BAT SURVEY REPORT CRAIGINMODDIE WIND FARM

Bat Survey Report 2020

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Craiginmoddie Wind Farm
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EXECUTIVE SUMMARY

RPS was commissioned by EnergieKontor UK Ltd (EKUK) to undertake bat surveys to assess potential effects from the proposed Craiginmoddie Wind Farm on bat species The aim of the surveys undertaken in summer 2020 were to identify the bat species present on Site, assess their activity level, locate roosts at significant risk of disturbance, and assess the potential risk level to each species.

An assessment of the habitat suitability for bat roosting, foraging and commuting was conducted, and a desk study was carried out in support of the field surveys.

During the desk study within 10km of the Site six species of bats were identified: whiskered/Brandt's, Daubenton's, Natterer's, Leisler's, brown long-eared, common pipistrelle and soprano pipistrelle. In the data search only one bat roost (soprano pipistrelle) was identified in the village of Kirkmichael approximately 9km to the north of the Site. The habitats within the Site are dominated by coniferous forestry plantation interspersed with open watercourses and rides of varying sizes. To the east section of the Site there is an area of restocked Sitka spruce (on moorland), and the Site is surrounded by open moorland and further forestry plantation. There are a number of watercourses and small waterbodies within the Site and in the surrounding area. The Site was considered to have moderate potential for foraging and commuting bats and negligible potential for roosting bats, due to the lack of buildings or trees with suitable features to support them within the Site.

Static detectors were deployed at twelve locations across the Site. Bat passes from eight bat species (common pipistrelle, soprano pipistrelle, Nathusius' pipistrelle, Daubenton's, Natterer's, Leisler's, noctule and brown long-eared bats) were recorded. When data from similar sites was compared using the online comparison tool Ecobat (in line with current guidance), bat activity levels at this Site were assessed as moderate.

An assessment of risk from the development concerning bat displacement and mortality was made using parameters outlined in the most recent industry standard guidance. Overall, the development is considered as presenting medium risk to bats.

Best practice mitigation measures are recommended within the report to minimise potential negative effects on bat species. These include micro-siting the proposed layout of the turbines, at least 50m from key habitat features commonly used by bats. Should this be achieved the impacts are likely to be low and not of a level to impact the bat population. Additional mitigation measures including monitoring and habitat management are also recommended.

1 INTRODUCTION

1.1 Background

RPS was commissioned by EnergieKontor UK Ltd (EKUK) to undertake bat surveys to assess potential effects from the proposed Craiginmoddie Wind Farm on bat species. The proposed development is for fourteen turbines and is located approximately 14.5 km east of Girvan, South Ayrshire (central Ordnance Survey (OS) grid reference NX 31270 98438).

The aims of the surveys were to:

- identify the bat species present on site;
- assess their activity level;
- locate roosts at significant risk of disturbance; and
- investigate the potential risk level to each species.

1.2 Relevant Protected Species Legislation

This section describes the legislation pertaining to bat species which may be present on site that informs the requirement for, and nature of, all bat related ecological surveys.

1.2.1 The Habitats Directive

The Habitats Directive (European Union Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) requires national governments to specify areas that are expected to ensure the conservation of flora and fauna species (Natura 2000 sites). A number of Annexes accompany the directive which outline the protected habitats and species associated with this legislation. Bat species are listed on Annex II (species requiring designation of Special Conservation Areas) and Annex IV (animals and plant species in need of strict protection) of the directive, and whilst no Natura 2000 sites are specifically designated for bat species within Scotland, all bat species are afforded appropriate protection under this legislation.

1.2.2 The Conservation of Habitats and Species Regulations 1994 (as amended)

The Habitats Directive is transposed into law in Scotland through the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended).

This legislation makes it an offence to deliberately or recklessly disturb European Protected Species (EPS). Their places of shelter are fully protected, and it is an offence to damage, destroy or obstruct access to, or otherwise deny, the animal use of a breeding site or resting site, whether deliberately or not. It is also an offence to disturb in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species, disturb in a manner, or circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young. Any activity which is likely to affect these species requires prior consultation with the relevant statutory nature conservation organisation (i.e. NatureScot) and may require a licence to be issued before they can be carried out.

1.3 Terms

The below terms will be used throughout the report:

- **Site** - the development's area, as shown in Figure 1; and
- **Survey boundary** – the Site plus a 250m buffer used for the bat scoping survey.

2 METHODOLOGY

2.1 Desk Study

A desk study received on 29 August 2020 was undertaken to support the field surveys. The South West Scotland Environmental Information Centre (SWSEIC) were contacted for records for all bat species within a 10km buffer of the Site within the last 10 years.

Where the data search returned records of bat species, the location of the record in relation to the edge of that species' known range in Scotland was assessed by consulting the Article 17 Habitats Directive Report 2019: Species Conservation Status Assessments 2019 (JNCC, 2019) and Mathews *et al*. (2018).

There are no known statutory designated sites in Scotland with bats as a qualifying feature, as such a search for these was not undertaken for the purpose of this report.

Aerial imagery (Google Earth Pro) and Ordnance Survey maps were studied to determine topographic and landscape features which might affect bats' use of the Site and surrounding area.

2.2 Field Surveys

2.2.1 Habitat Assessment

An assessment of the survey area was carried out by an experienced RPS ecologist. The potential value of the habitats and features present for foraging and commuting bats was assessed within the site boundary and a 250m bat survey area (Figure 1) using the criteria from the current guidance (Collins, 2016), displayed in Table 1.

Table 1: Bat Habitat Suitability Criteria

Suitability	Description of Roosting Habitat	Foraging and Commuting Habitat
Negligible	Negligible habitat features on site not likely to be used by roosting bats.	Negligible habitat features on site not likely to be used by commuting or foraging bats.
Low	A structure with one or more potential roost sites that could be used by individual bats opportunistically. However, these potential roost sites do not provide enough space, shelter, protection, appropriate conditions and/or suitable surrounding habitat to be used on a regular basis or by larger numbers of bats (i.e. unlikely to be suitable for maternity or hibernation).	Habitat that could be used by small numbers of commuting bats such as gappy hedgerow or un-vegetated streams, but isolated, i.e. not very well connected to the surrounding landscape by other habitat. Suitable, but isolated habitat that could be used by small numbers of foraging bats such as a lone tree (not in a parkland situation) or a patch of scrub.
Moderate	A structure or tree of sufficient size and age to contain potential roost features but with none seen from the ground or features seen with only very limited roosting potential.	Continuous habitat connected to the wider landscape that could be used by bats for commuting such as lines of trees and scrub or linked back gardens. Habitat that is connected to the wider landscape that could be used by bats for foraging such as trees, scrub, grassland or water.
High	A structure or tree with one or more potential roost sites that could be used by bats due to its size, shelter, protection, conditions and surrounding habitat but unlikely to support a roost of high conservation status (with respect to roost type only – the assessments in this table are made irrespective of species conservation status, which is established after presence is confirmed).	Continuous, high-quality habitat that is well connected to the wider landscape that is likely to be used regularly by commuting bats such as river valleys, streams, hedgerows, lines of trees and woodland edge. Site close to and connected to known roosts.

Table Notes

Table reproduced from Bat Conservation Trust (BCT) Guidance (Collins, 2016)

2.2.2 Activity Surveys

Ground-level Static Surveys

Activity surveys, comprising of the deployment of static recorders were completed during the main bat activity season (May to September) covering the three key activity periods: spring migration, maternity and autumn dispersal. The surveys were designed using an indicative turbine layout, prior to receiving

infrastructure plans. Therefore, following guidance, they were designed to sample the indicative developable Site's habitats at the time of commissioning.

To comply with current industry guidance (SNH, 2019), static detectors were deployed for a minimum of ten nights in each activity period. Deployment dates are shown in Table A.1, in Appendix A. Under current guidance detectors should be placed at ten potential turbine locations, plus a third of additional potential turbine sites to a maximum of 40 detectors (SNH, 2019), therefore twelve static detectors were used as this is proportional to the proposed number of turbines for the development.

Anabat Swift, Anabat Express and Song Meter SM2BAT bat detectors, recording to SD cards, were used for the static monitoring. The types of detectors used at each location are shown in Table A.1, in Appendix A. The Anabat Swift and Song Meter bat detectors were programmed to record in full spectrum with the Anabat Express recording in zero crossing. Omnidirectional microphones were used on all detectors, and where possible detectors were placed 2m above the ground. They were programmed to begin recording an hour before sunset and stop one hour after sunrise. Standard guidance recommends recording within 30 minutes of sunset and sunrise; however, extending this to 1 hour of sunrise and sunset allows for the assessment of any early emerging species on the Site.

Weather Data

The weather data (temperature and wind speed) for the spring and autumn deployment was collected from the Weather Station ID is IGIRVA3 located at OS grid reference NX 30898 95674, from the Wunderground website[1]. Rainfall data was received from the Scottish Environment Protection Agency (SEPA) Penwhapple Reservoir number 335375 at OS grid reference NX 25606 97473. The Davis Weather Station and data logger did not collect data for these time periods due to a technical fault.

The weather data for the summer deployment was collected by a remote Davis Weather Station and data logger located at OS grid reference NX 68163 87355 within the Site.

The hourly rainfall during the deployment of detectors throughout spring, summer and autumn is displayed in Table B.1, Appendix B. Nights where there were weather conditions which were deemed suboptimal including high rainfall, windspeed over 5m/s and nights under 8°C are highlighted in grey.

2.3 Data Analysis

Recordings from the bat activity surveys were analysed with specialised software (Kaleidoscope Pro, Version 5.1.9g) by an experienced ecologist to confirm the bat species present.

Kaleidoscope Pro software compares the echolocation pulses to an integrated library of bat calls, and automatically identifies the call as corresponding to a particular species. Following the batch analysis of all calls, 10% of all *Pipistrellus* species calls and noise files were manually checked. All calls of *Myotis* species, *Nyctalus* species and calls with no auto-identification or with multiple bats within the same call were checked manually to confirm identification.

During manual analysis, calls were assigned to species according to their key parameters and where applicable their peak frequency, as shown in Table 2 (Russ, 1999).

Table 2: Bat Species and their Call Frequency Parameters

Species	Latin Name	Call Frequency
Soprano pipistrelle	*Pipistrellus pygmaeus*	FM/qCF calls above 52 kHz
Pipistrelle unidentified species	*Pipistrellus spp.*	FM/qCF calls between 40 and 42 kHz; and, 48 and 52 kHz
Common pipistrelle	*Pipistrellus pipistrellus*	FM/qCF calls between 40 kHz and 48 kHz
Nathusius' pipistrelle	*Pipistrellus nathusii*	FM/qCF calls below 40 kHz
Natterer's bat	*Myotis nattereri*	FM call with wide range between 23 and 107 kHz
Daubenton's bat	*Myotis daubentonii*	FM call with wide range between 30 and 81 kHz
Myotis spp.	-	FM calls greater than 30 kHz

[1] https://www.wunderground.com

Species	Latin Name	Call Frequency
Brown Long-eared bat	*Plecotus auritus*	FM calls greater than 30 kHz with two harmonics
Noctule	*Nyctalus noctula*	FM/qCF calls below 23 kHz
Leisler's bat	*Nyctalus leisleri*	qCF calls between 23 and 28 kHz
Nyctalus spp.	-	Low (less than 30 kHz) qCF or FM calls

Table Notes

FM – Frequency modulated call; CF – constant frequency call; qCF – quasi-constant frequency call. Bats combine variation within their echolocation pulses to create different call 'shapes'. These call shapes can be described in terms of the degree of FM, CF and qCF components they contain.

Not all calls could be positively assigned to species. Call frequencies and shapes can be shared by bat species within the same genus and can change according to the habitat they are flying in, i.e. open areas with no trees or structures such as moorlands, or cluttered environments which contain trees, areas of scrub or linear features such as burns and conifer plantation/woodland edge. Bats adapt their call patterns within their habitats to enable prey detection and navigation and as such, the recordings may differ in parameters. For example, both Leisler's bat and noctules can echolocate at the same frequency and with the same call shape and therefore, where it is not possible to distinguish species they have been assigned to the *Nyctalus* species category and not identified to species level. Similarly, a bat was classified as *Myotis* species if differences in call shape and frequency between Daubenton's bats and Natterer's bats (the most likely *Myotis* species bat to be found in the area) could not be discerned.

2.3.1 Bat Activity Indices

Static detectors record bats as they pass but there is no observer to record whether one bat passes a hundred times, or a hundred bats pass in succession, or the direction of flight. Therefore, in order to standardise the data and enable some comparison of deployment nights, the accepted approach is to use bat 'passes' as a unit of activity.

Numbers of bat 'passes' recorded are used as the standard measure to create a relative index of bat activity. During transects, the number of times a bat was encountered is described as the number of bat passes. A bat 'pass' was defined as a series of ≥ 2 consecutive echolocation calls having <1 second separating each call, and up to 10 seconds long (Hayes, 1997; Cook *et al*., 2008).

For automated detector data, the index of bat activity used was the number of files recorded each night which contained bat calls, taken as the number of bat passes per night (bppn). As one file has been taken to equating to one bat pass, an average nightly activity index (Bat Activity Index (BAI)) was calculated for each detector deployment. The BAI also removes any bias created by the variation in the duration of the static detector deployment periods.

2.3.2 Ecobat

The Ecobat[2] tool is an online freely available means of comparing activity levels found on this site with other sites within a given radius at the same time of year and in comparable weather conditions.

The reference range comparison dataset was stratified to include:

- only records from within 30 days of the survey date;
- only records from within 100 km2 of the survey area.

Ecobat generates a percentile rank for each night of activity and provides a numerical way of interpreting the levels of activity recorded at a site across regions in Britain. The percentiles provide a numerical indicator of the relative importance of a nights' worth of bat activity by comparing it other sites within 100km and 30 days of the record. Percentiles can then be assigned to activity categories (low, moderate, high) to provide a quantifiable measure of bat activity (Table 3).

[2] http://www.ecobat.org.uk/

Table 3: Percentile Score and Categorised Level of Bat Activity

Percentile	EcoBat Activity Category
81 to 100	High (5)
61 to 80	Moderate to High (4)
41 to 60	Moderate (3)
21 to 40	Low to Moderate (2)
0 to 20	Low (1)

2.3.3 Risk Assessment

The risk to bats from wind turbines is from death either by direct collision or death through injury (including barotrauma[3]). The impact of a single bat death is unlikely to be significant on any scale, but cumulative losses of individual bats could potentially threaten the viability of local or even national populations. The relevance of the loss of a single bat on local populations depends on the size of a local population, and the online tool Ecobat uses relevant data sets allowing consideration of location within the assessment.

The risk assessment carried out within this report follows that outlined in the current guidance (SNH, 2019). Tables 4 and 5 below present the factors to consider when assessing potential risk to bats. Table 4 gives an indication of potential site risk based on a consideration of habitat and development related features. Project Size and Habitat Risk criteria are outlined in Table C.1 and C.2 in Appendix C.

Table 4: Initial Site Risk Assessment

Site Risk Level (1-5)		Project Size		
		Small*	Medium*	Large*
Habitat Risk	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5

Table Notes

Table adapted from SNH et al. (2019). Green (1-2) - low/lowest site risk; Amber (3) - medium site risk; Red (4-5) - high/highest site risk.

An overall assessment of risk can then be made by considering the site assessment in relation to the bat activity output from Ecobat, which considers the relative vulnerability of each species of bat present, at the population level (Table 5).

Table 5: Overall Risk Assessment

Site Risk Level (from Table 5)	Ecobat Activity Category					
	Nil (0)	Low (1)	Low-moderate (2)	Moderate (3)	Moderate-high (4)	High (5)
Lowest (1)	0	1	2	3	4	5
Low (2)	0	2	4	6	8	10
Med (3)	0	3	6	9	12	15
High (4)	0	4	8	12	15	18
Highest (5)	0	5	10	15	20	25

Table Notes

Table adapted from SNH *et al.* (2019). Overall assessment: Low (green) 0 – 4; Medium (amber) 5 – 12; High (red) 15 – 25.

[3] Barotrauma is when soft tissues, such as the lungs, are damaged due to the sudden change in air pressure in the wake of rotating turbine blades. It results in fatal internal bleeding (Baerwald *et al.*, 2009).

2.4 Limitations

2.4.1 Desk Based Assessment

The desk study data is third party controlled data, purchased for the purposes of this report only. RPS cannot vouch for its accuracy and cannot be held liable for any error(s) in these data.

2.4.2 Ecobat Analysis

There are limitations associated with this assessment in so far as the use of the Ecobat analysis tool as required by SNH (2019)[2] is reliant on third party data, and the accuracy of the results returned using the Ecobat tool requires a substantial amount of records to be present.

It should be noted that the Reference Range[4] (as shown in Table D.1 Appendix D) that Ecobat returned to provide the above analysis was below the recommended 200+ for: Daubenton's bat with 91 records, Natterer's bat with 23 records, brown long-eared bat with 121 records and Nathusius' pipistrelle one record. There is nothing that can be done regarding the Reference Range provided by Ecobat as this is reliant on third party data, the number of records provided to Ecobat and the abundance of the particular species in the reference area. Whilst the Reference Range provided for these species is limited, Ecobat does still provide a comparable assessment of bat activity for the region which should be considered during the assessment of the effects of the development on bat species and their populations.

2.4.3 Surveys

During the summer deployment detector failure due to technical issues meant that no data was collected at detector location 07. In the autumn deployment there were partial failures due to technical issues at detector locations 01, 03, 04 and 07. Also during the autumn deployment technical issues caused a complete failure at detector locations 05 and 11. Given the coverage of the Site and the data collected is it deemed that this will not have a detrimental effect on the assessment of the Site or the conclusions drawn from the data.

During the spring deployment five out of eleven nights deployment had some periods which were not of optimal weather conditions. This is not unusual for this time of year in Scotland and has not had a detrimental effect on the assessment of the Site or the conclusions drawn from the data.

The detector locations were based on the initial plan which since then has been altered. As the static detector locations shown in Figure 1 cover a representative sample of the habitats this change has not had a detrimental effect on the assessment of the Site, or the conclusions drawn from the data.

2.4.4 Accurate Lifespan of Ecological Data

The majority of ecological data remain valid for only short periods due to the inherently transient nature of the subject. In line with current CIEEM guidance[5] the survey results and associated assessments contained in this report are considered valid for eighteen months from the date of data collection, assuming no significant changes to the Site conditions.

[4] The Reference Range is the number of nights for each species within the Ecobat database that the site data is compared to with to provide an estimate of comparable activity levels (low, moderate or high). Ecobat guidance recommends a Reference Range of 2000+ records to be confident in the relative activity level.

[5] https://cieem.net/wp-content/uploads/2019/04/Advice-Note.pdf

3 RESULTS

3.1 Desk Study

3.1.1 Bat Records

Six species of bat have been recorded within 10km of the Site boundary along with one confirmed bat roosting site of a soprano pipistrelle bat. The details of all the bat records returned from SWSEIC can be found in Table 6 and 7.

Table 6: Bat Species Recorded with in 10km of the Site

Scientific Name	Common Name	Number of Records	Last Recorded
Myotis	Unidentified Bat	5	2016
Myotis mystacinus/brandtii	Whiskered/Brandt's Bat	1	2016
Myotis daubentonii	Daubenton's Bat	5	2016
Myotis nattereri	Natterer's Bat	7	2016
Nyctalus leisleri	Lesser Noctule	3	2016
Pipistrellus	Pipistrelle Bat species	27	2016
Pipistrellus pipistrellus	Common Pipistrelle	14	2016
Pipistrellus pygmaeus	Soprano Pipistrelle	20	2016

Table 7: Bat Roosts Recorded

Scientific Name	Common Name	Date	Location	Grid Reference
Pipistrellus pygmaeus	Soprano Pipistrelle	2014	Kirkmichael (Straiton Road), Ayrshire	NS 3408 0844

3.1.2 Bat Species Range Relative to the Site

The bat species range assessment, as shown in Table 8, identified that the wind farm was within the known range of five species of bats, and is on the edge of the known range of one other (JNCC, 2019).

Table 8: Species Range Relative to the Site

Species	Site's Relationship to Known Range	Known Roost within 10 km
Common pipistrelle	Within its known range	None
Soprano pipistrelle	Within its known range	One record
Daubenton's bat	Within its known range	None
Natterer's bat	At the edge of its known range	None
Whiskered/Brandt's	Within its known range	None
Leisler's	Within its known range	None

3.2 Field Survey Results

3.2.1 Habitat Assessment

The Site is dominated by coniferous forestry plantation interspersed with open watercourses and rides of varying sizes. To the east section of the Site there is an area of restocked Sitka spruce (*Picea sitchensis*) on moorland, and the Site is surrounded by open moorland and further forestry plantation.

The watercourses such as the Auchengairn Burn located in the south of the Site offer good connectivity to the wider environment via the Dalquhairn Burn and the River Stincher. Although the Site itself is dominated by conifer plantation this connects visa the Auchengairn Burn to an area of mature trees bordering the Dalquhairn Burn.

Overall, the Site was considered to have moderate potential for foraging and commuting bats with no opportunities for roosting bats.

The only potential roosting opportunity was identified with in the survey boundary (Doughty Farm). The farm is located just over 1km south east of the nearest turbine location. No access to the farm was available at the time of the surveys; however, given the distance from the nearest turbine location and the more optimal habitat to the south of the Site the likelihood of any potential roosts being affected by the Craiginmoddie Wind Farm development is negligible.

The locations of the static detectors are detailed in Table 9 and Figure 1 with a brief description of the surrounding habitat and the presence of any linear features such as watercourses and woodland edges.

Table 9: Location of Static Bat Detectors

Detector	OS Grid Reference	Habitat Type(s)	Details	Photos
Location 01	NX 30472 97824	Plantation woodland	Located adjacent to the access track in a large clearing and at the junction of several forest rides.	 Photo 01. Detector location 01
Location 02	NX 30846 97795	Plantation woodland	Located beside the main access track, flanked by plantation woodland.	 Photo 02. Detector location 02
Location 03	NX 31336 97660	Plantation woodland	Located beside the main access track, flanked by plantation woodland.	 Photo 03. Detector location 03
Location 04	NX 31693 97123	Plantation woodland	Located in a large clearing, flanked by plantation woodland.	 Photo 04. Detector location 04
Location 05	NX 31605 98378	Restocked moorland	Located out on a section of moorland approximately 100m from a small watercourse to the east and approximately 100m from a woodland edge to the north. At time of survey the area had being restocked with Sitka spruce.	 Photo 05. Detector location 05

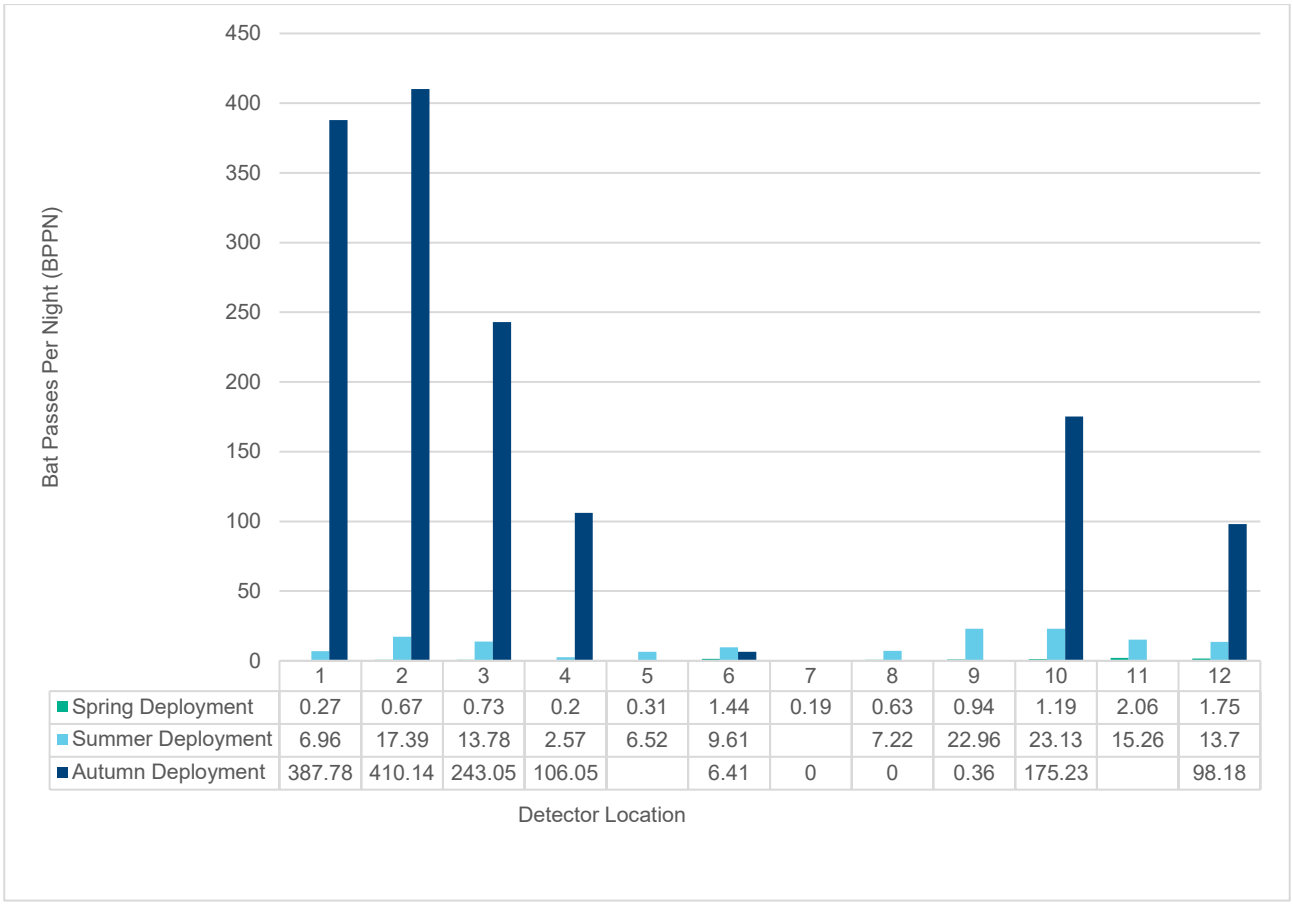
Detector	OS Grid Reference	Habitat Type(s)	Details	Photos
Location 06	NX 32047 98755	Restocked moorland	Located out on a section of moorland approximately 100m from a woodland edge to the north. At time of survey the area had being restocked with Sitka spruce.	 Photo 06. Detector location 06
Location 07	NX 32655 98897	Restocked moorland	Located out on a section of moorland approximately 300m from a woodland edge to the north. At time of survey the area had being restocked with Sitka spruce.	 Photo 07. Detector location 07
Location 08	NX 33026 99641	Plantation woodland	Located beside the main access track flanked by plantation woodland.	 Photo 08. Detector location 08
Location 09	NX 32539 99676	Plantation woodland	Located beside the main access track flanked by plantation woodland.	 Photo 09. Detector location 09
Location 10	NX 32058 99778	Plantation woodland	Located beside the main access track flanked by plantation woodland.	 Photo 10. Detector location 10
Location 11	NX 31426 99157	Plantation woodland	Located on a forest ride flanked by plantation woodland.	 Photo 11. Detector location 11

Detector	OS Grid Reference	Habitat Type(s)	Details	Photos
Location 12	NX 31055 98877	Plantation woodland	Located on a forest ride flanked by plantation woodland.	 Photo 12. Detector location 12

3.2.2 Activity Surveys

Overall Activity Levels

Details of the deployment dates and bat activity levels for all bat species can be found in Table A.1. Appendix A. This data gives a general overview of the differences in activity levels across the seasons for this Site without being compared to other sites. A summary of this data is provided in Graph 1:



	1	2	3	4	5	6	7	8	9	10	11	12
Spring Deployment	0.27	0.67	0.73	0.2	0.31	1.44	0.19	0.63	0.94	1.19	2.06	1.75
Summer Deployment	6.96	17.39	13.78	2.57	6.52	9.61		7.22	22.96	23.13	15.26	13.7
Autumn Deployment	387.78	410.14	243.05	106.05		6.41	0	0	0.36	175.23		98.18

Graph 1 – Summary of bat activity at each detector location through the three deployment periods. Blank boxes within the data indicate detector failure during a deployment period.

In summary, activity recorded across the Site during the surveys was:

- **Spring Deployment** – During the spring deployment bats were recorded at all twelve static detector locations. Location 11 experienced the highest activity levels with 2.06 bppn. Location 07 experienced the lowest activity levels at 0.19 bppn. The activity levels during the spring season is the lowest of the three seasons;
- **Summer Deployment** – During the summer deployment bats were recorded at all eleven operational static detector locations (due to technical failure Location 07 was not functional). Locations 09 and 10

recorded the highest bat activity levels of 22.96 and 23.13 bppn respectively. Several locations experienced similar activity levels including locations 02 (17.39 bppn), 03 (13.78 bppn), 10 (15.26 bppn) and 12 (13.70 bppn). The lowest activity levels were experienced at locations 01 (6.69 bppn), 04 (2.57 bppn), 05 (6.52 bppn), 06 (9.61 bppn) and 08 (7.22 bppn). Overall, the activity levels are higher than those during the spring deployment period; and

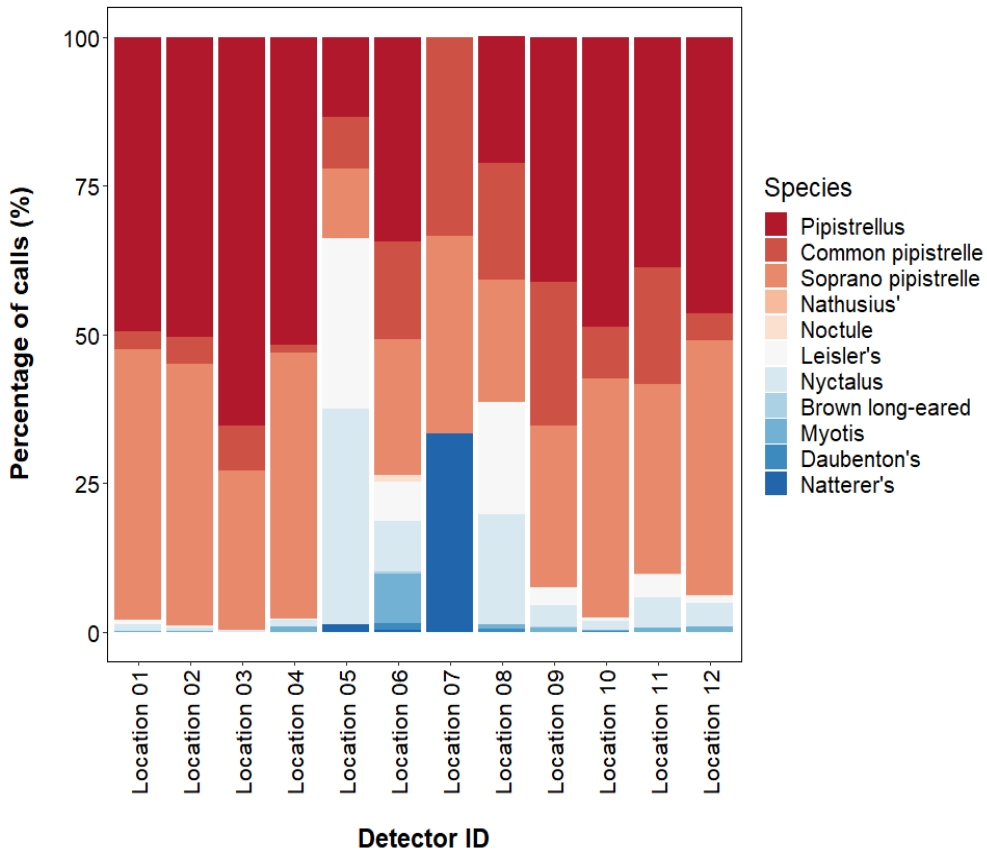
- **Autumn Deployment** – During the autumn deployment bats were recorded at eight of the ten operational static detector locations. Locations 07 and 08 recorded no bat passes. Locations 01 and 02 experienced the highest activity levels of 387.78 and 410.14 bppn respectively. The lowest activity levels were experienced at locations 06 and 09 of 6.4 and 0.36 bppn respectively. The remaining locations were relatively high with 03 (243.05 bppn), 04 (106.05 bppn), 10 (175.23 bppn) and 12 (98.18 bppn). The autumn deployment shows the highest activity levels from the three seasons.

Species Composition

During the three deployments eight bat species were recorded. These include:

- *Pipistrellus* species including soprano, common and a single Nathusius' pipistrelle pass;
- *Nyctalus* species with calls characteristic of both Leisler's and noctule bat recorded;
- *Myotis* species with calls characteristic of Daubenton's and Natterer's bats; and
- Brown long-eared bat.

Graph 2 below is an Ecobat output showing the percentage species composition of passes at each detector location across all three seasons. As can be seen the most frequent species is the *Pipistrellus* species (common and soprano).



Graph 2 – Percentage species composition of passes at each detector across all seasons.

Assessment of Activity Levels from Ecobat Output

Using the median percentile[6] from Table D.1, Appendix D (a visual representation of these can be found in Graph E.1, Appendix E) and Table 3 Percentile Score and Categorised Level of Bat Activity from (Section 2.3.2) a summary of the key findings of the Ecobat assessment for each species group are as follows:

- *Pipistrellus* species (including common and soprano) – Recorded at all detector locations with activity levels ranging from moderate to high. The only exception is location 07 where the activity levels for pipistrellus species is low;
- Nathusius' pipistrelle – Only a single pass recorded at detector location 09;
- *Nyctalus* species (including Leisler's and noctule) – Recorded at all detector locations except for location 07. The activity levels vary from low to moderate;
- *Myotis* species (including Daubenton's and Natterer's) – were recorded at all detector locations at low activity levels except for location 06 where the levels rose to moderate/high; and
- Brown long-eared bat – recorded at six detector locations (02, 04, 06, 09,10 and 12) at low activity levels.

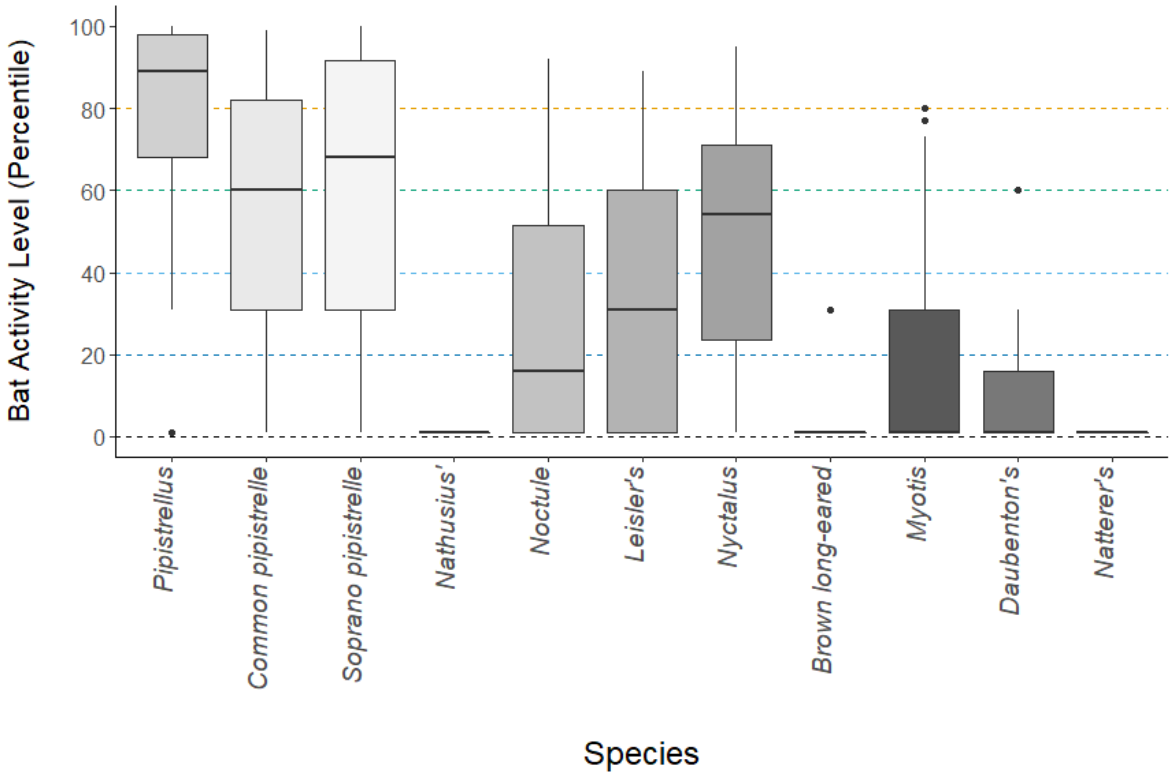
Table D.2 in Appendix D shows a summary of the number of nights recorded bat activity fell into each activity band for each species across all deployment periods. This total is discussed in relation to 624 deployment nights (taken as the number of nights the detectors were operational across all locations and deployments). The finding of the Ecobat assessment for each species group are as follows:

- *Pipistrellus* species (including common and soprano) – Nights of high or high/moderate activity levels were recorded at detector locations 01, 02, 03 (one night only of high/moderate activity), 04, 05, 06, 08, 09, 10, 11 and 12. The total number of nights of high or moderate/high activity recorded over these locations was 398 (64%). The maximum activity level for *Pipistrellus* species at location 07 was low for one night each of common and soprano pipistrelle;
- Nathusius' pipistrelle – Only recorded one night of low activity;
- *Nyctalus* species (including Leisler's and noctule) – Nights of high or high/moderate activity levels were recorded at detector locations 01, 02, 03, 04, 05, 06, 08, 09, 10, 11 and 12. The total number of nights of high or moderate/high activity recorded over these locations was 76 (12%). No *Nyctalus* species passes was recorded at detector location 07;
- *Myotis* species (including Daubenton's and Natterer's) – Nights of high or high/moderate activity levels were recorded at detector locations 04 and 06. The total number of nights of high or moderate/high activity recorded over these locations was eight (1%); and
- Brown long-eared bat – The maximum activity levels of no more than low/moderate activity levels were recorded on one night at location 09. Eight nights of low activity were recorded across locations 02, 04, 06, 09, 10 and 12 (1%).

Graph 3 below illustrates the activity level for each species across the whole Site and generally confirms the findings summarised above in that:

- *Pipistrellus* species (common and soprano) have moderate/high to high levels of activity;
- *Nyctalus* species including Leisler's and noctule have low/moderate to moderate activity levels;
- *Myotis* species (Daubenton's and Natterer's)have low to moderate activity levels;
- Brown long-eared bats low levels of activity; and
- There was a single Nathusius' pipistrelle species pass.

[6] The median is a simple measure of central tendency. To find the median, we arrange the observations in order from smallest to largest value. If there is an odd number of observations, the median is the middle value. If there is an even number of observations, the median is the average of the two middle values.



Graph 3 – The activity level (percentile) of bats recorded across each night of the bat survey for the entire Site.

4 DISCUSSION AND CONCLUSION

4.1 Species

4.1.1 Data Search

The desk study returned records of seven species of bats within 10 km of the Site: whiskered/Brandt's, Daubenton's, Natterer's, Leisler's, brown long-eared, common pipistrelle and soprano pipistrelle. In the data search only one bat roost (soprano pipistrelle) was identified in the village of Kirkmichael approximately 9km to the north of the Site.

4.1.2 Field Surveys

The activity surveys undertaken through the bat activity period of 2020 across the Site identified the presence of eight species of bats: common pipistrelle, soprano pipistrelle, Nathusius' pipistrelle, Daubenton's, Natterer's, Leisler's, noctule and brown long-eared bats.

Tables C.1 and C.2 in Appendix C outline the collision vulnerability of different bat species when considering the impact of new wind farm developments. The species identified at risk are:

- Leisler's and noctule – high collision risk and rarest species;
- Common and soprano pipistrelle – widespread species with high collision risk;
- Daubenton's and Natterer's – rarer species with low collision risk;
- Nathusius' pipistrelle – rarest with high collision risk; and
- Brown long-eared – rarer species with low risk of collision.

Leisler's, noctule and Nathusius' bats are the most vulnerable species due to their flight activity habits and their rarity. In particular, they frequently forage and commute high over treetops at potential turbine Rotor Sweep Height (RSH), and therefore may be subject to greater risk from turbines than any other species identified during the activity surveys.

4.2 Use of the Site by Bats

Key results of the study in general are:

- Highest levels of activity were observed during the autumn dispersal season;
- *Nyctalus* species were recorded at moderate activity levels across the Site;
- *Pipistrellus* species were recorded at high and moderate/high activity levels of activity across the Site;
- Nathusius' pipistrelle bat was only recorded on one occasion at detector location 09;
- *Myotis* species were recorded at generally low to moderate activity levels across the Site; and
- Brown long-eared bats were recorded at low levels of activity levels at six locations.

4.3 Risk Assessment

An assessment of risk from the development can be made using parameters outlined in the most recent industry standard guidance (SNH, 2019); see Tables 5 and 6 in Section 2.3.3 of this report and using the comparative assessment information provided by Ecobat for bat activity levels as summarised Section 3.2.2.3 (Results).

The project size is of a large scale, which includes developments comprising turbines over 100m in height (Table 4) The value of the habitats and features present for foraging, commuting and roosting bats was assessed, using the criteria from current guidance (Collins, 2016). The habitat risk is considered to be moderate based on these criteria.

Although the coniferous forestry plantation and open moorland offers limited quality foraging habitat that could be used by small numbers of foraging bats, there are a number of watercourses offering good foraging and commuting habitat into good foraging habitat located to the south of the Site. The woodland edges and forestry tracks and rides with the watercourses also offer good connectivity to the wider environment. Therefore, the initial site risk assessment score for the Site is high (according to the parameters presented in Table 4).

Given the Site risk level is high, Table 10 provides an assessment of the potential risk to each bat species based on their comparative activity levels as report in section 3.2.2 Results Activity Surveys of this document and the Potential Vulnerability of Scottish Bat Populations (Table C.2, Appendix C).

Table 10: Assessment of the Potential Risk to Each Bat Species

Species	Site Activity Levels	Collision Risk	Potential Risk	Comments
Pipistrellus species (including soprano and common bats)	High	Medium	Medium	Despite the higher activity levels for these species no roost of high conservation value i.e. maternity roost or swarming site was identified therefore the overall potential risk for this species is deemed to be medium.
Nathusius' pipistrelle	Low	High	Low	Given that only one call was recorded at one location the potential risk to this species is deemed to be low.
Nyctalus species (including Leisler's and noctule)	Low/ moderate	High	Medium	These species are within their known ranges with the lack of evidence of a roost of high conservation value the overall potential risk to these species is deemed to be medium.
Myotis (including Daubenton's and Natterer's bats)	Low/ moderate	Low	Low	Given the low activity levels for these species and low collision risk.
Brown long-eared bat	Low	Low	Low	Given the low activity levels for these species and low collision risk.

The overall risk assessment for the development is considered as presenting medium risk to for all bat species (see Table 6). The scores in the table are a product of multiplying the Site risk level and the Ecobat activity category. It should also be noted that the activity level of bats at the Site may be an over-estimation for the entire area as detectors were placed in accessible areas i.e. tracks, rides and water courses, which were suitable for the deployment of the static detectors. By the very nature of these locations, within the Site these would also be the most suitable for use by bat species, and thus activity levels recorded may not be representative of a lower activity in general across the wider Site.

5 RECOMMENDATIONS

5.1 Mitigation

The surveys have highlighted the presence of species of bat that are deemed to be relatively vulnerable due to their rarity and collision risk.

However, from the Ecobat analysis the Site has been given an overall assessment of medium risk to bats. This assessment has been predominantly taken from the Ecobat assessment but reference should also be taken to the use of the Site by bats i.e. the highest activity was identified during the autumn dispersal at detector locations 01 and 02 with the majority of bat passes attributed to *Pipstrellus* species.

Therefore, to minimise the identified potential negative effects to bat populations from the proposed scheme, a number of best practice mitigation measures are recommended. These include:

- adjusting turbine locations to avoid key habitat features;
- habitat management; and
- monitoring.

Should the below mitigation be achieved then it is expected that the impacts will be reduced to a level which will not significantly affect the local population bats.

5.2 Turbine Location

Current NatureScot (SNH, 2019) guidance recommends that wind turbine blade tips should be more than 50m away from features likely to be used by foraging and commuting bats, such as trees, watercourses and waterbodies.

Buffer distance should be factored into the iterative layout design process to maintain separation of turbines and bat habitat. It is particularly important this is also used when woodland edges are created after key-holing and during any further micro-siting exercises which may follow design freeze. Buffer distance can be estimated using the following formula:

$$b = \sqrt{(50+bl)^2 - (hh - fh)^2}$$

Where bl = blade length; hh = hub height; fh = feature height (all in metres).

It is understood that where turbines are located within the plantation woodland the key hole area is to be 100m with an option, if required, for felling and canopy management between 100m and 200m should larger turbines be required.

5.3 Habitat Management

Due to the nature of the habitat i.e. commercial woodland, it is likely that the felling of plantation woodland may cause bats to utilise the Site in different ways than the current survey shows.

To maintain low collision risk, the Habitat Management Plan for the Site should seek to maintain the habitats within 50m of the turbine blade rotor sweep radius in a state which offers poor foraging for bats. As the habitat on or adjacent to the Site changes, i.e. changes in woodland boundaries and/or creation of woodland edges by key-holing, then the habitat management methods should be revised.

5.4 Monitoring

To assess the success of the above activities on Site to mitigate for any potential effects of the development to bat species, monitoring of turbine locations for bat corpses caused through collision with or barotrauma from turbines should be completed through the first two years of the operational phase of the development. Checks should be completed on a monthly basis between May and September by trained operations staff. If in the unlikely event bat mortality is recorded during the bat activity period at turbine locations, management

activities should be considered to further reduce the interaction of bats and turbines at the Site such as increases in buffer distance from woodland edges and key-holed plantation boundaries.

6 REFERENCES

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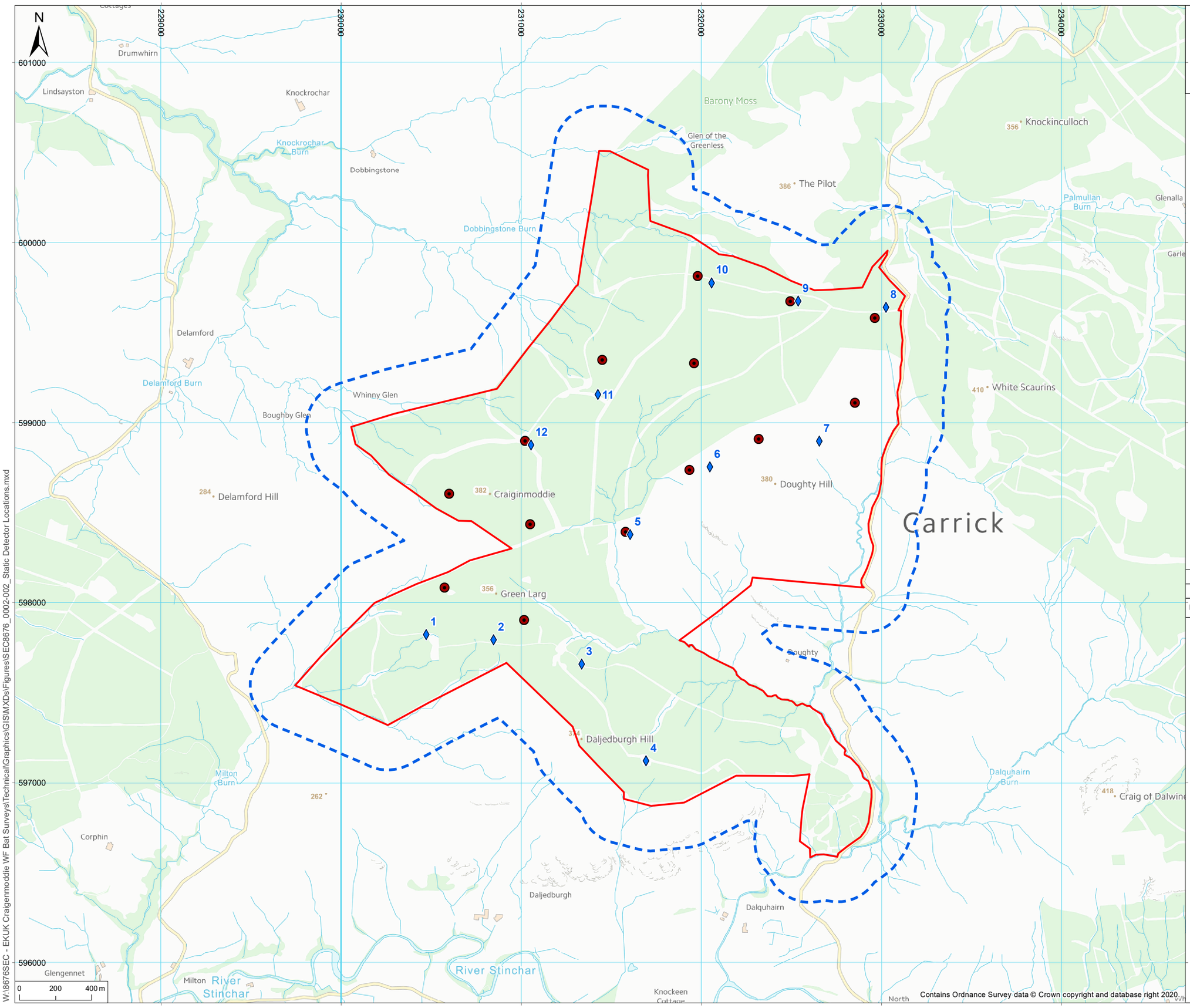
Figures



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Notes
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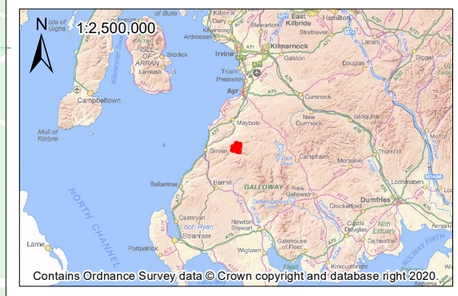
Legend

- Site boundary
- Bat survey area (250m buffer)
- Proposed turbine
- Static detector locations



Rev	Description	By	CB	Date

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Client: EnergieKontor UK Ltd

Project: Craiginmoddie Wind Farm

Title: Static Detector Locations

Status	Drawn By	PM/Checked By
FINAL	KAG	HL
Project Number	**Scale @ A3**	**Date Created**
SEC8676	1:20,000	NOV 2020
Figure Number		**Rev**
1		**-**

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Appendix A

Static Detector Results: Bat Activity Levels

Table A.11: Static Detector Results: Bat Activity Levels

Location	Dates deployed		Type of detector used	Nights Deployed	Number of nights operative	Nights Operative (%)	Nights Bats Recorded (Activity Period)	Files with Bat Activity Recorded	BAI Over Total Deployment Period (bppn)
Spring Deployment									
01	30/04/2020	14/05/2020	Anabat Swift	15	15	100%	4	4	0.27
02	30/04/2020	14/05/2020	Anabat Swift	15	15	100%	4	10	0.67
03	30/04/2020	14/05/2020	Anabat Express	15	15	100%	6	11	0.73
04	30/04/2020	14/05/2020	Anabat Swift	15	15	100%	3	3	0.20
05	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	5	5	0.31
06	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	6	23	1.44
07	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	2	3	0.19
08	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	4	10	0.63
09	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	5	15	0.94
10	29/04/2020	14/05/2020	Anabat Express	16	16	100%	8	19	1.19
11	29/04/2020	14/05/2020	Anabat Swift	16	16	100%	7	33	2.06
12	29/04/2020	14/05/2020	Anabat Express	16	16	100%	9	28	1.75
Summer Deployment									
01	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	15	160	6.96
02	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	19	400	17.39
03	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	14	317	13.78
04	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	15	59	2.57
05	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	13	150	6.52
06	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	11	221	9.61
07	08/06/2020	01/07/2020	Anabat Express	23	0	0%			
08	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	15	166	7.22
09	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	15	528	22.96
10	08/06/2020	01/07/2020	Anabat Express	23	23	100%	15	532	23.13
11	08/06/2020	01/07/2020	Anabat Swift	23	23	100%	18	351	15.26
12	08/06/2020	01/07/2020	Anabat Express	23	23	100%	17	315	13.70
Autumn Deployment									
01	19/08/2020	10/09/2020	Song Meter	22	9	41%	8	3490	387.78
02	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	16	9023	410.14
03	19/08/2020	10/09/2020	Anabat Express	22	21	95%	13	5104	243.05
04	19/08/2020	10/09/2020	Anabat Express	22	19	86%	17	2015	106.05
05	19/08/2020	10/09/2020	Anabat Swift	22	0	0%			
06	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	14	141	6.41
07	19/08/2020	10/09/2020	Anabat Swift	22	2	9%	0	0	0.00
08	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	0	0	0.00
09	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	1	8	0.36
10	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	16	3855	175.23
11	19/08/2020	10/09/2020	Anabat Swift	22	0	0%			
12	19/08/2020	10/09/2020	Anabat Swift	22	22	100%	19	2160	98.18

Appendix B

Weather Data

Table B.12: Weather Data

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
Spring						
30.04.20	05:36	20:49	8:04 PM	8.5	0	0
			9:04 PM	7.3	0.2	0
			10:04 PM	7.5	0	0
			11:04 PM	6	0	0
			12:04 AM	6.7	0	0
			1:04 AM	6.4	0	0
			2:04 AM	6.4	0	0
			3:04 AM	6.3	0	0
			4:04 AM	5.2	0.1	0
			4:59 AM	4.7	0	0
01.05.20	05:34	20:51	8:04 PM	10.2	1.8	0
			9:04 PM	9.4	1.4	0
			10:04 PM	8.9	1.7	0
			11:04 PM	8.9	1.3	0
			12:04 AM	8.9	0.9	0
			1:04 AM	8.2	0	0
			2:04 AM	8.5	0	0
			3:04 AM	8.2	1.2	0
			4:04 AM	7.7	0	0
			4:59 AM	8.4	1	0
02.05.20	05:32	20:53	8:04 PM	12.8	0.8	0
			9:04 PM	9.6	0.2	0
			10:04 PM	6.3	0.5	0
			11:04 PM	4.8	0	0
			12:04 PM	8.9	0.9	0
			1:04 AM	8.2	0	0
			2:04 AM	8.5	0	0
			3:04 AM	8.2	1.2	0
			4:04 AM	7.7	0	0
			4:59 AM	8.4	1	0
03.05.20	05:29	20:55	8:04 PM	12.8	0.8	0
			9:04 PM	9.6	0.2	0
			10:04 PM	6.3	0.5	0
			11:04 PM	4.8	0	0
			12:04 AM	5.1	0	0
			1:04 AM	4.7	0	0
			2:04 AM	4.8	0	0
			3:04 AM	3.9	0.1	0
			4:04 AM	3	0.7	0
			4:59 AM	2	1.4	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
04.05.20	05:27	20:57	8:04 PM	11.2	1.7	0
			9:04 PM	9.8	2.5	0
			10:04 PM	9.1	1.5	0
			11:04 PM	8.7	2.5	0
			12:04 AM	7.1	1.5	0
			1:04 AM	5.7	0.2	0
			2:04 AM	5.1	0.2	0
			3:04 AM	2.9	0.4	0
			4:04 AM	2.4	0.8	0
			4:59 AM	2.3	0.4	0
05.05.20	05:25	20:59	8:04 PM	11.2	0	0
			9:04 PM	7.2	0.1	0
			10:04 PM	5.9	0	0
			11:04 PM	5.2	0	0
			12:04 AM	4.9	0.3	0
			1:04 AM	8.2	1.3	0
			2:04 AM	8.7	1.4	0
			3:04 AM	8.6	1.6	0
			4:04 AM	8.2	1.5	0
			4:59 AM	7.9	1.7	0
06.05.20	05:23	21:01	8:04 PM	14.8	0	0
			9:04 PM	9.3	0.4	0
			10:04 PM	6.1	0	0
			11:04 PM	4.3	0.4	0
			12:04 AM	4.7	0.4	0
			1:04 AM	6.9	0.2	0
			2:04 AM	8.1	0.4	0
			3:04 AM	6.8	0	0
			4:04 AM	4.7	0	0
			4:59 AM	3.9	0.4	0
07.05.20	05:21	21:03	8:04 PM	15.1	1.9	0
			9:04 PM	13.2	1	0
			10:04 PM	13.2	1.2	0
			11:04 PM	12.6	1.1	0
			12:04 AM	12.2	1.3	0
			1:04 AM	12	1.2	0
			2:04 AM	12	0.7	0
			3:04 AM	11.5	1	0
			4:04 AM	11.9	0.4	0
			4:59 AM	10.3	0	0
08.05.20	05:19	21:05	8:04 PM	13.4	0.5	0
			9:04 PM	11.3	0	0
			10:04 PM	9.2	0	0
			11:04 PM	9.1	0.2	0
			12:04 AM	10.1	0.2	0
			1:04 AM	10.6	0	0
			2:04 AM	10.3	0.3	0
			3:04 AM	10.5	0.2	0
			4:04 AM	10.5	0	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			4:59 AM	10.3	0	0
09.05.20	05:17	21:07	8:04 PM	14.5	0.4	0
			9:04 PM	13.2	0	0
			10:04 PM	12.3	0	0
			11:04 PM	11.3	0	0
			12:04 AM	11.1	0	0
			1:04 AM	10.9	0.4	0
			2:04 AM	10.6	0.2	0
			3:04 AM	9.3	2	0
			4:04 AM	8	2	0
			4:59 AM	7.6	2.5	0
10.05.20	05:15	21:08	8:04 PM	7.2	1.7	0
			9:04 PM	5.5	1.1	0
			10:04 PM	3.7	0.8	0
			11:04 PM	2.1	0.1	0
			12:04 AM	1.2	0.4	0
			1:04 AM	0.4	0	0
			2:04 AM	-0.8	0.5	0
			3:04 AM	-1.1	0	0
			4:04 AM	-0.8	0.2	0
			4:59 AM	-0.6	0.2	0
Summer						
08.06.20	04:37	21:51	9:04 PM	13.1	0.7	0
			10:04 PM	10.9	0.1	0
			11:04 PM	8.9	0	0
			12:04 AM	8.6	0	0
			1:04 AM	10.3	0.6	0
			2:04 AM	10.5	0.2	0
			3:04 AM	10.5	0.3	0
			4:04 AM	10.1	0	0
			4:59 AM	9.2	0	0
09.06.20	04:34	21:52	8:04 PM	11.3	2	1.2
			9:04 PM	9.8	0.1	1
			10:04 PM	9.5	0.1	0.2
			11:04 PM	9.3	0.4	0
			12:09 AM	9.4	0.3	0
			1:09 AM	9.3	0.3	0
			2:04 AM	9.3	0.8	0
			3:04 AM	9.5	0.6	0
			4:04 AM	9.7	0.9	0
			4:59 AM	9.8	0.6	0
10.06.20	04:36	21:53	8:04 PM	12.2	0.4	0
			9:04 PM	12.1	0.4	0
			10:04 PM	11	0.3	0
			11:04 PM	10.4	0.4	0
			12:04 AM	10.8	0.7	0
			1:04 AM	10.9	0.9	0
			2:04 AM	10.6	1	0
			3:04 AM	10.2	1.3	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			4:04 AM	9.5	1.2	0
			4:59 AM	9.3	0.4	0
11.06.20	04:36	21:54	8:04 PM	12.3	1.1	1.4
			9:04 PM	10.7	0.9	1.6
			10:04 PM	10.3	0.2	0.2
			11:04 PM	10.3	0.1	1.2
			12:04 AM	10.4	0.4	0.2
			1:04 AM	10.4	0.3	0
			2:04 AM	10.7	1.8	0
			3:04 AM	10.5	1.6	0
			4:04 AM	10.5	2.7	0
			4:59 AM	10.7	1.2	0
12.06.20	04:35	21:55	8:04 PM	12.3	0.7	0.4
			9:04 PM	12.1	0.5	1.2
			10:04 PM	11.5	0.8	0
			11:03 PM	11.4	0.9	0
			12:04 AM	11.4	0.9	0
			1:04 AM	10.7	0.8	0
			2:04 AM	10	0	0
			3:04 AM	10.7	0.1	0
			4:04 AM	10.6	0	0
			4:59 AM	10.7	0	0
13.06.20	04:35	21:55	8:04 PM	20.8	1.1	0
			9:04 PM	15.8	0	0
			10:04 PM	13.9	0.3	0
			11:04 PM	13	0.4	0
			12:04 AM	13	0.2	0
			1:04 AM	11.8	0.2	0
			2:09 AM	10.8	0	0
			3:04 AM	10.6	0.3	0
			4:04 AM	10.6	0.4	0
			4:59 AM	10.3	0.1	0
14.06.20	04:35	21:56	8:04 PM	22.9	0.1	0
			9:04 PM	20.9	0.2	0
			10:04 PM	15.2	0	0
			11:04 PM	12.9	0.1	0
			12:04 AM	12.1	0	0
			1:04 AM	11.7	0	0
			2:04 AM	11.5	0.1	0
			3:04 AM	10.7	0	0
			4:04 AM	10.8	0	0
			4:59 AM	10.6	0	0
15.06.20	04:35	21:56	8:04 PM	21	0	0
			9:04 PM	17.2	0	0
			10:04 PM	16.2	0	0
			11:04 PM	14	0	0
			12:09 AM	12.8	0	0
			1:04 AM	12	0	0
			2:04 AM	12.2	0	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			3:04 AM	11.2	0	0
			4:04 AM	10.7	0	0
			4:59 AM	12.3	0	0
16.06.20	04:35	21:57	8:04 PM	16.1	0	0
			9:04 PM	15.2	0.1	0.2
			10:04 PM	14.6	0.3	0
			11:04 PM	14.2	0.5	0
			12:04 AM	13.6	0.4	0
			1:04 AM	13.5	0.1	0
			2:04 AM	13.3	0.4	0
			3:04 AM	12.9	0.2	0
			4:04 AM	12.4	0	0
			4:59 AM	11.7	0	0
17.06.20	04:35	21:57	8:04 PM	16.5	0	0
			9:04 PM	16.1	0	0
			10:04 PM	14.2	0	0
			11:04 PM	13.3	0	0
			12:04 AM	12.2	0	0
			1:04 AM	12.7	0	0
			2:04 AM	12.5	0	0
			3:04 AM	11.6	0.2	0
			4:04 AM	11.7	0.1	0
			4:59 AM	11.1	0.1	0
18.06.20	04:35	21:58	8:04 PM	20.4	0.3	0
			9:04 PM	18.3	0	0
			10:04 PM	16.3	0.7	0
			11:04 PM	15.6	0.4	0
			12:04 AM	14.2	0	0.4
			1:04 AM	13.6	1.1	0
			2:04 AM	13.3	0.2	0.2
			3:04 AM	13.2	0.6	0
			4:04 AM	13.2	0	0
			4:59 AM	12.8	0	0
19.06.20	04:35	21:58	9:04 PM	12.4	1.9	0
			10:04 PM	12	0.8	0
			11:04 PM	12.1	1.2	0
			12:04 AM	11.5	1	0.2
			1:04 AM	11.2	0.9	0
			2:04 AM	11.4	0.4	0
			3:04 AM	11.5	0.3	0
			4:04 AM	11.7	0.3	0
			4:59 AM	11.9	0.3	0
20.06.20	04:35	21:58	9:04 PM	14.5	2.3	0
			10:04 PM	14.6	2.2	0
			11:04 PM	14.4	1.6	0
			12:04 AM	13.7	1.7	0.2
			1:04 AM	13	1.7	0.6
			2:04 AM	12.7	2.3	1.8
			3:04 AM	12.5	2.2	1.2

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			4:04 AM	12.4	2	0.8
			4:59 AM	12.5	1.5	2.4
21.06.20	04:35	21:59	9:09 PM	12.5	0.1	0.2
			10:04 PM	11.6	0.1	0
			11:04 PM	11.9	0.1	0
			12:04 AM	12.1	0.6	0
			1:04 AM	10.9	0.4	0
			2:04 AM	10.7	1	0
			3:04 AM	10.4	0.5	0
			4:04 AM	10.1	0.7	0
			4:59 AM	10.2	1.1	0
22.06.20	04:35	21:59	9:04 PM	14.2	3.8	0
			10:04 PM	14.3	2.8	0
			11:04 PM	14.4	4.1	0
			12:04 AM	14.6	3.2	0.2
			1:04 AM	14.3	2.6	0.4
			2:04 AM	14	1.8	0
			3:04 AM	14	0.7	0
			4:04 AM	13.7	0.5	0
			4:59 AM	13.7	0.8	0
23.06.20	04:36	21:59	9:04 PM	16.1	2.3	0
			10:04 PM	15.9	1.2	0
			11:04 PM	15.4	1.6	0
			12:04 AM	15.3	1.1	0
			1:04 AM	15.1	0.8	0
			2:04 AM	14.4	1	0
			3:04 AM	14.5	1.9	0
			4:04 AM	14.6	2	0
			4:59 AM	14.1	2.3	0
24.06.20	04:36	21:59	9:04 PM	17.8	0	0
			10:04 PM	14.2	0	0
			11:04 PM	13.1	0.3	0
			12:04 AM	12.3	0	0
			1:04 AM	12.6	0	0
			2:04 AM	11.8	0.1	0
			3:04 AM	11.4	0.1	0
			4:04 AM	11.3	0.4	0
			4:59 AM	11.7	0	0
25.06.20	04:36	21:59	9:04 PM	24.6	0.8	0
			10:04 PM	22.8	0.5	0
			11:04 PM	22.4	0.1	0
			12:04 AM	22.3	2.7	0
			1:04 AM	19.3	1.6	1
			2:04 AM	19.2	1.3	0.4
			3:04 AM	17.9	0.2	0
			4:04 AM	16.6	0	0
			4:59 AM	16.2	0.8	0
25.06.20	04:36	21:59	9:04 PM	14.6	2.1	0
			10:04 PM	13.7	2.1	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			11:04 PM	13.2	1.5	0
			12:04 AM	12.8	1.5	0.4
			1:04 AM	12.4	0.9	0
			2:04 AM	12.3	0.7	0.4
			3:04 AM	12.6	0.1	0
			4:04 AM	13	0.2	0
			4:59 AM	12.6	0	0
26.06.20	04:36	21:59	9:04 PM	12.7	3.2	0
			10:04 PM	12.3	3.4	0
			11:04 PM	11.8	3.8	0
			12:04 AM	11.4	4.2	0
			1:04 AM	11.2	3.9	0
			2:04 AM	10.9	4.9	0
			3:04 AM	11	4.5	0
			4:04 AM	11	4.2	0
			4:59 AM	11.2	4.1	0
27.06.20	04:37	21:58	9:04 PM	11.6	4.4	0.2
			10:04 PM	11.8	4.1	0
			11:04 PM	11.7	3.9	0.4
			12:04 AM	11.4	4.2	0.4
			1:04 AM	11.2	3.9	2.6
			2:04 AM	10.9	4.9	3.8
			3:04 AM	11	4.5	2.8
			4:04 AM	11	4.2	3
			4:59 AM	11.2	4.1	1.8
28.06.20	04:38	21:58	9:04 PM	11.6	4.4	0.8
			10:04 PM	11.8	4.1	0.4
			11:04 PM	11.7	3.9	0.6
			12:04 AM	11.9	3.9	0.4
			1:04 AM	12.2	4	0
			2:04 AM	12.4	3.8	0.4
			3:04 AM	12.1	3.5	0.8
			4:04 AM	12.3	3.9	2.6
			4:59 AM	11.9	3.7	1
29.06.20	04:39	21:58	9:04 PM	12.7	4	0
			10:04 PM	12.2	2.7	0
			11:04 PM	11.7	3.4	0.2
			12:04 AM	11.7	2.6	0
			1:04 AM	11.7	2.7	0.2
			2:04 AM	11.8	1.8	0
			3:04 AM	12.1	2	0
			4:04 AM	12.2	2.3	0
			4:59 AM	12.2	1.6	0
30.06.20	04:39	21:58	9:04 PM	13.6	0.2	0
			10:04 PM	13.6	0	0
			11:04 PM	12.9	0	0
			12:04 AM	12.8	0	0
			1:04 AM	12.7	0	0
			2:04 AM	12.6	0	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			3:04 AM	12.5	0	0
			4:04 AM	12.4	0	0
			4:59 AM	12.4	0	0
Autumn						
18.08.20	05:55	20:40	7:04 PM	17.4	0	0
			8:04 PM	16.4	0	0.4
			9:04 PM	15.9	0.8	0
			10:04 PM	15.7	0.5	0
			11:04 PM	15.6	0	0
			12:04 AM	16.2	0.1	0.2
			1:04 AM	16.2	0	0
			2:04 AM	15.8	0	0
			3:04 AM	15.2	0	0
			4:04 AM	15.2	0	0
			5:04 AM	14.9	0	0
			6:04 AM	13.8	0	0
			6:59 AM	14.6	0.9	0
19.08.20	05:57	20:38	7:04 AM	20.5	2.2	0
			8:04 AM	19.1	1.3	0
			9:04 AM	18.6	2.3	0
			10:04 AM	19	1.9	0
			11:04 AM	19.3	1.8	0.2
			12:04 PM	18.4	1.3	0
			1:04 PM	19	1.9	0.8
			2:04 PM	17.5	2.7	1.8
			3:04 PM	16	2.7	0
			4:04 PM	14.9	2.3	0
			5:04 PM	14.9	3.4	0
			6:04 PM	14.7	2.1	0
			6:59 PM	15.1	3.1	0
20.08.20	05:59	20:36	7:04 PM	16.5	1.9	0.4
			8:04 PM	16.1	2.1	0.8
			9:04 PM	15.8	2.3	0.4
			10:04 PM	15.8	2.5	0
			11:04 PM	16.3	2.5	0
			12:04 AM	16.6	2.3	0
			1:04 AM	16.8	3.3	1
			2:04 AM	15.9	2.5	0.2
			3:04 AM	16.4	3.3	2.2
			4:04 AM	14.9	2.6	0.4
			5:04 AM	14.4	2.5	0
			6:04 AM	14.5	2.5	0.6
			6:59 AM	14.8	2.4	2.2
21.08.20	06:01	20:33	7:04 PM	16.3	1.9	0
			8:04 PM	15.7	2.3	0.4
			9:04 PM	15.9	3.3	0
			10:04 PM	15.9	2.7	0
			11:04 PM	15.7	3.4	0
			12:04 AM	15.4	2.6	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			1:04 AM	15.2	2.3	0
			2:04 AM	14.8	2.6	0
			3:04 AM	14.1	2.3	0
			4:04 AM	14.4	3	0
			5:04 AM	14.4	2.9	0
			6:04 AM	14.3	2.5	0
			6:59 AM	14.5	2.8	0
22.08.20	06:03	20:31	5:04 PM	15.7	2.1	0
			6:04 PM	15.8	1.7	0
			7:04 PM	17.4	0.7	0
			8:04 PM	16.3	1.3	0
			9:04 PM	14.1	0.7	0
			10:04 PM	13.8	1.4	0
			11:04 PM	14.3	1.2	0
			12:04 AM	14.7	1	0
			1:04 AM	14.5	1.2	0
			2:04 AM	14.5	2.1	0
			3:04 AM	14.2	0.7	0
			4:04 AM	13.9	0.9	0
			5:04 AM	13.8	1.5	0
			6:04 AM	13.7	1	0
			6:59 AM	13.7	1.1	0
23.08.20	06:05	20:29	7:04 PM	13.1	0	0
			8:04 PM	12.7	0	0
			9:04 PM	12.1	0.2	0
			10:04 PM	12.2	0.9	0
			11:04 PM	12.2	2.1	0
			12:04 AM	11.8	1.8	0
			1:04 AM	11.5	1.6	0
			2:04 AM	11.2	1.3	0
			3:04 AM	11.2	1.3	0
			4:04 AM	11	0.9	0
			5:04 AM	11.2	1.1	0
			6:04 AM	11	0.6	0
			6:59 AM	10.2	0.2	0
24.08.20	06:07	20:26	7:04 PM	19.2	0	0
			8:04 PM	13.4	0	0
			9:04 PM	10.7	0	0
			10:04 PM	10	0	0
			11:04 PM	9.7	0.3	0
			12:04 AM	12.7	1.8	0
			1:04 AM	13.4	0.7	0
			2:04 AM	12.7	0.4	0
			3:04 AM	14	2.1	0
			4:04 AM	13.8	1.6	0
			5:04 AM	14.2	2.3	0
			6:04 AM	12.4	2.4	1.4
			6:59 AM	12.1	3	0
25.08.20	06:09	20:24	7:04 PM	16.5	0.1	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			8:04 PM	15.5	0.3	0
			9:04 PM	14.7	0.5	0
			10:04 PM	14.5	0.7	0
			11:04 PM	14.4	0.9	1
			12:04 AM	13.6	0	1.8
			1:04 AM	13.5	0.5	2.4
			2:04 AM	13.4	1.5	2.8
			3:04 AM	13.2	0.4	1.2
			4:04 AM	13	0	0.4
			5:04 AM	12.7	0	0.2
			6:04 AM	12.6	0	0
			6:59 AM	12.6	0	0
26.08.20	06:10	20:21	7:04 PM	15.3	0.4	0
			8:04 PM	14.6	0.1	0.2
			9:04 PM	13.5	0	0
			10:04 PM	13	0	0
			11:04 PM	13.7	0.2	0
			12:04 AM	13.9	0.4	0
			1:04 AM	13.6	0	0
			2:04 AM	13.4	0	0
			3:04 AM	13.8	0	0
			4:04 AM	13.5	0	0
			5:04 AM	13.2	0	0.2
			6:04 AM	13.4	0	0
			6:59 AM	13.1	0	0
27.08.20	06:12	20:19	7:04 PM	13.2	0.1	0.8
			8:04 PM	12.2	0.3	0.6
			9:04 PM	11.9	0.2	0.4
			10:04 PM	11.8	0.4	0.2
			11:04 PM	11.9	0	0.8
			12:04 AM	11.8	0.1	0.2
			1:04 AM	11.6	0	0.8
			2:04 AM	12.1	1.3	0.4
			3:04 AM	11.8	1.8	0.8
			4:04 AM	11.6	0.8	0.6
			5:04 AM	11.3	2	0.2
			6:04 AM	10.9	1.2	0
			6:59 AM	10.8	2.5	0
28.08.20	06:14	20:16	5:04 PM	13.4	0.1	0
			6:04 PM	14.7	0.7	0
			7:04 PM	16.4	0.8	0
			8:04 PM	13.3	0.8	0
			9:04 PM	12.2	0.6	0
			10:04 PM	12.9	0.6	0
			11:04 PM	11.1	1.1	0
			12:04 AM	11.1	1.3	0
			1:04 AM	10.9	0.5	0
			2:04 AM	10.7	0.9	0
			3:04 AM	9.8	0	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			4:04 AM	9.8	0.3	0
			5:04 AM	9.2	0.1	0
			6:04 AM	9.2	0.7	0
			6:59 AM	9.6	0.3	0
29.08.20	06:16	20:14	7:04 PM	14.6	0.1	0
			8:04 PM	12.6	0.2	0
			9:04 PM	11.9	0.2	0
			10:04 PM	12	0.5	0
			11:04 PM	10.2	0.3	0
			12:04 AM	9.6	0.2	0
			1:04 AM	10.1	0	0
			2:04 AM	10.1	0	0
			3:09 AM	9.6	0	0
			4:04 AM	8.1	0	0
			5:04 AM	8.1	0	0
			6:04 AM	6.6	0	0
			6:59 AM	6.2	0	0
30.08.20	06:18	20:11	5:04 PM	18.3	0.9	0
			6:04 PM	15.3	0.6	0
			7:04 PM	18.1	0.4	0
			8:04 PM	14.8	0	0
			9:04 PM	12.4	0	0
			10:04 PM	11.4	0	0
			11:04 PM	11.3	0	0
			12:04 AM	10.8	0	0
			1:04 AM	11	0	0
			2:04 AM	10.9	0	0
			3:04 AM	10.9	0	0
			4:04 AM	10.8	0	0
			5:04 AM	11.1	0	0
			6:04 AM	11.7	0.2	0
			6:59 AM	11.7	0.6	0
31.08.20	06:20	20:09	7:04 PM	16.9	0.7	0
			8:04 PM	14.1	0.6	0
			9:04 PM	12.8	0.7	0
			10:04 PM	12.1	0.6	0
			11:04 PM	12.3	0.8	0
			12:04 AM	12.1	0.8	0
			1:04 AM	11.8	0.9	0
			2:04 AM	12.6	1.1	0
			3:04 AM	12.6	0.6	0
			4:04 AM	12.7	1.2	0
			5:04 AM	12.9	1.2	0
			6:04 AM	13.1	0.7	0
			6:59 AM	13	0.8	0
01.09.20	06:22	20:06	7:04 PM	15.9	0.9	0
			8:04 PM	15.1	1.3	0
			9:04 PM	14.7	1	0
			10:04 PM	14.6	0.8	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			11:04 PM	14.7	1	0
			12:19 AM	15.1	1.7	0
			1:04 AM	15.1	1.7	0
			2:04 AM	15.2	1.8	0
			3:04 AM	15.2	1.9	0
			4:04 AM	15.4	3.2	0
			5:04 AM	14.9	2.3	0
			6:04 AM	15.2	2.6	0
			6:59 AM	15.1	2.8	0
02.09.20	06:24	20:04	7:04 PM	16.1	2.2	0
			8:04 PM	16.4	2.1	0.8
			9:04 PM	16.7	2.7	0.2
			10:04 PM	16.8	2.4	1.8
			11:04 PM	17.4	2.7	1.2
			12:04 AM	14.5	0.2	0.8
			1:04 AM	14.6	0.6	0
			2:04 AM	14.7	2.2	0
			3:04 AM	14.5	1	0
			4:04 AM	14.7	2.3	0
			5:04 AM	14.4	3.1	0
			6:04 AM	14.5	0.7	0
			6:59 AM	14.8	1.9	0
03.09.20	06:25	20:01	7:04 PM	16.5	2.1	0
			8:04 PM	14.5	2.3	0
			9:04 PM	14.4	2.9	0
			10:04 PM	14	2.7	0
			11:04 PM	14	3.9	0
			12:04 AM	13.7	3.7	0
			1:04 AM	13.8	3.4	0
			2:04 AM	13.6	4.4	0
			3:04 AM	13.3	3.5	0
			4:04 AM	13.3	4.1	0
			5:04 AM	13	3.4	0
			6:04 AM	12.8	4	0
			6:59 AM	12.8	3.3	0
04.09.20	06:27	19:59	7:04 PM	14.3	3.4	0
			8:04 PM	13.8	3.2	0
			9:04 PM	13.3	3.5	0.4
			10:04 PM	12.1	2.9	0
			11:04 PM	12.7	2.8	0.2
			12:09 AM	12	2.3	0
			1:04 AM	12	2.6	0.2
			2:04 AM	11.8	3.1	0
			3:04 AM	12.1	2.6	0
			4:04 AM	12.4	3	0
			5:04 AM	12.7	2.7	0
			5:09 AM	12.7	2.7	0
			6:04 AM	12.8	3	0
			6:59 AM	12.8	3	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
05.09.20	06:29	19:56	7:04 PM	12.7	1.8	0
			8:04 PM	13	1.5	0.8
			9:04 PM	12	0.4	0
			10:04 PM	12.7	2.7	0.4
			11:04 PM	12.7	2.2	0.2
			12:04 AM	12.8	2.1	0
			1:04 AM	12.9	2.1	0
			2:04 AM	13	1.9	0
			3:04 AM	12.9	1.5	0
			4:04 AM	13	1.6	1.2
			5:04 AM	11.3	0	1
			6:04 AM	11.3	0	2
			6:59 AM	11.1	0.5	1.8
06.09.20	06:31	19:54	7:04 PM	14.9	0.6	0
			8:04 PM	13.8	0	0
			9:04 PM	13.9	0.4	0
			10:04 PM	12.3	0	0
			11:04 PM	12.7	0.1	0
			12:04 AM	12.8	0.7	0
			1:04 AM	12.7	0.4	0
			2:04 AM	12.4	1.2	0
			3:04 AM	12.9	2	0.6
			4:04 AM	12.8	1.4	1.2
			5:04 AM	12.9	1.5	0.8
			6:04 AM	12.8	1.6	1.2
			7:04 AM	12.7	2.1	0.4
07.09.20	06:33	19:51	7:04 PM	15.1	1.1	0
			8:04 PM	14.8	1.7	0.2
			9:04 PM	14.9	2.3	0
			10:04 PM	14.8	0.8	0
			11:04 PM	14.7	1	0
			12:04 AM	14.6	1.7	0.2
			1:04 AM	14.4	0.8	0
			2:04 AM	14.3	1	0
			3:04 AM	14.7	1.7	0
			4:04 AM	14.6	0.4	0
			5:04 AM	14.2	0.2	0
			6:04 AM	14.1	0	0
			6:59 AM	14.6	0.8	0
08.09.20	06:35	19:49	7:04 PM	20.2	2.8	0
			8:04 PM	19.6	2.9	0
			9:04 PM	19.3	3.1	0
			10:04 PM	19.3	4.1	0.8
			11:04 PM	18.4	4.9	2.2
			12:04 AM	15.8	2.2	0
			1:04 AM	14.1	1.5	0
			2:04 AM	13.3	2.1	0
			3:04 AM	12.9	2.2	0
			4:04 AM	13.1	1.7	0

Date	Sunrise	Sunset	Time	Temperature (°C)	Wind Speed (m/s)	Rain Data from SEPA
			5:04 AM	13.2	2.3	0
			6:04 AM	13.4	2.8	0
			6:59 AM	13.4	2.9	0
09.09.20	06:37	19:46	7:04 PM	14.1	2.2	0
			8:04 PM	12.8	2.2	0
			9:04 PM	12.6	1.5	0
			10:04 PM	12.4	1.5	0
			11:04 PM	12.1	1.1	0
			12:04 AM	12	0.9	0
			1:04 AM	11.8	0.7	0
			2:04 AM	11.8	1.1	0
			3:04 AM	11.6	0.9	0
			4:04 AM	12.2	0.8	0
			5:04 AM	11.7	1.4	0
			6:04 AM	12.6	1.2	0
			6:59 AM	12.6	1.7	0
10.09.20	06:39	19:44	7:04 PM	12.8	1.3	0
			8:04 PM	12.7	1.3	0
			9:04 PM	12.9	1.9	0
			10:04 PM	12.9	2.3	0
			11:04 PM	12.7	2.6	0
			12:04 AM	12.7	1.7	0
			1:04 AM	12.8	2.7	0
			2:04 AM	12.7	2.6	0
			3:04 AM	12.6	2.2	0
			4:04 AM	12.7	3.2	0
			5:04 AM	13	3.8	0
			6:04 AM	13.1	4.2	0
			6:59 AM	13.2	4.5	0

Appendix C

Wind Farms and Bats

Bats are at risk of mortality not only by direct collision with wind turbines, but also by barotrauma due to the very low air pressure in the wake of rotating turbine blades (Baerwald *et al*., 2009)[7]. Barotrauma causes damage to soft tissues such as the lungs resulting in fatal internal bleeding. Bats will travel long distances to and from roosting sites, often via preferential commuting routes. The potential mortality risk from wind turbines can be significant if these intersect preferential commuting routes or include areas of high foraging activity. In order to assess the potential impact of a proposed wind energy development on bats, the new guidance concerning bats and onshore wind turbines published in 2019 (SNH *et al*., 2019)[2] recommends study and assessment of bat activity within the proposed wind energy development site and the surrounding landscape.

British bat species have slow reproduction cycles, mostly with only one young being born per year. Therefore, populations are vulnerable to even small losses of individual adult bats. Female bats spend the summer in maternity roosts, in which they give birth and rear their young. The same individual bats may return to the same maternity roost sites every year. Cumulative losses of individual bats from a particular roost site could potentially threaten the viability of a local breeding population.

Studies in the United States and mainland Europe have identified the autumn migration period (commuting to hibernating sites) as the peak risk period for bat mortality at wind turbines in these countries, accounting for about three-quarters of all bat deaths. The species affected make mass migrations on narrow routes, which have resulted in high mortality where these intersect with wind energy sites. The remaining quarter of deaths are of local resident species. High mortality rates have also been found throughout the year where wind turbines are positioned close to bat roosts, commuting or foraging routes.

In the UK there is a lack of data regarding the behaviour of bats during the migratory season and UK bats are believed to migrate to a lesser degree than individuals of the same species in mainland Europe. In the UK, there is no evidence of the narrow-front mass migrations mentioned above. However, there is growing evidence of short distance migrations even up to 100km (between summer sites, autumn swarming or mating sites, and winter sites) for some UK species. There is also a lack of data on bat activity or bat mortality at operational UK wind farm sites. Therefore, any assessment of the potential impacts on bats must take regard of the potential similarities with foreign observations and can only be approximate.

During the main bat activity season, from approximately April to October (although the duration of the activity period at any location is dependent on the climate conditions) bats commute from their roosts to their feeding sites. Flight activity habits vary between species with some making regular flights at 'rotor swept height' (RSH); noctules usually commute along distinct routes, high over treetops and also feed high, often within RSH. Most species stay low during commuting and make use of landscape features such as hedges or trees but may still forage at higher altitudes and reach the RSH. European studies have shown the highest number of deaths in the following species; noctules, common pipistrelles and Nathusius' pipistrelles. The very few UK records that have been collated show deaths of common pipistrelle, soprano pipistrelle, Natterer's bat, and noctule. These records are mostly incidental observations during other studies.

Different species have different flight patterns, flight heights, foraging strategies and echolocation calls and therefore have different risk of collision with wind turbines. Table C.1 categorises which bat species are potentially most vulnerable to collision based on physical and behavioural characteristics.

[7] Baerwald, E.F., Edworthy, J. Holder, M. Barclay R.M.R. (2009). *A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities.* Journal of Wildlife Management 73: 1077-1081.

Table C.1: Collision Vulnerability of Different Bat Species

Factor	Risk of Turbine Impact		
	Low Risk	Medium Risk	High Risk
Habitat preference	Bats preferring cluttered habitat	Bats able to exploit background cluttered space	Bats preferring to use open habitat
Echolocation characteristics	• Short range • High frequency • Low intensity • Detection distance ~15m	Intermediate – more plastic in their echolocation	• Long range • Low frequency • High intensity • Detection distance ~80m
Wing shape	• Low wing loading • Low aspect ratio • Broadest wings	Intermediate	• High wing loading • High aspect ratio • Narrow wings
Flight speed	Slow	Intermediate	Fast
Flight behaviour and use of landscape	• Manoeuvre well • Will travel in cluttered habitat • Keeps close to vegetation Gaps may be avoided	Some flexibility	• Less able to manoeuvre • May avoid cluttered habitat • Can get away from unsuitable habitat quickly • Commute across open landscape
Hunting techniques	• Hunt close to vegetation • Exploit richer food sources in cluttered habitat • Gleaners	• Hunt in edge and gap habitat • Aerial hawkers	• Less able to exploit insect abundance in cluttered habitat • Aerial hawker • Feed in open
Migration	Local or regional movements.	Regional migrant in some parts of range	Long-range migrant in some parts of range
Conclusion	**Myotis spp.** **Long eared-bats** **Horseshoe bats**	**Serotine** **Barbastelle**	**Common pipistrelle** **Soprano pipistrelle** **Noctule** **Leisler's bat** **Nathusius' pipistrelle**

Table Notes

Table adapted from SNH *et al*. (2019).

When assessing the impact of a proposed wind farm on bat mortality, it is important to consider not only the bat activity recorded on site and the collision vulnerability of different bat species but also the level of potential vulnerability of populations of British bat species. In this way, negative impacts on the Favourable Conservation Status (FCS) at both the local and national level of rare or vulnerable species can be avoided. This comprehensive assessment can help to inform the assessment of potential risk and guide the decision-making process in relation to the mitigation options considered for the wind farm development. Table C.2 presents the level of potential vulnerability of populations of Scottish bat species.

Table C.2: Potential Vulnerability of Scottish Bat Populations

Relative Abundance	Collision Risk		
	Low Collision Risk	Medium Collision Risk	High Collision Risk
Widespread species			Common pipistrelle Soprano pipistrelle
Rarer species	Brown long-eared bat Daubenton's bat Natterer's bat		
Rarest species	Whiskered bat Brandt's bat		Nathusius' pipistrelle Noctule bat Leisler's bat

Table Notes

Table adapted from Wray *et al*. (2010). Yellow – low population vulnerability; Orange – medium population vulnerability; Red – high population vulnerability.

Appendix D

Key Metrics for Each Species Recorded

The reference range is the number of nights for each species that the data were compared to.

Table D.1: Key Metrics for Each Species Recorded

Detector ID	Species/Species Group	Median Percentile	95% CIs	Maximum Percentile	Nights Recorded	Reference Range
Location 01	*Myotis*	1	1 - 1	31	4	952
Location 01	*Myotis daubentonii*	1	1 - 1	1	2	91
Location 01	*Myotis nattereri*	1	0	1	1	23
Location 01	*Nyctalus*	50	16 - 75	91	10	1737
Location 01	*Nyctalus leisleri*	31	1 - 59.5	88	11	1114
Location 01	*Pipistrellus*	99	90.5 - 99.5	100	8	3511
Location 01	*Pipistrellus pipistrellus*	70	38 - 83.5	95	14	2641
Location 01	*Pipistrellus pygmaeus*	73	36 - 85	100	18	2835
Location 02	*Myotis*	1	1 - 23.5	46	12	952
Location 02	*Myotis daubentonii*	1	1 - 1	31	3	91
Location 02	*Nyctalus*	50	31 - 55.5	80	22	1737
Location 02	*Nyctalus leisleri*	31	16 - 46	78	16	1114
Location 02	*Nyctalus noctula*	46	1 - 92	92	3	555
Location 02	*Pipistrellus*	95	82 - 96.5	100	27	3511
Location 02	*Pipistrellus pipistrellus*	90	48 - 94.5	99	14	2641
Location 02	*Pipistrellus pygmaeus*	88	65 - 90	100	34	2835
Location 02	*Plecotus auritus*	1	1 - 1	1	2	121
Location 03	*Myotis*	1	1 - 1	1	3	952
Location 03	*Nyctalus*	16	1 - 38.5	60	8	1737
Location 03	*Pipistrellus*	95	88 - 97.5	100	21	3511
Location 03	*Pipistrellus pipistrellus*	65	42 - 76	96	29	2641
Location 03	*Pipistrellus pygmaeus*	87	59.5 - 90.5	100	26	2835
Location 04	*Myotis*	53	23.5 - 68.5	77	6	952
Location 04	*Nyctalus*	31	1 - 59.5	73	12	1737
Location 04	*Nyctalus leisleri*	1	1 - 27.5	54	5	1114
Location 04	*Pipistrellus*	60	49.5 - 75.5	99	23	3511
Location 04	*Pipistrellus pipistrellus*	1	1 - 42.5	84	14	2641
Location 04	*Pipistrellus pygmaeus*	50	30.5 - 65	99	28	2835
Location 04	*Plecotus auritus*	1	0	1	1	121
Location 05	*Myotis nattereri*	1	1 - 1	1	3	23
Location 05	*Nyctalus*	65	54 - 82	89	9	1737
Location 05	*Nyctalus leisleri*	60	33 - 72	84	11	1114
Location 05	*Pipistrellus*	57	46 - 68	86	4	3511
Location 05	*Pipistrellus pipistrellus*	16	1 - 38.5	75	8	2641
Location 05	*Pipistrellus pygmaeus*	1	1 - 34.5	73	11	2835

Detector ID	Species/Species Group	Median Percentile	95% CIs	Maximum Percentile	Nights Recorded	Reference Range
Location 06	*Myotis*	46	16 - 60	80	12	952
Location 06	*Myotis daubentonii*	1	1 - 1	60	3	91
Location 06	*Myotis nattereri*	1	1 - 1	1	2	23
Location 06	*Nyctalus*	53	23.5 - 75.5	91	6	1737
Location 06	*Nyctalus leisleri*	16	1 - 44.5	88	10	1114
Location 06	*Nyctalus noctula*	68	0	68	1	555
Location 06	*Pipistrellus*	71	59.5 - 87	94	11	3511
Location 06	*Pipistrellus pipistrellus*	57	37 - 70	89	14	2641
Location 06	*Pipistrellus pygmaeus*	46	31 - 59.5	88	21	2835
Location 06	*Plecotus auritus*	1	1 - 1	1	2	121
Location 07	*Myotis nattereri*	1	0	1	1	23
Location 07	*Pipistrellus pipistrellus*	1	0	1	1	2641
Location 07	*Pipistrellus pygmaeus*	1	0	1	1	2835
Location 08	*Myotis*	1	1 - 1	1	2	952
Location 08	*Myotis daubentonii*	1	0	1	1	91
Location 08	*Nyctalus*	46	23.5 - 68	90	7	1737
Location 08	*Nyctalus leisleri*	39	16 - 60	89	10	1114
Location 08	*Pipistrellus*	73	54 - 91	91	4	3511
Location 08	*Pipistrellus pipistrellus*	39	16 - 54	87	12	2641
Location 08	*Pipistrellus pygmaeus*	46	23.5 - 60	75	14	2835
Location 09	*Myotis*	1	1 - 1	1	6	952
Location 09	*Nyctalus*	65	48 - 73	81	5	1737
Location 09	*Nyctalus leisleri*	46	1 - 58.5	71	9	1114
Location 09	*Pipistrellus*	94	89.5 - 96	98	6	3511
Location 09	*Pipistrellus nathusii*	1	0	1	1	59
Location 09	*Pipistrellus pipistrellus*	71	36 - 83.5	97	13	2641
Location 09	*Pipistrellus pygmaeus*	65	48 - 79.5	93	17	2835
Location 09	*Plecotus auritus*	16	16 - 16	31	2	121
Location 10	*Myotis*	16	1 - 31	46	10	952
Location 10	*Myotis daubentonii*	1	1 - 16	31	5	91
Location 10	*Nyctalus*	57	30.5 - 70.5	90	16	1737
Location 10	*Nyctalus leisleri*	31	31 - 60	89	7	1114
Location 10	*Nyctalus noctula*	1	0	1	1	555
Location 10	*Pipistrellus*	95	81 - 96	100	26	3511
Location 10	*Pipistrellus pipistrellus*	79	59.5 - 81	98	30	2641
Location 10	*Pipistrellus pygmaeus*	88	70.5 - 91.5	100	31	2835
Location 10	*Plecotus auritus*	1	0	1	1	121
Location 11	*Myotis*	1	1 - 1	1	4	952
Location 11	*Nyctalus*	60	31 - 71.5	78	6	1737
Location 11	*Nyctalus leisleri*	1	1 - 38	75	7	1114
Location 11	*Nyctalus noctula*	1	0	1	1	555
Location 11	*Pipistrellus*	89	68 - 90.5	93	10	3511
Location 11	*Pipistrellus pipistrellus*	63	51 - 70	86	18	2641
Location 11	*Pipistrellus pygmaeus*	65	38 - 71.5	90	24	2835

Detector ID	Species/Species Group	Median Percentile	95% CIs	Maximum Percentile	Nights Recorded	Reference Range
Location 12	*Myotis*	1	1 - 16	46	29	952
Location 12	*Myotis daubentonii*	1	0	1	1	91
Location 12	*Nyctalus*	54	23.5 - 72.5	95	15	1737
Location 12	*Nyctalus leisleri*	54	1 - 81	88	6	1114
Location 12	*Nyctalus noctula*	16	16 - 16	31	2	555
Location 12	*Pipistrellus*	87	48.5 - 89.5	99	29	3511
Location 12	*Pipistrellus pipistrellus*	46	33 - 60	91	29	2641
Location 12	*Pipistrellus pygmaeus*	72	45.5 - 74	99	42	2835
Location 12	*Plecotus auritus*	1	0	1	1	121

Summary table showing the number of nights recorded bat activity fell into each activity band for each species.

Table D.2: Summary Table Showing the Number of Nights Recorded Bat Activity Fell into Each Activity Band for Each Species

Detector ID	Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Location 01	*Myotis*	0	0	0	1	3
Location 01	*Myotis daubentonii*	0	0	0	0	2
Location 01	*Myotis nattereri*	0	0	0	0	1
Location 01	*Nyctalus*	1	3	2	1	3
Location 01	*Nyctalus leisleri*	1	3	0	2	5
Location 01	*Pipistrellus*	8	0	0	0	0
Location 01	*Pipistrellus pipistrellus*	6	3	1	1	3
Location 01	*Pipistrellus pygmaeus*	8	3	0	0	7
Location 02	*Myotis*	0	0	3	2	7
Location 02	*Myotis daubentonii*	0	0	0	1	2
Location 02	*Nyctalus*	0	7	6	5	4
Location 02	*Nyctalus leisleri*	0	3	4	3	6
Location 02	*Nyctalus noctula*	1	0	1	0	1
Location 02	*Pipistrellus*	19	5	1	0	2
Location 02	*Pipistrellus pipistrellus*	10	1	0	1	2
Location 02	*Pipistrellus pygmaeus*	19	7	2	3	3
Location 02	*Plecotus auritus*	0	0	0	0	2
Location 03	*Myotis*	0	0	0	0	3
Location 03	*Nyctalus*	0	1	1	2	4
Location 03	*Pipistrellus*	19	2	0	0	0
Location 03	*Pipistrellus pipistrellus*	11	7	2	1	8
Location 03	*Pipistrellus pygmaeus*	16	4	1	2	3
Location 04	*Myotis*	0	3	1	0	2
Location 04	*Nyctalus*	0	4	1	2	5
Location 04	*Nyctalus leisleri*	0	0	2	0	3
Location 04	*Pipistrellus*	7	7	4	4	1
Location 04	*Pipistrellus pipistrellus*	1	3	1	1	8
Location 04	*Pipistrellus pygmaeus*	8	5	3	2	10

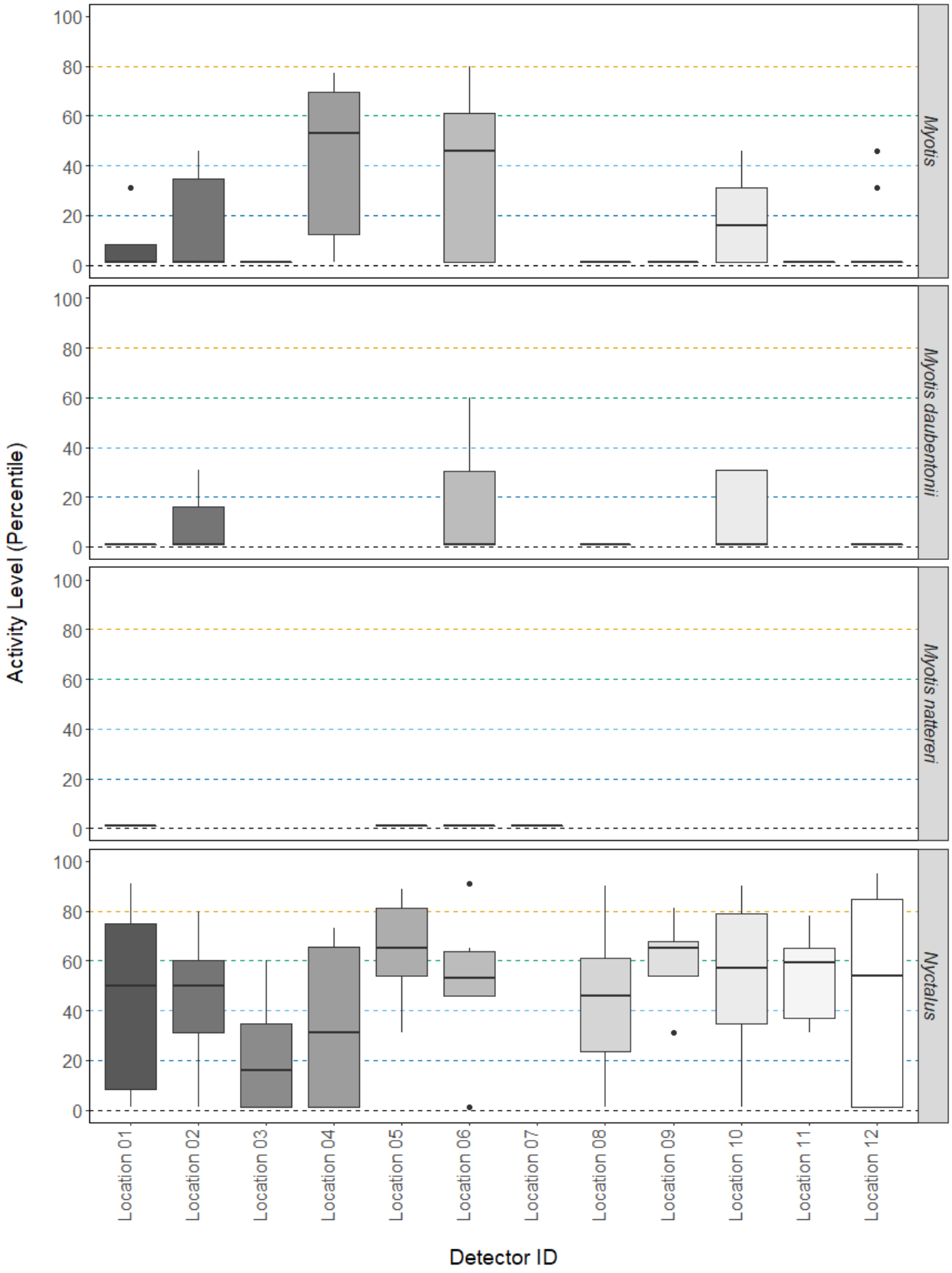
Detector ID	Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Location 04	*Plecotus auritus*	0	0	0	0	1
Location 05	*Myotis nattereri*	0	0	0	0	3
Location 05	*Nyctalus*	3	3	2	1	0
Location 05	*Nyctalus leisleri*	2	5	1	2	1
Location 05	*Pipistrellus*	1	1	2	0	0
Location 05	*Pipistrellus pipistrellus*	0	1	1	2	4
Location 05	*Pipistrellus pygmaeus*	0	2	1	1	7
Location 06	*Myotis*	0	4	3	1	4
Location 06	*Myotis daubentonii*	0	1	0	0	2
Location 06	*Myotis nattereri*	0	0	0	0	2
Location 06	*Nyctalus*	1	2	2	0	1
Location 06	*Nyctalus leisleri*	1	0	2	2	5
Location 06	*Nyctalus noctula*	0	1	0	0	0
Location 06	*Pipistrellus*	5	3	3	0	0
Location 06	*Pipistrellus pipistrellus*	2	5	4	1	2
Location 06	*Pipistrellus pygmaeus*	4	4	3	6	4
Location 06	*Plecotus auritus*	0	0	0	0	2
Location 07	*Myotis nattereri*	0	0	0	0	1
Location 07	*Pipistrellus pipistrellus*	0	0	0	0	1
Location 07	*Pipistrellus pygmaeus*	0	0	0	0	1
Location 08	*Myotis*	0	0	0	0	2
Location 08	*Myotis daubentonii*	0	0	0	0	1
Location 08	*Nyctalus*	1	1	3	0	2
Location 08	*Nyctalus leisleri*	1	2	2	3	2
Location 08	*Pipistrellus*	1	2	1	0	0
Location 08	*Pipistrellus pipistrellus*	1	1	4	2	4
Location 08	*Pipistrellus pygmaeus*	0	6	2	2	4
Location 09	*Myotis*	0	0	0	0	6
Location 09	*Nyctalus*	1	2	1	1	0
Location 09	*Nyctalus leisleri*	0	2	3	1	3
Location 09	*Pipistrellus*	6	0	0	0	0
Location 09	*Pipistrellus nathusii*	0	0	0	0	1
Location 09	*Pipistrellus pipistrellus*	5	2	3	0	3
Location 09	*Pipistrellus pygmaeus*	7	3	3	3	1
Location 09	*Plecotus auritus*	0	0	0	1	1
Location 10	*Myotis*	0	0	2	3	5
Location 10	*Myotis daubentonii*	0	0	0	2	3
Location 10	*Nyctalus*	4	4	4	0	4
Location 10	*Nyctalus leisleri*	1	1	1	4	0
Location 10	*Nyctalus noctula*	0	0	0	0	1
Location 10	*Pipistrellus*	19	4	0	2	1
Location 10	*Pipistrellus pipistrellus*	13	7	7	0	3
Location 10	*Pipistrellus pygmaeus*	18	6	4	2	1
Location 10	*Plecotus auritus*	0	0	0	0	1

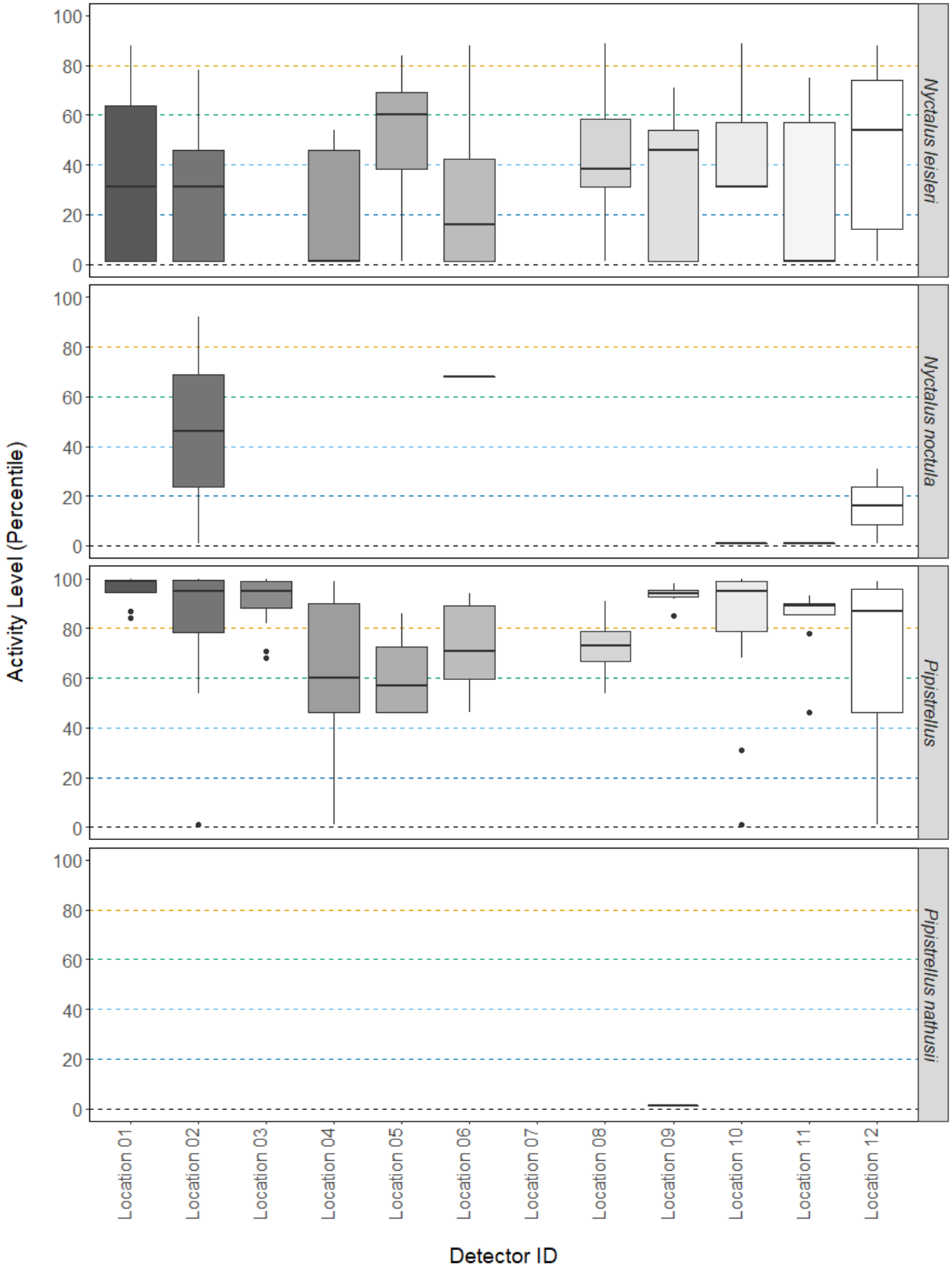
Detector ID	Species/Species Group	Nights of High Activity	Nights of Moderate/ High Activity	Nights of Moderate Activity	Nights of Low/ Moderate Activity	Nights of Low Activity
Location 11	*Myotis*	0	0	0	0	4
Location 11	*Nyctalus*	0	3	1	2	0
Location 11	*Nyctalus leisleri*	0	2	1	0	4
Location 11	*Nyctalus noctula*	0	0	0	0	1
Location 11	*Pipistrellus*	8	1	1	0	0
Location 11	*Pipistrellus pipistrellus*	1	11	4	1	1
Location 11	*Pipistrellus pygmaeus*	5	8	1	3	7
Location 12	*Myotis*	0	0	1	6	22
Location 12	*Myotis daubentonii*	0	0	0	0	1
Location 12	*Nyctalus*	5	2	2	0	6
Location 12	*Nyctalus leisleri*	2	0	2	0	2
Location 12	*Nyctalus noctula*	0	0	0	1	1
Location 12	*Pipistrellus*	17	2	3	0	7
Location 12	*Pipistrellus pipistrellus*	4	9	2	6	8
Location 12	*Pipistrellus pygmaeus*	14	10	2	4	12
Location 12	*Plecotus auritus*	0	0	0	0	1
Total number of nights of each activity band		288	194	120	99	267

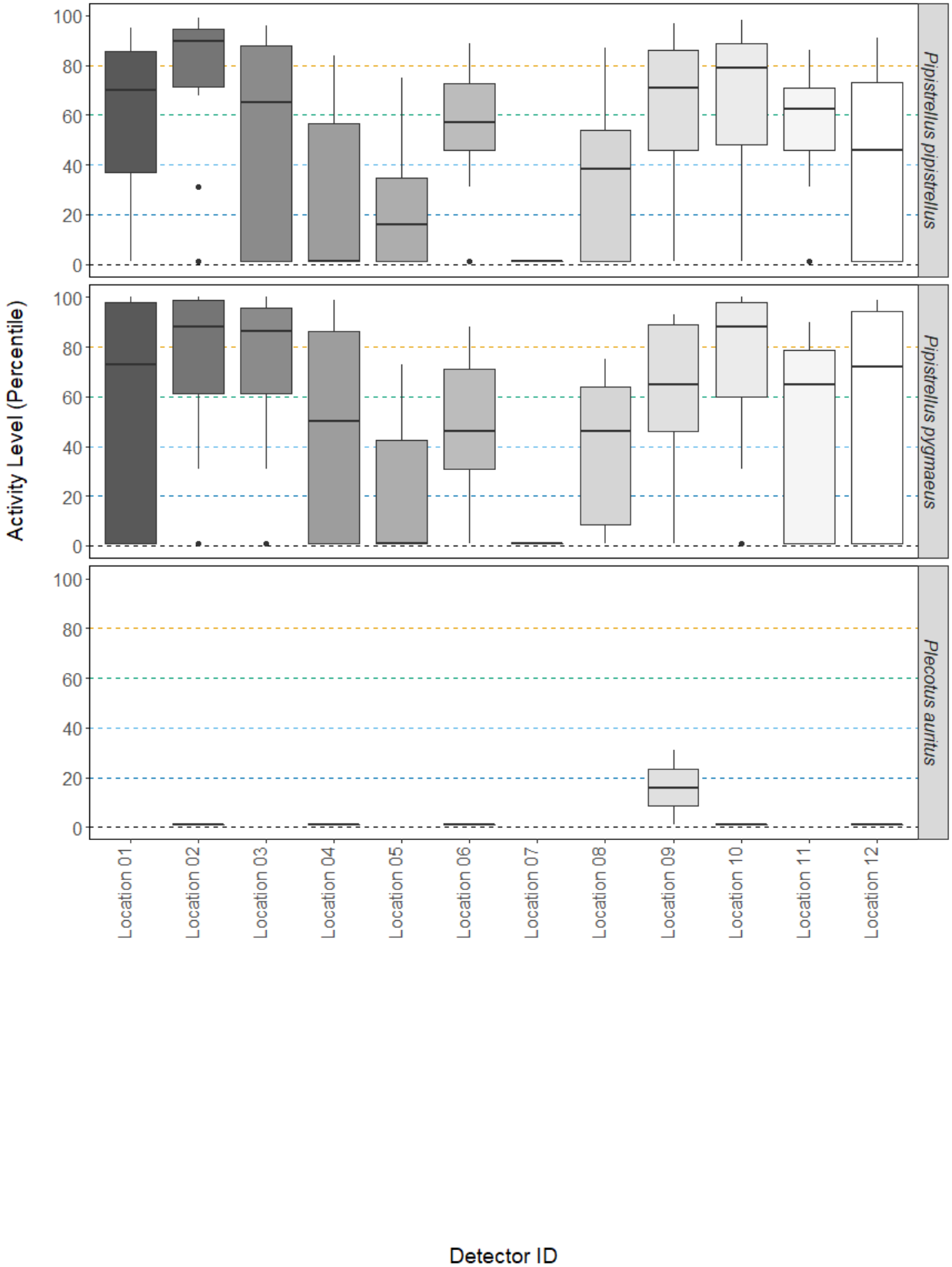
Appendix E

Graph E.1

Graph E.1 – The recorded activity of bats during the survey. The centre line indicates the median activity level whereas the box represents the interquartile range (the spread of the middle 50% of nights of activity).




Activity Level (Percentile)
100
80
60
40
20
0
Nyctalus leisleri
Nyctalus noctula
Pipistrellus
Pipistrellus nathusii
Location 01
Location 02
Location 03
Location 04
Location 05
Location 06
Location 07
Location 08
Location 09
Location 10
Location 11
Location 12
Detector ID


Activity Level (Percentile)
100
80
60
40
20
0
Pipistrellus pipistrellus
Pipistrellus pygmaeus
Plecotus auritus
Location 01
Location 02
Location 03
Location 04
Location 05
Location 06
Location 07
Location 08
Location 09
Location 10
Location 11
Location 12
Detector ID

CRAIGINMODDIE WIND FARM TECHNICAL APPENDIX 9.4: FISH HABITAT SURVEY (INC. FRESHWATER PEARL MUSSEL) GEL19117

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29/01/2020

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Revision	Notes	Date
0	First Draft	15/11/2019
0.1	QA'd Report for Client Comment	27/01/2020

Quality Assurance

This report has been prepared according to Gavia Environmental Quality Management Process.

Gavia Environmental employs consultant scientists who are members of appropriate professional institutions and adhere to professional codes of conduct.

Disclaimer

This report is presented to **Energie Kontor** in respect of **Craiginmoddie Wind Farm Technical Appendix 9.4: Fish Habitat Survey (Inc. Freshwater Pearl Mussel)**, and may not be used or relied on by any other person or by the client in relation to other matters not covered specifically by the scope of this report.

Notwithstanding anything to the contrary contained in the report, Gavia Environmental Ltd is obliged to exercise reasonable skill, care, and diligence in the performance of the services required by **Energie Kontor** and shall not be liable except to the extent that it has failed to exercise reasonable skill care and diligence, and this report shall be read and construed accordingly.

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Table of Contents

1 Introduction

1.1 Background

Gavia Environmental Ltd. ('GEL') was commissioned Energie Kontor ('the Client') to undertake a fish and freshwater pearl mussel habitat (FWPM) survey and *In situ* water quality monitoring at the proposed Craiginmoddie Wind Farm, ('the Development'), which is located at Grid Reference NX 31563 99342, approximately 4.5 kilometres (km) north east of the village of Barr in South Ayrshire.

1.2 Study Objectives

To undertake an initial fish and freshwater pearl mussel habitat assessment to assess habitat quality and utilisation potential. The assessment covered waterbodies that flow into and out of the development site boundary and assigned a geographic value to each watercourse / receptor and provided information on the suitability or not of these receptors in relation to support populations of fish and FWPM.

1.3 Survey Locations

The Proposed Development is located on an upland area of predominantly conifer plantation / felled land with some areas of modified wet heath.

Tributaries of the River Girvan catchment drain to the north west of the Development. The Dobbingstone Burn and several of its unnamed, minor tributaries flow west across the development site boundary, towards the Lindsayston Burn, a sub-catchment of the River Girvan. The River Girvan itself supports populations of Atlantic salmon *Salmo salar* as well as brown trout *Salmo trutta*, European eel *Anguilla anguilla*, sea lamprey *Petromyzon marinus* and brook lamprey *Lampetra planeri*.

Tributaries of the River Stinchar catchment drain the majority of the development area to the south west of Doughty Hill. The Auchengairn Burn and minor tributaries flow south east toward Dalquhairn Burn which is a sub-catchment of the River Stinchar. The River Stinchar itself supports similar species as are present in the River Girvan and is an important river for salmon angling (SSE, 2015).

There are two main existing access routes on the Development through the conifer plantations. Both of these are off the main road to the east of the Site. The first of these tracks to the north of the Site runs to the west, north of Doughty hill towards Craiginmoddie Hill. The second of these tracks to the south of the Site runs west, to the north of Daljedburgh Hill, south of Auchengairn Burn. Some minor tributaries of this burn are culverted by the track.

Fourteen survey locations were selected for the baseline fish habitat assessment HD1 – HD11 (July 2019) and HD12 – HD14 (October 2019). An assessment of water quality was also carried out at each of these locations. Surveys were carried out on two separate visits between July and October 2019. Fish habitat survey locations are displayed in Table 1-1 below.

Table 1-1 Fish Habitat Survey Locations and Rationale for Selection

Survey Location	Watercourse	Catchment	British Grid Reference	Rationale
HD1	Dalquhairn Burn	River Stinchar	NX 32690 96598	Downstream of an existing access track, forestry operations and development boundary.
HD2	Auchengairn Burn	River Stinchar	NX 32740 97274	Downstream of an existing access track and within development boundary.
HD3	Dobbingstone Burn	River Girvan	NX 31386 00159	Dobbingstone Burn. Downstream of an existing access track,

Survey Location	Watercourse	Catchment	British Grid Reference	Rationale
				forestry operations and within development boundary.
HD4	Unnamed watercourse	River Girvan	NX 31341 99952	Downstream of an existing access track, forestry operations and within development boundary. Tributary of the Dobbingstone Burn.
HD5	Unnamed watercourse	River Girvan	NX 31326 99752	Downstream of an existing access track, forestry operations and within development boundary. Tributary of the Dobbingstone Burn.
HD6	Unnamed watercourse	River Girvan	NX 31139 99550	Downstream of an existing access track, forestry operations and within development boundary. Tributary of the Dobbingstone Burn.
HD7	Unnamed watercourse	River Girvan	NX 3031399108	Downstream of forestry operations and within development boundary.
HD8	Unnamed Watercourse	River Girvan	NX 30167 98990	Downstream of forestry operations and within development boundary.
HD9	Unnamed watercourse	River Girvan	NX 30078 98961	Downstream of forestry operations and within development boundary.
HD10	Unnamed watercourse	River Stinchar	NX 31872 97495	Downstream of forestry operations and within development boundary.
HD11	Unnamed watercourse	River Stinchar	NX 31527 97734	Downstream of forestry operations and within development boundary.
HD12	Auchengairn Burn	River Stinchar	NX 31688 97895	Downstream of forestry operations and within development boundary buffer.
HD13	Unnamed watercourse	River Stinchar	NX 29713 97519	Downstream of forestry operations, an existing access track and within development boundary buffer. A tributary of the Milton Burn
HD14	Unnamed watercourse	River Stinchar	NX 30047 97862	Downstream of forestry operations, an existing access track and within development boundary buffer. A tributary of the Milton Burn

Using aerial photography and OS mapping, the only areas that were deemed to be suitable for FWPM habitat evaluation were on the Dalquhairn Burn and the Auchengairn Burn, which are both tributaries of the River Stinchar catchment. The criteria used for this initial evaluation included riparian land use, channel stability, flow type and altitude/gradient. This was followed by an on-the-ground assessment of the sections of watercourse most likely to contain FWPM (see optimal habitat criteria Table 2-2). Along the length of these watercourses of evaluation points were selected and assessed (July 2019), these are presented in Table 1-2 below.

Table 1-2 FWPM Survey Locations and Rationale for Selection (July 2019)

Survey Location	Watercourse	Catchment	British Grid Reference	Rationale
HDPM1	Dalquhairn Burn	River Stinchar	NX 32684 96599	D/S of an existing access track, forestry operations and development boundary.
HDPM2	Auchengairn Burn	River Stinchar	NX 32871 97086	D/S of an existing access track, forestry operations and within development boundary.

See Appendix A for photographs/descriptions and Appendix B for site mapping.

1.4 Survey Limitations

Water quality and fish habitat parameters were not recorded at HD4 due to the watercourse being almost dry at the time of survey.

2 Methodology

2.1 Desk Study

A desktop study was carried out at the start of the commission and ahead of the field survey. Information sources used for this study are described below:

- Google Earth (http://earth.google.co.uk) - aerial imagery was obtained and used to inform the field survey;
- Ordnance Survey Map – site mapping was reviewed to inform site selection
- SEPA (http://www.sepa.org.uk) - the SEPA Water Classification Hub was referred to and information on the classification status of the affected watercourses was noted; and
- SFCC (https://www.sfcc.co.uk/wild-fisheries-web-map.html) – interactive map describing various parameters including Marine Scotland data on Atlantic salmon distribution and SEPA data on barriers to fish migration; and
- Review of existing wind farm developments in close proximity to the Site (various sources).

2.2 River / Fish Habitat Survey

2.2.1 Fieldwork

During the field surveys a combination approach was adopted and observations were made in the context of methods developed by Hendry and Cragg-Hine (1997), and those developed for river/fish habitat surveying (EA, 2003 and SFCC, 2007). Predominant habitat was recorded within specific stretches, and the habitat was defined as described in Table 2-1. The habitats described are regarded as definable parts of a spectrum of habitats commonly found in watercourses. Where spawning gravels were present and accessible, an assessment of their quality in terms of stability, compaction and siltation was made. In addition, the bankside structure and surrounding land use was also described where appropriate.

Table 2-1 Fish Habitat Classifications

Habitat Type	Classification
Salmon spawning gravel	Stable gravel up to 30 cm deep that is not compacted or contains excessive silt. Substrate size predominantly pebbles and smaller cobbles depending on fish size.
Trout spawning gravel	Stable gravel up to 30 cm deep that is not compacted or contains excessive silt. Substrate size varies from gravels, pebbles and smaller cobbles depending on fish size.

Habitat Type	Classification
Salmon fry habitat	Shallow (<0.2 m) and fast flowing water indicative of riffles and runs with a substrate dominated by pebbles and smaller cobbles.
Salmon parr habitat	Riffle/run habitat that is generally faster and deeper than fry habitat (0.2 - 0.4 m). Substrate size* from large pebbles/smaller cobbles to boulder.
Trout fry habitat	Slow to medium flowing shallow water with a substrate dominated by pebbles and smaller cobbles, often concentrated at stream margins.
Trout parr habitat	Variety of substrate sizes; undercut banks, tree roots, big rocks; deeper, slower water.
Lamprey spawning habitat	Stable gravel up to 30 cm deep that is not compacted or contains excessive silt (but may contain some sand). Substrate size varies from gravels to pebbles.
Juvenile lamprey habitat	Optimal: Stable fine sediment or sand ≥15cm deep with low water velocity and the presence of organic detritus/plant material. Sub-optimal: Shallow sediment (<15cm deep), often patchy and interspersed among coarser substrate.
Eel Habitat	Frequently burrow into mud and utilise cover from larger instream substrate and bankside crevices (e.g. gaps in bank modifications such as walls and log revetments).
Glides	Smooth laminar flow with little surface turbulence. Shallow glide ≤ 0.3m, deep glide > 0.3m.
Pools	No perceptible flow. Shallow pool ≤ 0.3m, deep pool > 0.3m.
Flow constriction	Where flows are accelerated between narrow banksides (usually combined with deep fast flows and bedrock substrates).

*Gravel (2-16mm), pebble (16-64mm), cobble (64-256mm), boulder (>256mm).

** If significant amounts of different habitat types were found to co-exist in the same section, these habitat classifications were adequately described. For example, in the case of salmonids, fry and parr habitat is classified as juvenile habitat. Where parr habitat is mentioned this refers to habitat that has principally been identified as habitat more suited to parr than fry, however, habitually contains a lower quantity of fry habitat and habitat which is suited to both fry and parr.

Salmonid definitions in Table 2-1 are adapted from SFCC Habitat Manual (2007) and Hendry & Cragg-Hine (1997), lamprey from Maitland (2003).

2.2.2 Analysis

During the fish habitat survey observations and target notes were recorded in the context of varying fish habitat types including; channel width, channel depths, flow types, substrate composition, instream and bankside cover, riparian canopy cover, fish spawning potential, riparian land uses and associated limiting factors. From this, further analysis was undertaken, and evaluations were made for modifications and utilisation potential (juvenile and adult fish), and fish habitat quality along the watercourse. Each survey location was then given a rating for fish habitat quality and fish utilisation potential (poor, low, moderate, good, or high).

2.3 Water Quality Monitoring

At each of the fish habitat survey locations, in-situ water quality monitoring was also carried out. Values were obtained using a *HI-98129 Pocket EC/TDS* and a *pH Tester*. The following parameters were monitored:

- Temperature;
- pH;
- Electrical Conductivity (EC) and;
- Total Dissolved Solids (TDS).

2.4 Fresh Water Pearl Mussel Habitat Survey

2.4.1 Habitat Classification

Freshwater Pearl Mussel habitat was graded taking the criteria in Table 2-2 below into consideration. For example, good habitat will include many of the optimal characteristics shown below with little obvious scope for detrimental effects such as eutrophication or acidification. Poor habitat will display few of the habitat requirements categorised and/or show potential/actual signs of harmful influences. Moderate habitat will contain some of the required criteria but may also show potential for negative impacts (Skinner et. al., 2003). Although not a full population survey, during the habitat survey the presence of any live FWPM specimens or dead shells was also noted if encountered. This may indicate habitat with the potential to support a FWPM population.

Table 2-2 Factors for Determining FWPM Habitat Classification

Optimal Habitat Requirements	Classification
• Water quality - oligotrophic conditions (poor in nutrients), pH 6.5-7.2, and with low overall conductivity (<100µs/cm). • Water depth - 0.1 -2m (optimal 0.3-0.4m). • Water velocity - 0.1- 2ms-1 (optimal 0.25-0.75ms-1), moderate flow preferably with areas of riffle. • Substrate - small sand patches stabilised amongst large stones or boulders. • Bankside cover - shade created by herbaceous vegetation and trees with little or no bank erosion. Shade keeps water temperatures down during the summer months, inhibits the growth of filamentous algae and is conducive to the presence of host salmonids. • Stable channels - little bed transport except in floods is important. Channel structure should not be altered in any way that will impede water flow, increase flooding, or alter the distribution of substrates.	• River engineering - For hydro-electric schemes, flood protection or fisheries reasons may cause local extinctions. Activities such as dredging and weir construction cause alteration or loss of suitable riverbed substrata. • Sedimentation - Can adversely affect juvenile pearl mussels and host salmonids which depend on a plentiful supply of oxygen to their habitat. • Eutrophication - Filamentous algal mats, high phytoplankton production and detritus formed by their decay indicate eutrophication conditions that are deleterious to freshwater pearl mussel populations. • Inorganic pollutants - Pyrethroid sheep dip is known be highly toxic but the direct effect on freshwater pearl mussels is not known. Indirect effects could occur through a reduction in salmonid numbers. • Acidification - Acidification is known to have deleterious effects on juvenile trout and salmon and could therefore have an indirect effect on freshwater pearl mussels. Acidification may also alter juvenile habitat.

2.4.2 Analysis

During the FWPM habitat survey observations and target notes were recorded in the context of varying habitat/flow types, water depth, substrate, bankside cover and potential limiting factors. From this, further analysis was undertaken, and evaluations were made for modifications and utilisation potential (juvenile and adult mussels), and FWPM habitat quality at survey locations.

3 Results

3.1 Desktop Study

3.1.1 Review of Mapping

3.1.1.1 Google Earth and Ordnance Survey Mapping

Sites were selected based on their topography and geographical location i.e. watercourses which fall within the Proposed Development boundary and their proximity to existing access tracks which are likely to be used by the development. Watercourses which appear on 1:25k

OS mapping were considered for site selection to give an appropriate appraisal for fish habitat across the Site.

3.1.1.2 SFCC interactive map

The SFCC interactive map which uses Marine Scotland data on the distribution of Atlantic salmon shows records of salmon on the Dalquhairn Burn watercourse, which is downstream of the development boundary. Due to an identified natural barrier on the Auchengairn Burn watercourse, it is likely that migratory fish including salmon and sea trout are limited in distribution beyond this point and therefore absent from tributaries of this watercourse. Salmon are recorded as present / likely present on the Lindsayston Burn of which the Dobbinstone Burn is a tributary of as far as ~NS 29306 00475 where there is a known natural impassable barrier so are not likely to be present within the development boundary. It is however likely that resident brown trout populations will be present within suitable habitat across the Site.

3.1.2 Classified Waterbodies

Dobbingstone Burn/Lindsayston Burn is a river (ID: 10459), in the Water of Girvan catchment. The main stem is approximately 7.1 kilometres in length. In 2017 SEPA classified the watercourse as having an overall status of *high*, an overall ecology status of *high*, fish status of *high* and fish barrier status of *high*.

Dalquhairn Burn is a river (ID: 10477), in the River Stinchar catchment. The main stem is approximately 4.7 kilometres in length. In 2017 SEPA classified the watercourse as having an overall status of *high*, an overall ecology status of *high*, fish status of *high* and fish barrier status of *high*.

All other watercourses within the development footprint are unclassified waterbodies.

3.1.3 Review of Existing Wind Farms in Close Proximity

The operational Hadyard Hill wind farm is located immediately west of the Development boundary. The land which Hadyard Hill is built on features some similar habitat characteristics as Craiginmoddie with coniferous plantation woodland present as well as wet modified bog and marshy grassland.

A fish habitat assessment was carried out as part of the Environmental Statement for the proposed Hadyard Hill Extension Wind Farm which partly was situated on the Energie Kontor Development being assessed. Reaches surveyed typically 'had no or very limited suitable in-stream habitat for any fish species of conservation interest'. At the locations of proposed water crossings, watercourses were 'either very minor headwater streams, generally less than 1 m width and which are likely to become dry during periods of low rainfall or are wet (generally acid) flushes with poorly defined channels'. Several of the proposed crossings were also found to be within 'densely shaded conifer plantations with pole-stage trees planted right up to the bankside'. There were two water crossing locations where there was 'some potential for resident brown trout to be present in the vicinity of the crossing' (SSE, 2015).

3.2 Fish Habitat Assessments

Table 3-1 presents a summary of the fish habitat characteristics recorded (July 2019) within the survey locations.

Table 3-1 Fish Habitat Assessments (July 2019 and October 2019)

Survey Location	British Grid Reference	Fish Utilisation Potential	Fish Habitat Quality	Reach Description and Limiting Factors
HD1	NX 32690 96598	*High*	*Good*	Wet width ~5.0 – 5.75m. Predominantly run / riffle / shallow glide flow types. Depth ranging from <10 - <40cm. Predominantly pebble / cobble / gravel substrate with some boulders which provides excellent instream cover and suitable spawning habitat for adult fish. Bankside cover provided by marginal vegetation on the right bank. Canopy cover is 75%. Land use is rough pasture and conifer plantation. Limiting factors: potential run off from forestry operations and potential pollution from adjacent sheep pens.
HD2	NX 32740 97274	*Good*	*High*	Wet width ~4.25 – 4.75m. Predominantly run / riffle / shallow glide flow types. Depth ranging from <10 - <40cm. Predominantly pebble / cobble / gravel substrate with some boulders which provides excellent instream cover. Some bankside cover provided by undercut and draping vegetation predominantly on the left bank. No canopy cover present. Land use is rough pasture and conifer plantation. Limiting factors: potential run off from forestry operations and impassable falls downstream.
HD3	NX 31386 00159	*Good*	*Good*	Wet width ~0.5 - 1.75m. A mixture of run / riffle / shallow glide / shallow pool flow types. Depth ranging from <10 - <30cm. A mixture of sand / gravel / pebble / cobble substrates which provide good instream cover. Some bankside cover provided by draping vegetation and undercut banks. Suitable habitat for trout fry and parr. Suitable spawning habitat due to substrate present. Land use is conifer plantation and felled woodland. Limiting factors: intensive felling operations adjacent, steep gradients creating possible impassable barriers further down the catchment. Trout parr observed on day of habitat survey.
HD4	NX 31341 99952	*Poor*	*Poor*	Minor watercourse / drain unlikely to support fish populations (almost dry at time of survey). Further fish habitat variables not recorded.
HD5	NX 31326 99752	*Poor*	*Low*	Wet width ~0.25 - 0.75m. Predominantly run / riffle / deep glide flow types. Depth all <10cm. Predominantly pebble / gravel substrate which provides limited instream cover. Limited bankside cover provided by some undercut banks and draping vegetation. Canopy cover 25%. Limited spawning habitat due lack of suitable depth. Land use is conifer plantation and felled woodland. Minor watercourse unlikely to support fish populations. Limiting factors: shallow depths, steep gradients and intensive felling operations.
HD6	NX 31139 99550	*Poor*	*Poor*	Minor watercourse / drain unlikely to support fish populations. Further fish habitat variables not recorded.
HD7	NX 3031399108	*Low*	*Low*	Wet width ~0.3 - 0.4m. Predominantly riffle / shallow pool / still marginal flow types. Depth ranging from <10 - 30cm. Predominantly bedrock substrate with some pebbles and cobbles which provides limited instream cover. Limited bankside cover provided by some undercut but mostly bare. Limited spawning habitat due to lack of gravel substrate and depths. Land use is conifer plantation. Limiting factors: impassable falls further down the catchment, forestry operations and areas of bedrock substrate across the stream channel.
HD8	NX 30167 98990	*Low*	*Low*	Wet width ~0.3 - 0.4m. Predominantly riffle / shallow pool / still marginal flow types. Depth ranging from <10 - 20cm. Predominantly gravel / pebble substrate which provides limited instream cover. Bankside cover provided by marginal/draping vegetation but is having a negative impact by totally enclosing the watercourse, limiting sunlight. No canopy cover provided by trees. Limited

Survey Location	British Grid Reference	Fish Utilisation Potential	Fish Habitat Quality	Reach Description and Limiting Factors
				spawning habitat due to lack of depths to support adult fish. Land use is conifer plantation. Limiting factors: impassable falls further down the catchment, forestry operations and overgrown stream channel.
HD9	NX 30078 98961	*Low*	*Low*	Wet width ~0.25 - 0.4m. Predominantly riffle / shallow pool / still marginal flow types. Depth ranging from <10 - 20cm. Predominantly gravel / pebble / bedrock substrate which provides limited instream cover. Limited bankside cover provided by draping vegetation. Canopy cover 80% Limited spawning habitat due to lack of depths to support adult fish. Land use is conifer plantation and rough pasture. Limiting factors: steep gradients, shallow depths and forestry operations.
HD10	NX 31872 97495	*Poor*	*Low*	Wet width ~0.3 – 0.75m. Predominantly riffle / constriction flow types. Depth ranging from <10 - <20cm. Predominantly pebble / cobble / bedrock substrate provides moderate instream cover. Limited bankside cover on the right bank provided by undercut but water depths are not suitable to support fish. Limited spawning habitat due to lack of gravel and steep gradient. Land use is conifer plantation and felled woodland. Limiting factors: impassable falls, shallow depths and steep gradients.
HD11	NX 31527 97734	*Low*	*Low*	Wet width ~0.4 – 1.0m. Predominantly riffle / constriction flow types. Depth ranging from <10 - <25cm. Predominantly pebble / cobble / bedrock substrate provides limited instream cover. Limited bankside cover. No canopy cover. Limited spawning habitat due to lack of gravel and steep gradient. Land use is conifer plantation. Limiting factors: impassable falls, bedrock substrates, flow constriction and steep gradients.
HD12	NX 31688 97895	*Moderate*	*Moderate*	Wet width ~1.0 – 1.5m. Predominantly run / riffle / shallow glide flow types. Depth ranging from <10 - <30cm. Predominantly bedrock / pebble / cobble / gravel substrates which provides good instream cover. Poor bankside cover provided due to bare bank faces and limited undercut. No canopy cover present. Land use is rough pasture and conifer plantation. Limiting factors: potential run off from forestry operations, erosion on the left bank and impassable falls downstream.
HD13	NX 29713 97519	*Low*	*Poor*	Wet width ~0.5 - 0.75m. Predominantly run / riffle types. Depth ranging from <10 - 20cm. Predominantly clay / gravel / pebble substrate which provides limited instream cover. Poor bankside cover provided by bare, eroded bank faces. No canopy cover provided by trees. Limited spawning habitat due to unsuitable substrate composition. Land use is conifer plantation and rough pasture. Limiting factors: potential run off from forestry operations and overgrown stream channel.
HD14	NX 30047 97862	*Low*	*Low*	Wet width ~0.3 - 0.5m. Predominantly riffle / shallow glide / still marginal flow types. Depth ranging from <10 - 20cm. Predominantly gravel / pebble substrate which provides limited instream cover. Bankside cover provided by draping vegetation but also limiting sunlight to stream bed. 5% canopy cover provided by a conifer tree. Limited spawning habitat due to lack of depths to support adult fish. Land use is rough pasture and conifer plantation. Limiting factors: poaching from livestock and potential run off from forestry operations further up the catchment.

3.3 Water Quality Monitoring

Table 3-2 presents the results of water quality variables recorded within each of the fourteen FHS locations. All locations had suitable flows for sampling at the times of survey except HD4 which was almost dry.

Table 3-2 Water Quality Monitoring (July 2019 and October 2019)

Survey Location	Temperature (°C)	pH	Conductivity (µS)	Total Dissolved Solids (ppm)
HD1	14.8	7.13	67	34
HD2	15.7	7.09	66	34
HD3	16.3	6.75	99	50
HD4	N/A	N/A	N/A	N/A
HD5	14.1	5.0	59	30
HD6	13.5	6.65	94	51
HD7	13.5	4.97	61	31
HD8	13.8	7.60	319	162
HD9	13.7	7.69	152	78
HD10	16.0	6.23	55	28
HD11	14.1	7.01	99	52
HD12	10.2	7.03	68	33
HD13	10.1	7.01	65	32
HD14	10.3	7.03	61	29

3.4 Freshwater Pearl Mussel Habitat Assessments

Table 3-3 presents a summary of the FWPM habitat characteristics recorded (July 2019) within the survey locations.

Table 3-3 Freshwater Pearl Mussel Habitat Assessments (July 2019)

Survey Location	British Grid Reference	FWPM Utilisation Potential	FWPM Habitat Quality	Survey Location Details and Limiting Factors
HDPM1	NX 32684 96599	*Good*	*Good*	Suitable depth and flow. Some patches of sand and gravel amongst larger substrate. Host fish possibly migratory salmon and sea trout.
HDPM2	NX 32871 97086	*Low*	*Moderate*	Areas of suitable depth and flow. Some patches of sand amongst larger substrate. Limiting factors: intensive forestry operations further up the catchment and impassable falls downstream. Host fish only likely to be brown trout.

4 Discussion

4.1 Fish Habitat Assessments

4.1.1 Salmonids

The habitat quality at each survey location was variable for supporting salmonid populations. Some sites had good combinations of flow types, instream cover, bankside cover, depths and variable substrates providing suitable habitat for fish. Others were unsuitable to support salmonid populations with limiting factors including steep gradients, shallow water depths and bedrock substrates.

Some sites were also affected by known barriers to fish migration further down the catchment like impassable falls. All but one of the survey locations are likely to be inaccessible to migratory fish due to impassable falls further down the Stinchar and Girvan catchments. Migratory fish within these catchments still have the potential to be impacted by cumulative effects of run off from the development as there is known populations of salmon (and most likely sea trout) downstream below the impassable sections.

Fish Utilisation Potential ranged from *Poor* (HD4, HD5, HD6 and HD10) to *Low* (HD7, HD8, HD9, HD11, HD13 and HD14) to *Moderate* (HD12) to *Good* (HD2 and HD3) and *High* (HD1).

Fish Habitat Quality followed similar suit and ranged from *Poor* (HD4, HD6 and HD13) to *Low* (HD5, HD7, HD8, HD9, HD10, HD11 and HD14) to *Moderate* (HD12) to *Good* (HD1 and HD3) and *High* (HD2).

4.1.2 Other Fish Species

Within the selected survey reaches, there were few areas of suitable habitat for juvenile lamprey i.e. fine, soft substrate in well oxygenated, slow flowing water, with most of the survey locations featuring coarser substrates, predominantly pebbles, cobbles, boulders or bedrock. The stream bed at HD3 features areas of sand and patches of silt which offer sub optimal conditions for juvenile lamprey due to sediment depth limitation (<30cm). There were areas of habitat where European eel may generally be found, in particular large instream/bankside boulders or bankside crevices to utilise as cover.

For the migratory lamprey species (*Petromyzon marinus* and *Lampetra fluviatilis*) and European eel it is not currently clear if they are able to freely access all of the survey locations. Downstream on the main tributaries (Lindsayston Burn and Auchengairn Burn) that drain the site are significant natural barriers to fish migration.

Although presence and distribution are unknown at this stage, there may also be other species of fish present across the site including three-spined stickleback, minnow and stone loach which are now commonly found in Scottish rivers.

4.2 Water Quality Assessments

4.2.1 Temperature

Values obtained for water temperature ranged from 10.1°C (HD13) to 16.3°C (HD3) with a mean value of 13.5°C. The variation in temperatures can both be attributed to seasonal variations in when monitoring was carried out (July and October) and also to the air temperature warming up gradually on the first day of survey (July). Also, some of the survey locations feature more canopy cover from plantations or are more overgrown than others, (HD6, HD7, HD8, HD9 and HD11) so the average temperature of these watercourses may typically be lower than those on cleared areas / open moorland (HD2, HD3 and HD10) which are exposed to more direct sunlight.

4.2.2 pH

Values obtained for pH ranged from 4.97 (HD7) to 7.69 (HD9) with a mean value of 6.71. Survey locations HD3, HD5, HD6, HD7 and HD10 can be described as acidic in nature (below pH 7).

The Freshwater Fish Directive states that the optimal pH range for salmonids and cyprinid fish is between pH 6 and pH 9 (EU, 2006). Similarly, the Water Framework Directive states that a 'High' standard for pH is >=6 to <=9 and a 'Good' standard is >=5.2 for rivers in Scotland (WFD, 2008). Sites HD5 and HD7 were out with these ranges and therefore may be unsuitable for fish. Monthly monitoring would be required however to validate this and confirm mean values for pH over a 12-month period. Fish habitat quality was also rated as Low at these sites.

Oliver (2000) states that the optimal target pH range for FWPM is between pH 6.5 and pH 7.2 with a low conductivity (<100µs/cm). All survey locations fell within this range except HD5, HD7 as well as HD8 and HD9 which also had the highest values for conductivity and TDS across all survey locations.

4.2.3 Conductivity

Values obtained for conductivity ranged from 55µs (HD10) to 319µs (HD8) with a mean value of 97 µs.

Oliver (2000) states that <100µs/cm is the target favourable conductivity for FWPM. All survey locations fell within this range except HD8 and HD9 which also had the highest values for pH and TDS across all survey locations.

4.2.4 Total Dissolved Solids

Values obtained for total dissolved solids ranged from 28ppm (HD10) to 162ppm (HD8) with a mean value of 50ppm. Survey location HD8 was also highest value obtained for conductivity. This is association is expected because particles within a watercourse increase conductivity.

4.3 Freshwater Pearl Mussel Habitat Assessment

Some isolated areas of habitat on the Dalquhairn Burn and the Auchengairn Burn were suitable for FWPM due to a combination of suitable depth and flow as well as patches of clean sand and gravel amongst some larger substrates. Other areas featured a combination of limiting factors such as substrate types (bedrock), intensive forestry operations, limited bankside cover and lack of suitable water depths.

The watercourses are also affected by significant barriers to fish migration (impassable falls). As mentioned above, all but one of the survey locations (HD1) are likely to be inaccessible to host migratory fish due to impassable falls on the Auchengain Burn and the Lindsayston Burn.

Freshwater Pearl Mussel Utilisation Potential ranged from *Low* (HDPM2) to *Good* (HDPM1). Neither of the survey locations were classified as *High* for freshwater pearl mussel utilisation potential.

Freshwater Pearl Mussel Habitat Quality ranged from *Moderate* (HDPM2) to *Good* (HDPM1). Neither of the survey locations were classified as *High* for freshwater pearl mussel habitat quality.

5 Conclusions and Recommendations

The current fish / FWPM habitat assessment results provide a baseline against which future fish habitat assessment results may be compared.

It is recommended that:

- Fully quantitative electrofishing surveys are carried out at all of the survey locations rated *Moderate* and above for fish habitat quality and fish utilisation potential to strengthen the overall baseline fish assessment.

Freshwater pearl mussel field surveys are carried out at the survey locations rated as Moderate and above for FWPM habitat quality and FWPM utilisation potential. It is also recommended that a construction and post-construction fish and water quality monitoring programme is carried out as part of an ongoing assessment of potential impacts, which may occur due to the development. This will help to protect the development in the longer term and provide evidence of scale of impact on the surrounding watercourses from any pollution incidents which may or may not be directly related to the development.

The suggested monitoring schedule for construction and post construction monitoring is as follows:

Fish habitat, fish fauna, FWPM habitat and FWPM fauna –- annually during construction (summer) and post-construction Year 1 (summer) and Year 2 (summer).

In addition, the following is construction advice also recommended:

- The presence of fish fauna within particular watercourses (as determined from fish fauna surveys) should be used to inform the design of any watercourse crossings, CAR license applications and mitigation for watercourse crossing installations;
- Appropriate mitigation measures should be incorporated into the scheme to avoid damage of watercourses and any resident fish populations;
- A suitably qualified / experienced aquatic clerk of works (ACoW) should be on Site for the duration of the construction period; and
- An appropriately designed water quality monitoring programme should be undertaken pre, during and post construction.

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7 Appendices

Appendix A: FHS Locations and Descriptions

Plate 1: HD1 – Facing upstream at the bottom of survey location – good fish habitat quality – Dalquhairn Burn.

Plate 2: HD2 – Facing upstream at the middle of survey location – High fish habitat quality – Auchengairn Burn.

Plate 3: HD3 – Facing upstream at the middle of survey location – good fish habitat quality – watercourse particularly at risk from run off from felling operations immediately upstream due to topography of the land on either bank.

Plate 4: HD4 – Facing upstream at the bottom of survey location – poor fish habitat quality – minor watercourse / drain.

Plate 5: HD5 – Facing upstream at the middle of survey location – low fish habitat quality – steep gradients with limited depth.

Plate 6: HD6 – Facing upstream at the bottom of survey location – poor fish habitat quality – minor watercourse / drain.

Plate 7: HD7 – Facing upstream at the middle of survey location – low fish habitat quality – limited depth and flow.

Plate 8: HD8 – Facing upstream at the middle of survey location – low fish habitat quality.

Plate 9: HD9 – Facing upstream at the middle of survey location – low fish habitat quality – steep gradients and limited depth.

Plate 10: HD10 – Facing upstream at the middle of survey location – low fish habitat quality – very steep gradients and limited depth.

Plate 11: HD11 – Facing upstream at the middle of survey location – steep gradient with mostly bedrock substrate with flow constriction - low fish habitat quality.

Plate 12: HD12 – Facing upstream at the middle of survey location – good instream cover - moderate fish habitat quality.

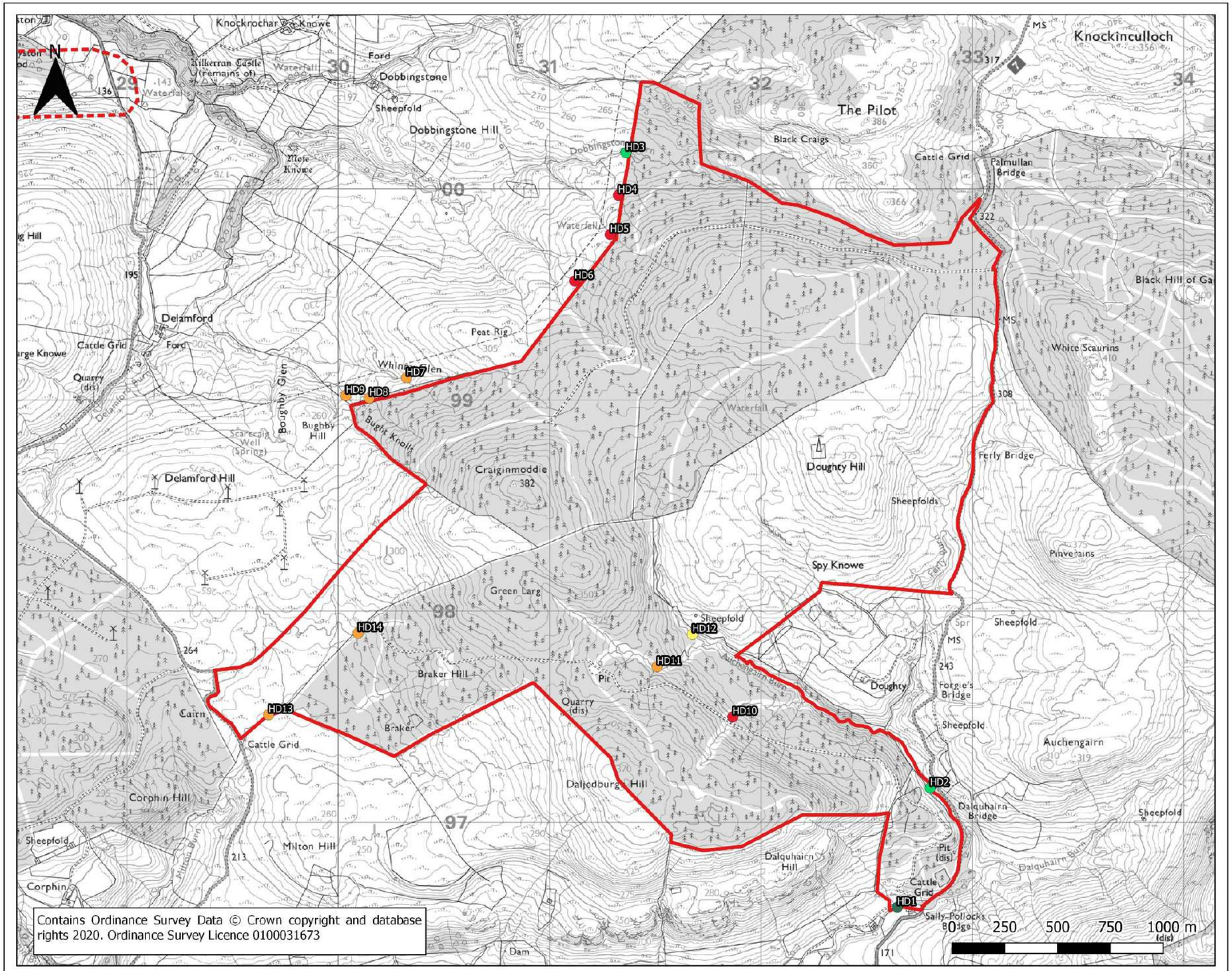
Plate 13: HD13 – Facing upstream at the bottom of survey location – low fish habitat quality.

Plate 14: HD14 – Facing upstream at the bottom of survey location – low fish habitat quality.

Plate 15: HDPM1 – Facing downstream at the middle of survey location – suitable substrates, depth and flow for FWPM.

Plate 16: HDPM 2 – Facing upstream at the bottom of survey location – some suitable substrates, depth and flow types for FWPM.

Appendix B: Figures



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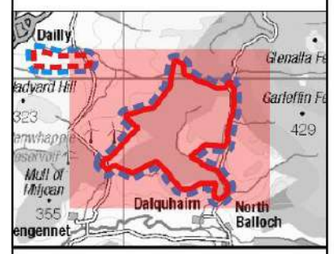
- Site Boundary

Fish Utilisation Potential

- High
- Good
- Moderate
- Low
- Poor



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Technical Appendix 9.4: Fish Habitat Survey (inc. FWPM)

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Energie Kontor

Title:
Figure 1
Fish utilisation potential

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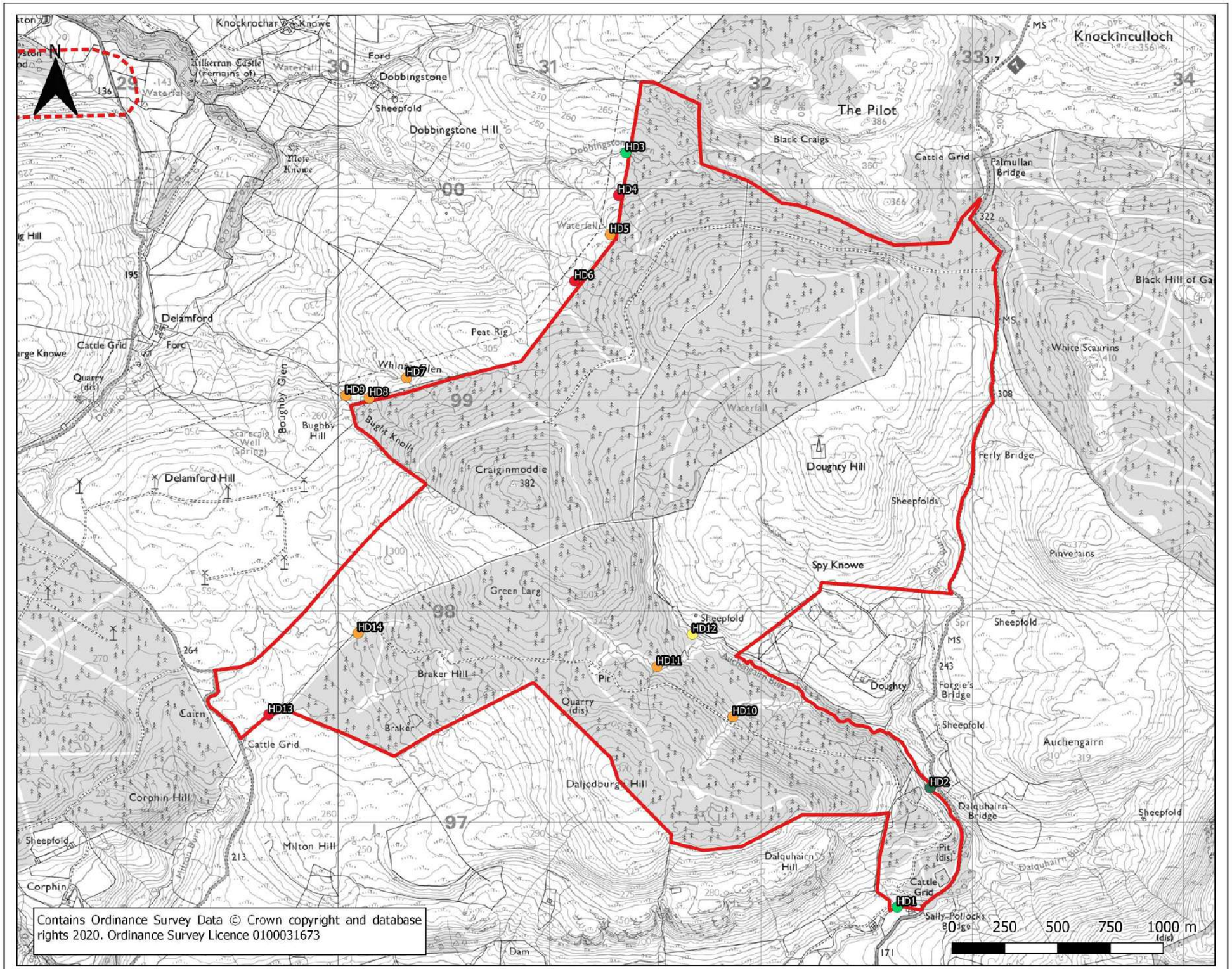

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Fish Habitat Quality

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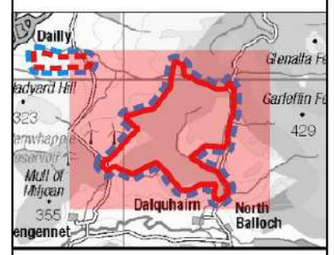
- Moderate
- Low
- Poor



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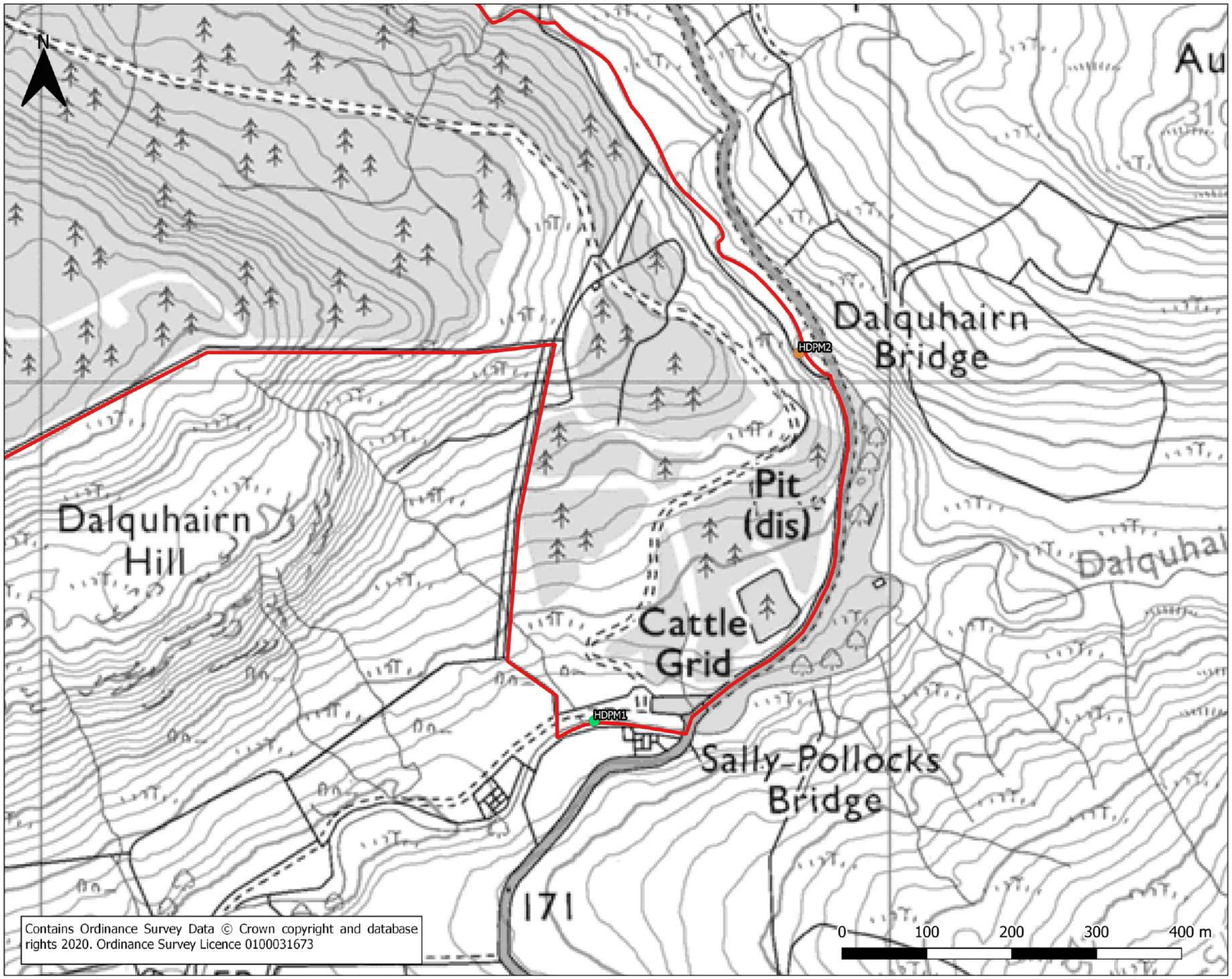

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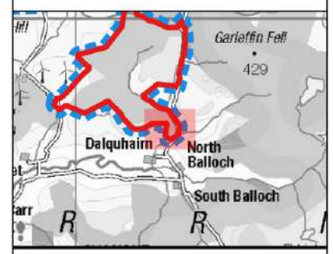

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Title:
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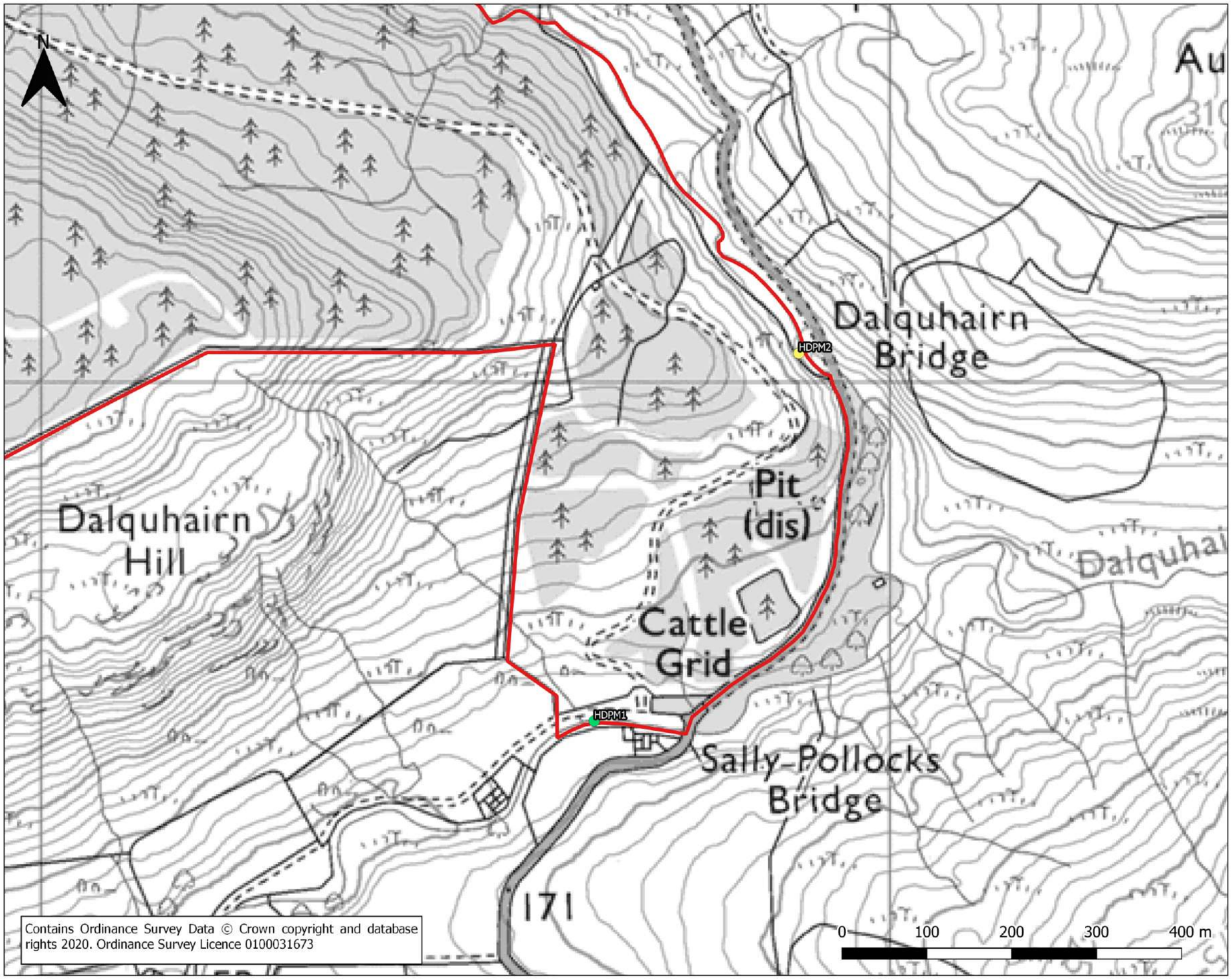

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FWPM Habitat Quality

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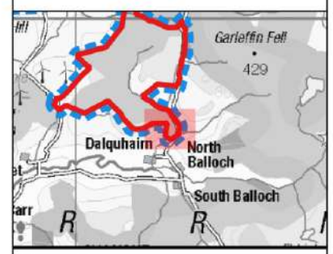
- Moderate



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Technical Appendix 9.4: Fish Habitat Survey (inc. FWPM)

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Title:
Figure 4
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