potential (poorly sorted).	Erosion on outside of bends and depositional point bars on inside. Some overhead cover from undercut banks.
Burn of Hamnavoe	HA5	HU 4970 6112	HU 4970 8147	Downstream end comprises run and shallow pool habitat. Substrate is mainly angular cobble and boulder. Step-pool morphology towards upstream end with small pools providing good habitat for trout parr. Lack of spawning habitat.	Steep eroding bank faces provide much coarse sediment to channel.
Burn of Hamnavoe	HA6	HU 4970 8147	HU 4969 8168	Moderate to steep gradient with torrent, run and shallow pools. Coarse substrates are unstable. Depth typically from 15 to 40 cm.	Unstable bank faces and much deposition of coarse substrates (cobble and boulder) as point bars. Lack of overhead cover.

Watercourse	Section Code	NGR		Instream habitat description	Banks and riparian habitat
		Downstream	Upstream		
Burn of Hamnavoe	HA7	HU 4969 8168	HU 4974 8200	Stream mainly shallower than HA6 with some bands of bedrock. Stream morphology changes greatly at HU 417 819 to lower gradient with run and pool sequences. The stream also becomes narrower - typically 2 to 2.5 m. Some good quality trout habitats plus spawning at upstream end of section.	Downstream end as HA6. Stable banks with good cover from undercuts at upstream end.
Burn of Hamnavoe	HA8	HU 4974 8200	HU 4976 8220	Low to moderate gradient with glide, run and riffle flow types. Stable mossy boulders surrounded by cobble, gravel and pebble. Spawning habitat present.	Mainly low, stable banks with lots of undercuts providing overhead cover.
Burn of Hamnavoe	HA9	HU 4976 8220	HU 4985 8240	Riffle, run and glide sequences. In places stream has cut down to bedrock. Substrate mainly stable boulder and cobble. Depth typically 15 to 40 cm with pool to 80 cm.	Low, stable banks with undercuts providing overhead cover.
Burn of Hamnavoe	HA10	HU 4985 8240	HU 4995 8256	Narrow stream with moderate gradient and partly embedded substrates. Little bed transport. Depth typically 10 to 40 cm with run and glide flow types.	Incised peat banks with undercut turf providing good overhead cover.
Burn of Hamnavoe	HA11	HU 4995 8256	HU 5012 8274	Very varied section. Includes some good trout fry habitats near the sheep fank. Further upstream the stream flows between steep peat bank faces and flow type is mainly glide. Substrates are partly embedded. Bands of bedrock in upper reaches.	Incised peat banks with undercut turf providing good overhead cover.
Burn of Hamnavoe	HA12	HU 5012 8274	HU 5021 8293	Pool/deep glide flow interspersed with runs. Partly embedded cobble and boulder but also some patchy spawning at tails of glides.	Incised peat banks with undercut turf providing good overhead cover.
Burn of Hamnavoe	HA13	HU 5021 8293	HU 5032 8322	Runs and shallow riffles alternate with glides. Good spawning habitat is widespread. Little instream cover on bed but good overhead cover. Many fry present. Depth in runs 5 to 15 cm and 50 cm in pools.	Eroding banks at top of section provide cobble, pebble and gravel to stream. Elsewhere undercuts provide good overhead cover.
Burn of Hamnavoe	HA14	HU 5032 8322	HU 5037 8346	Good trout fry habitat with widespread spawning potential. Run, glide and shallow pool flow types.	Some areas of low, stable, grassy banks alternating with more deeply incised peat.
Burn of Hamnavoe	HA15	HU 5037 8346	HU 5015 8370	A little steeper than section HA14 with occasional patches of bedrock. Runs and shallow pools. Sections of embedded substrates but also some patches of pebble and gravel providing spawning opportunities.	Steep peat bank faces. Little erosion. Moderate cover from undercuts.
Unnamed tributary	HA16	HU 4990 8256	HU 5016 8259	Channel is partly unstable and braided at upstream end of reach. Substrate mainly of angular cobble and pebble with a little bedrock. Trout seen.	Active erosion of bank faces. Peat bank with some undercut turf creating overhead cover.
Unnamed tributary	HA17	HU 5016 8259	HU 5035 8266	Runs and shallow pools with some torrent. Depth 5 to 25 cm with substrate of angular cobble, boulder and shattered pebbles. Patchy bedrock.	Eroding peat bank faces.
Unnamed tributary	HA18	HU 5035 8266	HU 5056 8062	Mixed habitat with some deep, incised slow flowing reaches to 50 cm depth alternating with shallower runs and pools. Some peat substrates in deeper sections but mainly cobble and pebble elsewhere. Fish seen.	Steep, eroding peat. Erosion is slow and little slumping.
Burn of Evrawater	EV1	HU 5003 8076	HU 5030 8120	The channel through the (dry) Loch of Hamnavoe is difficult to follow as the stream is braided and in many places flows beneath turf. The upper parts of the	Wetland and wet pasture in lower reaches. Much eroding peat in upper

Watercourse	Section Code	NGR		Instream habitat description	Banks and riparian habitat
		Downstream	Upstream		
				section runs through and over eroded peat. No fish seen and habitat is mainly unsuitable.	parts of section.
Burn of Evrawater	EV2	HU 5030 8120	HU 5048 8149	Small shallow stream. Substrate is mainly mineral hardpan or eroded peat. Parts of the section flow underground. Depth mainly less than 10 cm. Largely unsuited to salmonid or other fish. Large deposits of eroded peat in pools.	Much eroded peat.
L. of Kettlester W inflow	KeW	HU 5133 8105	HU 5119 8112	Tiny first order stream. Partly flowing beneath turf. No movable substrate - bed is either eroded peat or mineral hardpan. Depth mainly less than 5 cm.	Peat banks. Low. No cover.
L. of Kettlester E inflow	KeE	HU 5141 5129	HU 5129 8115	Tiny first order stream. Inflow to loch is via a 15 m long peat pipe with stream below turf. Streambed in lower 50 m is mineral hardpan. Further upstream the burn is a poorly defined channel through peat hags with near-stagnant pools linked by tiny runs. Stream is totally unsuited to fish production.	Peat hags and bog.
Burn of Horsewater	HO1	HU 5310 8189	HU 5280 8170	Lower reaches immediately upstream of Loch of East Yell have moderate gradient. Substrate is cobble embedded in mineral hardpan. Flow type is mainly run with occasional shallow pools. Further upstream gradient is steep with torrents and little pools. Immobile substrate embedded in hardpan. Some bryophytes. Some sections up to 15 m long flow beneath turf.	Incised channel through earth and peat banks. Many short sections flow under turf.
Burn of Horsewater	HO2	HU 5280 8170	HU 5262 8172	Substrate is mineral hardpan with some gritty sand and peat. Depth varies from 5 to 40 cm. Flow types are torrent, run and shallow pool. Many little cascades to 0.5 m in height. Pools might support trout but habitat of poor quality and spawning substrates lacking.	Much undercut with some peat tunnel.
Litla Water outflow	HO3	HU 5239 8156	HU 5228 8170	Tiny channel incised in peat alternating with poorly defined wet flush habitat. Totally unsuited to salmonid fish.	Wet flush and incised peat.
Swarta Shun outflow	HO4	HU 5238 8148	HU 5220 8126	All visible substrate is peat. Much of the section is below ground. The rest is a simple incised peat channel with some small pools close to Horse Water.	Incised peat. Banks close over stream in many places.
Green Burn	GR1	HU 5201 8318	HU 5196 8300	Lower part of survey section is 1.8 to 2 m wide with substrate of slightly unstable angular cobble, boulder and pebble. Gradient is moderate to steep with many sections of run and riffle. Depth 10 to 30 cm. Gradient eases approximately 80 m upstream of the Gossabrough road bridge and the stream is 30 to 80 cm with glide and pool flow types linked by short runs. Substrate in these reaches is partly embedded, stable boulder and cobble with some granule.	Low stable grassy banks in lower reaches giving way to stepper incised peat faces further upstream. Wet width mainly equals bed and undercuts provide plenty overhead cover.
Green Burn	GR2	HU 5196 8300	HU 5190 8281	Most of section is 30 to 70 cm deep with slow to moderate current speed. The channel is incised between steep peat bank faces. Substrates mainly hard and immobile with short sections of soft peat. The top 30 m of the section are steeper and shallower with substrates of cobble, pebble and boulder.	Good overhead cover from undercut banks.
Green Burn	GR3	HU 5190 8281	HU 5180 8264	Downstream end has stable substrates of cobble and boulder. Further upstream the channel is deeply entrenched between peat banks and substrate is mainly sand and gravel lying in a thin layer on top of peat. There is another short (15 m)	Good overhead cover from undercut banks. Stable.

Watercourse	Section Code	NGR		Instream habitat description	Banks and riparian habitat
		Downstream	Upstream		
				section of boulder habitat immediately downstream of the B9081 road.	
Green Burn	GR4	HU 5180 8264	HU 5162 8241	Channel is incised through peat. Broad pools are linked by narrow runs. Substrate is almost entirely peat with a few areas where coarse sand and gravel form a thin layer on top. Depth typically 30 cm to 1 m. Poor quality habitat for trout or eels.	Incised peat with overhead cover from undercuts. Upper reaches flow through eroded peat hags.

Annex 5. Stream survey data and salmonid habitat quality.

Section Code	Visible streambed (%)	Width (m)		Substrate		Instream cover	Bankside cover (% of bank length)		Accessible to salmon/sea trout?	Quality for salmon		Quality for trout	
		Wet	Bank	Stability	Compaction		Left	Right		Fry	Parr	Fry	Parr
AR1	90	5.5	6.5	Stable	Uncompacted	Good	10 - 25	10 - 25	Yes	Good	Good	Good	Good
AR2	50	10	10	Stable	Uncompacted	Good	10 - 25	10 - 25	Yes	Good	Good	Good	Good
AR3	50	6	6	Stable	Partly	Good	10 - 25	10 - 25	Yes	Good	Good	Good	Good
AR4	50	7	7	Stable	Partly	Good	10 - 25	10 - 25	Yes	Good	Good	Good	Good
AR5	60	4.5	4.5	Stable	Uncompacted	Good	>25	>25	Yes	Moderate	Good	Moderate	Good
HA1	70	3.5	4	Moderate	Uncompacted	Good	<10	<10	Yes	Good	Good	Good	Moderate
HA2	70	3.5	4	Unstable	Uncompacted	Good	<10	<10	Yes	Good	Good	Moderate	Moderate
HA3	60	3	3.5	Moderate	Uncompacted	Moderate	<10	<10	Yes	Moderate	Moderate	Moderate	Moderate
HA4	60	3	4	Moderate	Uncompacted	Moderate	10 - 25	10 - 25	Yes	Moderate	Moderate	Moderate	Moderate
HA5	60	3	3.2	Moderate	Uncompacted	Good	10 - 25	10 - 25	Yes	Moderate	Moderate	Moderate	Good
HA6	70	3.3	4	Unstable	Uncompacted	Good	<10	<10	Yes	Moderate	Moderate	Moderate	Moderate
HA7	60	3.0	3.5	Moderate	Uncompacted	Good	10 - 25	10 - 25	Yes	Moderate	Moderate	Moderate	Moderate
HA8	50	2.5	2.7	Stable	Uncompacted	Moderate	>25	>25	Yes	Moderate	Moderate	Moderate	Good
HA9	40	2.0	2.0	Stable	Partly	Moderate	>25	>25	Yes	Poor	Moderate	Moderate	Good
HA10	50	1.8	1.8	Stable	Partly	Moderate	>25	>25	Yes	Poor	Moderate	Moderate	Moderate
HA11	40	1.8	1.8	Stable	Partly	Moderate	10 - 25	10 - 25	Unknown	Poor	Poor	Moderate	Moderate
HA12	30	1.8	1.8	Moderate	Partly	Moderate	>25	>25	Unknown	Poor	Poor	Moderate	Moderate
HA13	50	1.5	1.5	Stable	Uncompacted	Poor	>25	>25	Unknown	Poor	Poor	Good	Moderate
HA14	70	1.6	1.7	Stable	Uncompacted	Poor	10 - 25	10 - 25	Unknown	Moderate	Poor	Good	Moderate
HA15	60	1.2	1.2	Stable	Partly	Moderate	10 - 25	10 - 25	Unknown	Poor	Poor	Moderate	Moderate
HA16	40	0.7	0.8	Moderate	Uncompacted	Poor-Moderate	10 - 25	10 - 25	Unknown	Poor	Poor	Poor-Moderate	Poor-Moderate
HA17	50	0.8	0.9	Unstable	Uncompacted	Poor-Moderate	10 - 25	10 - 25	Unknown	Poor	Poor	Poor-Moderate	Poor-Moderate
HA18	50	0.7	0.8	Stable	Partly	Poor-Moderate	>25	>25	Unknown	Poor	Poor	Poor-Moderate	Poor
EV1	20	0.6	0.6	Stable	Partly	Poor	>25	>25	Unknown	Unsuitable	Unsuitable	Poor-unsuitable	Poor-unsuitable
EV2	60	0.5	0.5	Stable	Compacted	Poor	10 - 25	10 - 25	Unknown	Unsuitable	Unsuitable	Poor-unsuitable	Poor-unsuitable

Section Code	Visible streambed (%)	Width (m)		Substrate		Instream cover	Bankside cover (% of bank length)		Accessible to salmon/sea trout?	Quality for salmon		Quality for trout	
		Wet	Bank	Stability	Compaction		Left	Right		Fry	Parr	Fry	Parr
KeW	80	0.5	0.5	Stable	Compacted	Poor	<10	<10	Unknown	Unsuitable	Unsuitable	Unsuitable	Unsuitable
KeE	90	0.5	0.5	Stable	Compacted	Poor	10 - 25	10 - 25	Unknown	Unsuitable	Unsuitable	Unsuitable	Unsuitable
HO1	30	0.6	0.6	Stable	Compacted	Poor	>25	>25	Yes	Unsuitable	Unsuitable	Poor	Poor
HO2	25	0.5	0.5	Stable	Compacted	Poor	>25	>25	Unknown	Unsuitable	Unsuitable	Poor	Poor
HO3	20	0.2	0.2	NA	NA	Poor	NA	NA	Unknown	Unsuitable	Unsuitable	Unsuitable	Unsuitable
HO4	30	0.3	0.3	NA	NA	Poor	NA	NA	Unknown	Unsuitable	Unsuitable	Unsuitable	Unsuitable
GR1	30	1.5	1.5	Stable	Partly	Moderate	>25	>25	Yes	Poor	Poor	Moderate	Moderate
GR2	10	1.5	1.5	Stable	Partly	Poor	>25	>25	Yes	Poor	Poor	Moderate	Moderate
GR3	25	1.1	1.1	Stable	Uncompacted	Poor	>25	>25	Yes	Poor	Poor	Moderate	Moderate
GR4	5	1.5	1.5	Stable	Uncompacted	Poor	>25	>25	Unknown	Unsuitable	Poor	Poor	Poor

Annex 6. Spawning habitats recorded during walkover surveys

Watercourse	Survey section	NGR	Area (m^2)	Washout risk?	Suitability	
					Salmon	Trout
Burn of Arisdale	AR3	HU 4843 8154	7	No	Suitable	Suitable
Burn of Arisdale	AR4	HU 4840 8162	9	No	Suitable	Suitable
Burn of Arisdale	AR4	HU 4837 8164	6	No	Suitable	Suitable
Burn of Arisdale	AR4	HU 4838 8166	8	No	Suitable	Suitable
Burn of Hamnavoe	HA2.1	HU 4942 8065	2	Possible	Suitable	Suitable
Burn of Hamnavoe	HA4.1	various	2	Possible	Unsuitable	Suitable
Burn of Hamnavoe	HA7.1	HU 4975 8195	2.5	No	Poor	Suitable
Burn of Hamnavoe	HA8.1	HU 4974 8209	1	No	Unsuitable	Suitable
Burn of Hamnavoe	HA8.2	HU 4974 8215	4.5	No	Suitable	Suitable
Burn of Hamnavoe	HA9.1	HU 4979 8230	0.5	No	Unsuitable	Suitable
Burn of Hamnavoe	HA9.2	HU 4983 8230	1	Poor	Unsuitable	Suitable
Burn of Hamnavoe	HA9.3	HU 4983 8231	0.8	No	Unsuitable	Suitable
Burn of Hamnavoe	HA11.1	HU 5004 8262	0.6	No	Unsuitable	Suitable
Burn of Hamnavoe	HA11.2	HU 5012 8274	1.7	No	Poor	Suitable
Burn of Hamnavoe	HA12.1	HU 5012 8275	1.5	No	Poor	Suitable
Burn of Hamnavoe	HA12.2	HU 5020 8290	0.5	No	Unsuitable	Suitable
Burn of Hamnavoe	HA13.1	HU 5025 8300	1.2	No	Poor	Suitable
Burn of Hamnavoe	HA13.2	HU 5024 8303	1.5	No	Poor	Suitable
Burn of Hamnavoe	HA13.3	HU 5027 8304	4.4	No	Poor	Suitable
Burn of Hamnavoe	HA13.4	HU 5033 8317	0.7	No	Poor	Suitable
Burn of Hamnavoe	HA14.1	HU 5033 8324	3	No	Poor	Suitable
Burn of Hamnavoe	HA14.2	HU 5033 8334	0.5	No	Poor	Suitable
Burn of Hamnavoe	HA14.3	HU 5035 8339	0.5	No	Poor	Suitable
Burn of Hamnavoe	HA15.1	HU 5037 8349	2	No	Poor	Suitable
Unnamed tributary	HA17.1	HU 5017 8257	0.5	No	Unsuitable	Suitable
Loch of Kettlester	NA	HU 5142 8105	5	No	Poor	Poor
Green Burn	Gr3.1	various	1.5	No	Unsuitable	Suitable
Green Burn	GR3.2	HU 5180 8265	2	No	Poor	Suitable

Annex 7.1. Habitat survey photographs Burn of Arisdale

Section AR1. HU 4856 8105

Section AR1. HU 4854 8121

Section AR2. pool behind weir HU 4858 8130

Section AR3. HU4848 8141

Section AR4. HU 4843 8158

Section AR5. HU 4842 8184

Annex 7.2. Habitat survey photographs Burn of Hamnavoe

Section HA1. HU 4934 8043

Section HA2. HU 4942 8066

Section HA3. HU 4954 8113

Section HA 4. HU 4970 8121

Section HA 5. HU 44971 8126

Section HA6. HU 4969 8149

Annex 7.2. Habitat survey photographs Burn of Hamnavoe

Section HA7. HU 4969 8168

Section HA8. HU 4973 8203

Section HA9. HU 4983 8231

Section HA 10. HU 4999 8255

Section HA 11. HU 5004 8267

Section HA11. Rock ramp at HU 5009 8273

Annex 7.2. Habitat survey photographs Burn of Hamnavoe

Section HA12. Spawning substrates at HU 5012 8275

Section HA12. HU 5019 8283

Section HA13. HU 5032 8322

Section HA13. HU 5024 8303

Section HA 14. HU 50 36 8342

Section HA15. HU 5032 8356

Annex 7.3. Habitat survey photographs Burn of Hamnavoe unnamed tributary

Section HA16. HU 5007 8259

Section HA17. HU 5016 8258

Section HA17. HU 5024 8259

Section HA18. HU 5042 8266

Annex 7.4. Habitat survey photographs Burn of Evrawater

Section EV1. HU 5020 8101

Section EV1. HU 5025 8106

Section EV2. HU 5038 8135

Section EV2. HU HU 5038 8135

Section EV2. HU 5038 8137

Section EV2. HU 5048 8149

Annex 7.5. Habitat survey photographs Loch of Kettlester inflow streams

Section KeW. HU 5133 8105 (looking up from loch)

Section KeW. HU 5120 8110

Section KeW. HU 5119 8112

Section KeE. HU 5141 8106 (looking up from loch)

Section KeE. HU 5139 8111

Section KeE. HU 5131 8114

Annex 7.5. Habitat survey photographs Mill Burn and Burn of Horsewater

Mill Burn near NTL (ruined click mill behind fence)

Section HO1. HU 5310 8189 (inflow to Loch of East Yell)

Section HO1. HU 5294 8179

Section HO2. HU 5280 8170

Section HO2. HU 5262 8172 (looking downstream)

Section HO2. HU 5262 8172 (Horse Water outflow)

Annex 7.6. Horse Water inflow streams

HO 3. Litla Water outflow at HU 5237 8155 (looking downstream to Horse Water)

Section HO3. HU 5310 8189 HU 5237 815 (looking upstream)

Section HO3. HU 5234 8166

Section HO4. Swarta Shun outflow HU 5238 8148 (looking downstream to Horse Water)

Section HO4. HU 5228 8131 (downstream end of peat pipe)

Section HO4. HU 5234 8144

Annex 7.7. Habitat survey photographs Green Burn

Section GR1. Culvert at HU 5201 8318

Section GR1. HU 5201 8318

Section GR2. HU 5199 8306

Section GR3. HU 5910 8280

Section GR3. HU 5187 8275

Section GR3. Culvert at 5180 8264

Annex 7.7. Habitat survey photographs Green Burn

Section GR3. Culvert at 5180 8264

Section GR3. Culvert at 5180 8264

Section GR4. HU 5180 8266

Section GR4. HU 5167 8254

Section GR3. HU 5162 8254

Section GR4. Riparian habitat at HU 5165 8249

Annex 8. Quantitative electric fishing site photographs

	Burn of Arisdale A1 downstream HU 48536 81142
	A1 site from downstream
	A1 upstream

Annex 8. Quantitative electric fishing site photographs contd.

	Burn of Arisdale A2 downstream HU 48382 81662
	A2 site from downstream
	A2 upstream

Annex 8. Quantitative electric fishing site photographs contd.

	Burn of Arisdale A3 downstream HU 48420 81778
	A3 site from downstream
	A3 upstream

Annex 8. Quantitative electric fishing site photographs contd.

	Burn of Hamnavoe H1 downstream HU 49614 81170
	H1 middle of section from upstream
	H1 upstream

Annex 8. Quantitative electric fishing site photographs contd.

	Burn of Hamnavoe H2 downstream HU 49739 82088
	H2 upstream
	Burn of Hamnavoe H3 downstream (from downstream) HU 50269 83061

Annex 8. Quantitative electric fishing site photographs contd.

	H3 site – typical habitat at survey site
	H3 upstream (looking downstream)
	Loch of Kettlester outflow K1 downstream HU 51612 80829

Annex 8. Quantitative electric fishing site photographs contd.

	Green Burn G1 downstream HU 52049 83276
	Green Burn G2 downstream HU 51913 82846
	G2 typical habitat at survey site