APPENDIX 8.1: PHASE 1 HABITAT SURVEY

The information contained within Phase 1 Habitat Survey that supported the 2009 ES was seen as relevant and thus was included in the 2018 EIA.

Viking Wind Farm Phase1 Survey
2005 & 2008
A Report for EnviroCentre/SSE

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Highland Ecology

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CONTENTS

3. Introduction

During April and early May 2008 the Nesting and Collafirth quadrants were re-surveyed to Phase1 level by Highland Ecology. This was to ensure compatibility with areas to the west, which were surveyed by HE in September 2005, and particularly to re-evaluate the blanket bog resource in terms of its condition and activity. In a previous survey of Nesting and Collafirth much of the ground had been classed as modified bog, and therefore undervalued, when in fact it is predominantly not modified bog in the strict Phase1 sense but unmodified, although fragmented, blanket bog.

The rate of Phase 1 survey in 2008 and 2005 was approximately 3 sq km per day so the accuracy is therefore much less than that of the detailed wind farm footprint NVC survey carried out later. However, using recent aerial photographs obtained for the project, it is possible that this survey along with the 2005 survey, could form a good basis for a wide scale peatland management plan.

4. Phase1 Habitat Types

2.1 Blanket bog

EC Habitats Directive 7130 Blanket bogs, UKBAP Priority Habitat

Blanket bog is the dominant vegetation type over the whole survey area. It occurs on peat over 50cm in depth and usually at least 2m deep. The vegetation is characterised by a range of species, the most frequent or constant vascular species being *Calluna vulgaris*, *Trichophorum cespitosum*, *Erica tetralix*, *Eriophorum vaginatum* and *Eriophorum angustifolium*. Unlike blanket bog throughout much of the rest of Scotland *Molinia caerulea* is absent. *Sphagnum* moss species, mainly *Sphagnum papillosum* and *Sphagnum capillifolium,* are usually at least patchily prominent in blanket bog and often form extensive continuous carpets in the wettest stands. In some drier blanket bog *Sphagnum* plays a reduced role and *Racomitrium lanuginosum* is very prominent.

Previous and current erosion is an important aspect of the blanket bog resource and special attention was given to the activity, i.e. current active build-up of peat, in different areas. To this end a rating system, devised for the subsequent, detailed wind farm footprint NVC survey, was also employed during the phase 1 survey in 2008. Data from Delting and Kergord (2005) was also interpreted in 2008 to form a similar, comparable assessment of active blanket bog. Blanket bog was graded from 5 (continuous, good condition vegetation with very little erosion) through to 1 (more or less completely eroded except for dry and continually eroding fragments of deep peat). A detailed description of the various criteria used to assign ranking is provided in Appendix 1 and a diagram showing the distribution of the blanket bog activity rankings is provided in Appendix 2.

2.2 Wet and dry dwarf shrub heath

Dwarf shrub heath, along with acid grassland, is a community of the shallower (i.e. less than 50cm deep) peats. It can be found commonly forming mosaics in areas of eroded and fragmented blanket bog as well as within more intact blanket bog where the peat thins over knolls or banks. It can also be found on more extensive slopes of shallower peat.

The characteristics of wet heath are a combination of ericoids, notably *Calluna vulgaris* but also *Empetrum nigrum*, *Erica tetralix* and *Erica cinerea* along with other mire species such as *Trichophorum cespitosum*, *Eriophorum angustifolium* and *Eriophorum vaginatum*. *Sphagnum* can be present but it is usually much more patchy than in blanket bog and can be trampled.

Dry heath can be found on the very steepest slopes and also within stretches of eroding blanket bog where it can resemble alpine heath over broad ridges and summits. It is usually completely dominated by *Calluna vulgaris*, although there can also be a little sparse *Vaccinium myrtillus* or *Erica cinerea*.

Due to a history of heavy grazing the heaths are frequently grassy in nature and occur in intimate mosaics with acid grassland.

2.3 Acid grassland

Acid grassland occurs throughout the survey area and is common in mosaics with dwarf shrub heath. It can be found in areas of eroding blanket bog and also in more uniform extents on steeper slopes with a heavy grazing history. It is also found in enclosed fields around the edges of the survey area.

Various species can predominate. In areas of blanket bog fragmentation the sward is usually a *Juncus squarrosus*-dominated one, although occasionally *Nardus stricta* can be the dominant species. These grasses are joined by a host of other grasses, notably *Festuca vivipara, Anthoxanthum odoratum*, *Agrostis canina* and *Deschampsia flexuosa*.

2.4 Other habitats

Other less extensive habitats are common through the survey area:

Acid flushes are frequent, in usually linear stands, through most blanket bog and areas of heath where it occupies soakways and seepage zones. *Juncus spp.* and a variety of mire species occur over a carpet of *Sphagnum* fallax and/or Sphagnum *denticulatum.*

More base-rich flushes have a suite of species unique to them including a diversity of sedges such as *Carex panacea, Carex viridula ssp. oedocarpa* and the bryophytes *Scorpidium scorpioides*, *Scorpidium revolvens* and *Campylium stellatum* along with *Pinguicula vulgaris*.

Other fragmentary or rare habitats found on the survey were marshy grassland, oligotrophic standing water and calcareous grassland.

APPENDIX 1

Active vs. Inactive blanket bog assessment criteria

Grading system 1 to 5 as follows (vegetated shallow peat = U6/Cv acid grassland/heath and/or substrate in hag bottoms):

1 More or less totally inactive, poor condition, 80-100% bare peat (or vegetated shallow peat)

- Widespread bare peat, substrate or wet heath/acid grassland on v. shallow soil.
- Very little cover, if any, of *Sphagnum*.
- Current erosion of remaining peat block edges and surfaces
- Maybe occasional fragments of remnant blanket bog but these not of any great size and usually eroding further.

2 Largely inactive, 50%-80 bare peat (or vegetated shallow peat)

- A large part of the area consists of bare peat, substrate or wet heath/grassland derived from former deeper peat.
- >50% bare surface or shallow peat
- Within this there might be some areas of active peat formation, either as existing blocks of uneroded blanket bog or as new active accumulation in the bottom of hags. These are not usually extensive.
- Condition may well be unfavourable (i.e. not recovering, or declining) due to ongoing erosion and/or trampling/grazing effects.

3 Intermediate, widespread larger scale peat erosion, 20-50% bare peat (or vegetated shallow peat)

- Typically a mosaic/patchwork of active and inactive areas, difficult to class as 2 or 4.
- There may be widespread hagging and bare peat or substrate, bare peat often in networks up to several metres wide
- 20-50% Bare peat surfaces or sparse re-vegetation
- There might also be small areas of new build-up of mire species, most importantly *Sphagnum* spp. U6a with Sphagnum building up on it. Small patches M17a and M1.
- These areas may be in current unfavourable condition due to trampling or they may be favourable and seen to be recovering.

- If exactly 50%-50% then judge by amount of re-vegetating surfaces vs. bare peat.

4 Areas of broadly intact bog with smaller scale but frequent bare peat erosion, 5-20% bare peat (or vegetated shallow peat)

- A large proportion of ground supports typical mire and peat-forming species, notably *Sphagnum* spp., though it may naturally not be prominent in the drier blanket bog types.
- Hags and bare peat etc. usually present and frequent, covering 5-20% of the ground as very frequent channels within peat but not usually wide or deep, i.e. up 0.5 to 2m
- Blanket bog may be continuing to erode in parts but better re-vegetating bare peat surfaces are more widespread here, along with areas of active building of Sphagnum etc. (U6a, M17a, M1) which can occupy hag bottoms, hollows and naturally damned channels in the peat.
- May be recoverable with reduced grazing

5 More or less fully active, good, stable condition blanket bog, <5% bare peat overall

- Widespread deep peat with little hagging and erosion, although there will usually be at least some.
- Continuously vegetated over large extents with typical mire species. In wetter stands there will be extensive unbroken *Sphagnum* carpets.
- Drier stands (e.g. M17b) may quite naturally have much less *Sphagnum* but here there will be extensive cover of *Racomitrium lanuginosum* and *Cladonia* spp. lichens and other typical associates. Where there are pools these will usually be well-vegetated with *Sphagnum cuspidatum* and/or *S. denticulatum* or *S. fallax* and typical vascular associates.

APPENDIX 2 – Blanket Bog Activity

APPENDIX 3 – Phase 1 Target Notes

Nesting

1. 45017 62040 Low lying areas of ground within hag systems, where peat has been eroded away in the past, support co-dominant *Calluna vulgaris* and *Juncus squarrosus* with frequent *Rhytidiadelphus loreus*, *Pleurozium schreberi*, *Hypnum Succisa pratensis* and *Hylocomium splendens*. *Sphagnum capillifolium* and *S. denticulatum* are occasional. Intact M17b blanket bog exists over higher ground. [KP]

2. 45235 61640 Over this higher ground a fine-grained mosaic of blanket bog (M17b), eroding and re-vegetating bare peat (M3) and re-vegetated *Calluna vulgaris*/*Juncus squarrosus* (dry heath/acid grassland) occurs through the different stages of erosion. [KP]

3. 44500 62000 Over the summit of Riven Hill peat has mainly eroded away to the mineral soil which is now mainly vegetated by *Calluna vulgaris* and *Juncus squarrosus* in an acid grassland/dry heath mosaic. Scattered peat hags remain with associated M17b. [KP]

4. 42490 62366 Area of modified bog enclosed within stock fence. Superficially much of this area appears as acid grassland but occurring over deep peat (>0.5m). Elsewhere, and forming a mosaic with acid grassland, are stands of *Eriophorum angustifolium* with *Juncus squarrosus*, *Sphagnum capillifolium*, *Carex panicea*, *Hypnum* sp. and *Racomitrium lanuginosum*. *Trichophorum cespitosum* becomes locally dominant and *Nardus stricta* and *Carex panicea* also become quite frequent in parts along with *Campylopus atrovirens*, *Sphagnum capillifolium* and *Juncus squarrosus*. Vegetation is generally not typical of NVC documentation. [KP]

5. 42697 62032 Bog pool forming behind *Juncus squarrosus* 'banks' within an area of shallower peat which appears to have been eroded away in the past and subsequently become re-vegetated by *Calluna vulgaris*, *Juncus squarrosus*, *Sphagnum capillifolium*, *S. cuspidatum*, *S. denticulatum*, *S. papillosum* and *Eriophorum angustifolium*. Peat throughout this habitat is 20-35cm deep. Photographs 4, 5 & 6. In general, over these low gradient slopes, M17b cut with eroding hags dominate the landscape. In most parts bare peat is becoming colonised *Eriophorum angustifolium*. [KP]

6. 42729 61567 Small pool forming. *Juncus squarrosus* 'banks' are complete with *Sphagnum* spp. starting to build up in-amongst. *Juncus squarrosus* and *Calluna vulgaris* with *Sphagnum* spp. dominate surrounding ground over fairly shallow peat. Photograph 7. [KP]

7. 42726 61188 Bare gravel and peat within eroding hags. Photograph 8 & 9. There is widespread peat erosion over this ridge of higher lying ground which is through to gravelly substrate in parts. Re-vegetation is patchy and often limited to areas where

peat has been completely lost. For the most part where there is bare peat it has become dried out on the surface and very unstable. [KP]

8. 42982 60593 Area of M17a with a fairly continuous carpet of *Sphagna* (*S. papillosum*, *S. palustre*, *S. capillifolium*). There is little damage to the peat surface and associated vegetation through this wetter type of blanket bog. [KP]

9. 42456 60369 Severe localised peat erosion with hags 1.5m+ high. Where the peat has been eroded away to mineral soil/gravel beneath some parts have become vegetated by *Juncus squarrosus* and *Calluna vulgaris*. These hags provide shelter to sheep over an otherwise exposed hilltop. Much of the *Juncus squarrosus* showed evidence of grazing at the time of survey. [KP]

10. 42655 60673 Extensive bare peat/gravel becoming vegetated by grasses and acrocarpous bryophytes up to 3cm tall. [KP]

11. 42376 61211 Localised erosion of peat leaving bare surface >100m² with limited re-vegetation by *Eriophorum angustifolium*. [KP]

12. 43293 62710 Small stream with emergent *Iris pseudacorus* and associated stands of M28 on both banks. [KP]

13. 43533 62440 Small soakways and flushes through surface of the bog support *Carex demissa*, *Potamogeton polygonifolius*, *Scorpidium scorpioides*, *Campylium stellatum*, *Sphagnum denticulatum* and *S. cuspidatum*. Disturbance is minimal and *Sphagnum* carpet (particularly *S. denticulatum*) continuous in parts with sparse *Eriophorum angustifolium* and *Eriophorum vaginatum*. [KP]

14. 43438 61853 Eroding hag system to 1m high. Colonisation of bare peat by *Eriophorum angustifolium* is frequent. Where the peat has been eroded away to a very thin covering or to the mineral soil/gravel beneath *Calluna vulgaris* and *Juncus squarrosus* dominate with frequent *Sphagnum capillifolium*. Erosion more or less equals re-vegetation as a whole. M17a blanket bog occurs as fragments. [KP]

15. 43217 61852 Over this flatter ground the blanket bog surface is structurally varied with small scale erosion. Hags are approximately 0.5m high. Re-vegetation of bare peat is frequent throughout and appears at a greater rate than erosion. This habitat is potentially fragile although in a stable/recovering condition at present. Photograph 1. [KP]

16. 43179 61567 Extensive eroding bare peat with patchy *Eriophorum angustifolium*. Erosion rates appear greater than re-vegetation. [KP]

17. 43739 61364 Gently sloping hillside with a diverse structure of M17b and M3. In parts where there has been more extensive erosion in the past re-vegetation and peat building is obvious with a good cover of *Sphagnum denticulatum* and *S. capillifolium* with frequent *Juncus squarrosus* in amongst a variety of species typically associated with M17a. When viewed from the opposite slopes to the west this habitat appeared quite significantly hagged and eroded. [KP]

18. 44119 61477 Pool forming on hilltop with dense *Juncus squarrosus* creating a bank along one side and eroding peat on the other. Photographs 2 & 3. There are several similar small pools over this area. In general this hilltop is a mosaic of acid grassland (U6) and dry heath over ground which appears to have been mainly stripped of peat by extensive past erosion, with some areas of intact M17b blanket bog and eroding bare peat. More areas appear to be re-vegetating than eroding. [KP]

19. 43851 60286 large area of intact M19a blanket bog (*Calluna vulgaris*, *Eriophorum vaginatum*, *Trichophorum cespitosum*, *Hylocomium splendens*, *Sphagnum capillifolium*, *Rhytidiadelphus loreus*) interspersed with smaller stands of the wetter M17a community which has good cover of *Sphagnum denticulatum*. [KP]

20. 42944 61113 Carpet of aquatic *Sphagna* (*Sphagnum denticulatum*/*cuspidatum*) covers this area with abundant *Eriophorum angustifolium* growing up through it. Drier 'islands' are dominated by a mixture of *Juncus squarrosus* and *Trichophorum cespitosum*. Towards the margins vegetation is more like M17a with frequent *Sphagnum papillosum* and *S. capillifolium*. [KP]

21. 45396 61261 Marginal slopes heavily grazed by sheep with topiarised *Calluna vulgaris* forming a fine-grained mosaic with *Juncus squarrosus* dominated grassland and more typical blanket bog (M17b/M19a). All habitats appear to be over deep peat. [KP]

22. 45145 62025 Re-vegetated area across summit resembles alpine heath (H14) in parts with abundant *Calluna vulgaris* accompanied by frequent *Racomitrium lanuginosum* and *Cladonia portentosa. Juncus squarrosus* and *Nardus stricta* are also conspicuous components of this vegetation. Elsewhere there is some exposed rocky substrate and bare peat but in general re-vegetation appears to be occurring at a faster rate than erosion. *Juncus squarrosus*/*Calluna vulgaris* dominated vegetation is common with scattered *Sphagnum papillosum* over shallow peat. Photographs 10 (N) & 11 (W) from 45068 61904. [KP]

23. 45092 61705 Small area of good condition M17a blanket bog with little/no erosion and a fairly continuous cover of *S. papillosum*, *S. capillifolium*, *S. palustre*, *S. cuspidatum*. [KP]

24. 44785 61498 Degree of hagging varies greatly over this hillside from intact bog to deep hags. Bare ground between hags is generally re-vegetating with *Juncus squarrosus* and *Calluna vulgaris*. [KP]

25. 44335 60960 Scattered small peat mounds. [KP]

26. 44341 60836 Drain cut through M17a/b bog >0.5m. Photograph 12. Similar drains occur down-slope of here and appear, from a distance, deeper. [KP]

27. 44062 59905 Localised deep hagging/severe erosion with some grassy re-vegetation and limited *Eriophorum angustifolium* over bare peat. To the north of here the bog is more-or-less intact. [KP]

28. 44017 59639 Localised severe hagging within wider area of better condition bog. Similar areas of more severe erosion are occasional but localised over the area. Photograph 13. [KP]

29. 41869 60991 Plateau of eroding blanket bog (photograph 14). Much of the bare peat is becoming colonised by sparse *Eriophorum angustifolium*. Hags mainly 0.5-1m high. [KP]

30. 42007 61167 Eroding bare peat (>500m^2) with associated hagging (M17b). There is some widely scattered *Eriophorum angustifolium* growing on peat and where the majority has been eroded away to mineral soil there are small patches of *Juncus squarrosus* (U6). [KP]

31. 42243 60224 Wetter area of bog (M17a/b) with pools and a good cover of *Sphagnum papillosum*. Where this flat lying ground meets the adjacent hill slopes there is quite extensive peat hagging/erosion. [KP]

32. 42434 59495 Spring head and flush with abundant *Montia fontana*, *Potamogeton polygonifolius* and *Carex nigra.* Also present are *Juncus bulbosus*, *Myosotis scorpioides*, *Ranunculus flammula*, *Cardamine pratensis*, *Juncus effusus* and *Philonotis fontana*. Towards the slightly drier margins there is frequent *Sphagnum cuspidatum*, *S. denticulatum*, *Carex nigra*, *Eriophorum angustifolium*, *Nardus stricta* and *Juncus bulbosus.* Photograph 15. At the spring head itself *Philonotis fontana* becomes abundant with occasional *Calliergon* sp. & *Cardamine pratensis*. Photograph 16. [KP]

33. 42594 59408 Spring head with abundant *Montia fontana*, *Cardamine pratensis*, *Potamogeton polygonifolius*, *Sphagnum denticulatum*, *Drepanocladus* sp., *Calliergon* sp., *Agrostis stolonifera*, *Ranunculus flammula*, *Carex nigra*, *Aulacomnium palustre* and *Philonotis fontana*. Although largely intact there is some degree of poaching through this habitat. Photograph 17. [KP]

34. 43389 59658 Spring head vegetated by *Sphagnum denticulatum*, *Carex nigra*, *Montia fontana*, *Agrostis stolonifera*, *Juncus effusus* and *Polytrichum commune*. [KP]

35. 42938 58982 Wide-scale peat erosion with fragments of old hags remaining. Bare mineral soil/gravel is becoming re-vegetated in parts, whereas areas of peat are not. Photographs 18 & 19. [KP]

36. 46101 59235 Drain cut through area of mainly intact blanket bog (M17a). Although *Sphagnum papillosum* is fairly constant through this habitat, areas of localised surface drying could be reduced through blocking up drains. Main species present include *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Sphagnum palustre*, *Molinia caerulea*, *Sphagnum capillifolium* and *Hylocomium splendens* (local). The drain itself is vegetated by *Potamogeton polygonifolius*, *Eriophorum angustifolium*, *Sphagnum denticulatum* and *Molinia caerulea.* There are localised small stands of acid grassland. [KP]

37. 45449 58829 Spongy *Sphagnum papillosum* through area of active (M17a) blanket bog. Occasional shallow drains through this habitat. In parts there is an increase in *Hylocomium splendens* and *Rhytidiadelphus loreus* over drier tussocks with *Sphagnum capillifolium*/*papillosum* in hollows and vegetation more closely corresponding to the documented M19 blanket mire. Old drains are vegetated by *Potamogeton polygonifolius*, *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Ranunculus flammula* and *Carex demissa*. [KP]

38. 44733 59021 Severe erosion with extensive (500m^2+) bare peat. Areas of hagging and erosion are quite varied over this hilltop with some fairly intact areas ranging through to areas of severe erosion such as this. [KP]

39. 44488 59286 Flush/soakway with *Carex rostrata*, *Carex demissa*, *Potamogeton polygonifolius*, *Scorpidium scorpioides* and *Juncus bulbosus.* [KP]

40. 44778 59977 Localised severe erosion/hagging. [KP]

41. 44479 54780 Steep sides along channel have a good amount of dry heath and patchy acid grassland. Heath most like H10 with some H21 where *Sphagnum* becomes quite prominent on shadier aspects. [TR]

42. 44831 55012 Area of heavily grazed blanket bog. Quite grassy with very short *Calluna vulgaris* and frequent areas of poaching. *Sphagnum* is impoverished, damaged and patchy. The community may be easily recoverable though. [TR]

43. 45056 55149 Acid grassland. Very short and sparse grasses over a carpet of hypnoid mosses. *Juncus squarrosus* is high cover along with *Agrostis capillaris*, *Juncus effusus*, *Bellis perennis*, *Thymus polytrichus*, *Rhytidiadelphus squarrosus*, *Rhytidiadelphus loreus*, *Hylocomium splendens*, *Dicranum scoparium* and *Pleurozium schreberi*. [TR]

44. 45545 55480 Blanket bog which is like M17b but with high *Juncus squarrosus* in places so transitional to M17c. *Calluna vulgaris* is of high cover along with *Eriophorum angustifolium*, *Sphagnum capillifolium* and *Hylocomium splendens*. There are also wet hollows with mainly *Sphagnum cuspidatum* (M1) and patches of U6 *Juncus squarrosus* acid grassland. [TR]

45. 45597 55714 Peat hags here to 1.5m high but there is some regeneration in the hag bottoms with *Eriophorum angustifolium* quite prominent and also the mosses *Sphagnum papillosum* and *Sphagnum cuspidatum* with some standing water in places. [TR]

46. 45113 57149 Large flat plain consisting of largely intact blanket bog, although there are a few areas of hagging within it. *Sphagnum papillosum* and *Sphagnum capillifolium* are very prominent in the vegetation along with *Calluna vulgaris*, *Eriophorum angustifolium*, *Eriophorum vaginatum* and the moss *Aulacomnium palustre*. [TR]

47. 44181 55136 Much of the area to the south of here is less than 50cm depth of peat so not officially blanket bog. But here there are frequent areas of active *Sphagnum* build-up in hollows plus fragments of deeper peat greater than 50cm. [TR]

48. 46178 57477 A3-A4 activity rating and consisting of the communities M17b and M3. [TR]

49. 45953 57701 A2-A1. Hags with remnant peat blocks continuing to erode and break down. Sheep aggravating erosion badly and preventing re-vegetation. [TR]

50. 45350 57658 Some M19 blanket bog here has *Calluna vulgaris* and mosses at about 50%-50%. The mosses are mainly *Hylocomium splendens* and *Rhytidiadelphus loreus*. There is *Empetrum nigrum* through this but it rather sparse. The drop in *Sphagnum* and *Racomitrium lanuginosum* is another difference between this and M17 blanket bog. [TR]

51. 44740 57342 An M10 sedge flush with *Scorpidium scorpioides*, *Carex echinata*, *Bryum pseudotriquetrum*, *Campylium stellatum* and *Carex panicea*. [TR]

52. 44036 58617 Massive wide-scale blanket bog erosion with almost entire bare peat surface, stony substrate or shallow peat acid grassland and heath. [TR]

53. 43806 55942 One of several M10 type flushes on the edge of blanket bog within acid grassland and heath mosaic. Sedges present are *Carex panicea* and *Carex viridula ssp. oedocarpa* along with *Juncus bulbosus* and the mosses *Scorpidium scorpioides*, *Bryum pseudotriquetrum* and *Blindia acuta*. [TR]

54. 43905 56298 Flushed ground (similar to M10) has *Thalictrum alpinum*, *Breutelia chrysocoma*, *Carex panicea*, *Carex viridula ssp. oedocarpa*, *Campylium stellatum*, *Selaginella selaginoides*, *Ctenidium molluscum* and *Drepanocladus sp*. [TR]

55. 44049 56687 Areas of currently eroding blanket bog with heavy grazing exacerbating erosion [TR]

56. 44202 56775 Currently eroding blanket bog with an activity rating of A3. There is some active peat formation in hag bottoms but also much eroding bare peat. Also areas of U6a where *Juncus squarrosus* is of high cover along with *Calluna vulgaris*, *Cladonia portentosa* and *Sphagnum capillifolium*. [TR]

57. 44006 57401 Area of A2 bare peat along with shallow peat acid grassland and heath consisting of *Calluna vulgaris*, *Juncus squarrosus*, *Empetrum nigrum*, *Sphagnum papillosum*, *Rhytidiadelphus loreus*, *Hylocomium splendens*, *Hypnum jutlandicum*. There are also patches of bare stony substrate and remnant blocks of M17b blanket bog but the shallow peat far outweighs these. Some areas of the grassland are like U5 with *Nardus stricta* taking dominance along with some *Juncus squarrosus*, *Galium saxatile*, *Dicranum scoparium*, *Agrostis capillaris* and *Pleurozium schreberi*. [TR]

58. 43680 56745 Summit area of widespread blanket bog erosion around half bare peat with about 10% remnant blanket bog (M17b) and the rest shallow peat U6 acid grassland and heath. [TR]

59. 43415 56739 Old eroded blanket bog now grassland and heath at around 70%-30%. U6 consists of *Juncus squarrosus*, *Nardus stricta*, *Polytrichum alpestre*, *Rhytidiadelphus squarrosus* and *Rhytidiadelphus loreus*. The heath consists of *Calluna vulgaris*, *Nardus stricta*, *Agrostis capillaris*, *Hypnum jutlandicum*, *Rhytidiadelphus loreus* and *Hylocomium splendens*. [TR]

60. 43685 54980 Eroded blanket bog now mainly heath and grassland with fragments of remaining bog. Heavy grazing and trampling by sheep. [TR]

61. 42988 55041 Blanket bog M17b with frequent erosion channels classed as A4. M17b composed of *Racomitrium lanuginosum*, *Eriophorum angustifolium*, *Calluna vulgaris*, *Eriophorum vaginatum*, *Cladonia portentosa*, *Sphagnum capillifolium*, *Empetrum nigrum*, *Hypnum sp* and *Cladonia uncialis*. Bare peat is frequent but these are not large areas and have some *Eriophorum angustifolium* colonising it. There also some M1 hollows with *Sphagnum cuspidatum* but these are generally trampled and poor. [TR]

62. 42600 55748 Black Loch is drained and not really a proper loch, more like a wet peaty hollow with some standing water with M3 and patches of M17a. [TR]

63. 42764 56174 Loch of the Andris now also drained and not a proper Loch. Still quite wet with patchy hollows of M1 and M17a and some areas of grassland. Photograph 32. [TR]

64. 43080 56263 Area of current bad erosion. Pools are present but will soon be eaten into by erosion of blanket peat and then drain. Need acting on urgently. Photograph 33. [TR]

65. 42065 58593 Steep slopes are a mix of acid grassland and heath at around 70:30% Main species are *Calluna vulgaris*, *Juncus squarrosus*, *Galium saxatile*, *Hylocomium splendens*, *Polytrichum commune*, *Rhytidiadelphus squarrosus* and *Festuca ovina*. [TR]

66. 42622 57451 Area of A3 eroding blanket bog with M17b consisting of *Racomitrium lanuginosum*, *Eriophorum vaginatum*, *Calluna vulgaris*, *Eriophorum angustifolium*, *Cladonia portentosa*, and *Pleurozium schreberi*. At times this is almost like M19 where hypnoids are prominent and *Racomitrium lanuginosum* drops off. There are also areas of M3 bare peat, shallow peat acid grassland and heath. [TR]

67. 42613 57317 2 large pools at edge of erosion area are threatened by being eaten into and draining. Urgent action is required to save these. Photograph 47. [TR]

68. 43563 57757 Very large area of intact M17a blanket mire with much *Sphagnum papillosum* and *Sphagnum capillifolium* cover. [TR]

69. 42631 58827 Variably eroding blanket bog with some big areas of bare peat. Very variable and several activity classes present so not mapped individually. The Loch is currently intact but erosion is getting very close and it is threatened. [TR]

Collafirth

70. 45763 67337 Heavily grazed/topiarised *Calluna vulgaris* towards margins of dry heath habitat. Areas of *Juncus squarrosus* grassland (U6) are also frequent through this area between typical dry heath and blanket bog. [KP]

71. 45715 67430 Good condition BB over slopes which appears most similar to the M19 NVC community, although transitional towards M17a where there is an increase in cover of *Sphagnum papillosum*. In general *Eriophorum vaginatum* tussocks are fairly conspicuous, although scattered, and occur with a mixture of *Sphagnum capillifolium*, *Plagiothecium undulatum*, *Rhytidiadelphus loreus*, *Calluna vulgaris* and *Trichophorum cespitosum*. Where the gradient increases acid grassland (U6) replaces blanket bog. [KP]

72. 44548 67612 Vast area of M17b/M3 with varying degrees of erosion, from more or less intact to localised hagging and associated bare peat. Photographs 20, 21 & 22. [KP]

73. 44014 66632 Low lying area of wetter ground supporting a mixture of abundant *Sphagnum denticulatum* and frequent *Sphagnum cuspidatum*. Higher plants are generally sparser and predominantly a mixture of rushes (*Juncus bulbosus*, *Juncus squarrosus*, *Juncus effusus*). In NVC terms this vegetation most closely relates to M6 (acid flush). Photograph 23. [KP]

74. 44756 66731 Extensive erosion along ridge to East-North-East of here with bare peat and deep hagging. [KP]

75. 45395 66457 Dramatic grazing effect along fence-line shown by photograph 24. [KP]

76. 45396 67790 Area of blanket bog with a good cover of *Sphagnum capillifolium*/*papillosum*/*cuspidatum* and frequent *Calluna vulgaris*, *Juncus squarrosus*, *Empetrum nigrum*, *Rhytidiadelphus loreus* and *Aulacomnium palustre*. The peat depth varies around 0.5m. Surrounding bog is varied M17a/c/M19a and generally intact with little/no erosion. [KP]

77. 44814 67691 Area of bare peat which has been eroded away in parts to bare gravel which is becoming vegetated by *Juncus squarrosus*. Hagging and associated erosion are more noticeable over this watershed although there is some re-vegetation in parts. [KP]

78. 41613 66147 Scattered base-rich flushes (M10) over this slope. *Carex demissa*, *Carex panicea*, *Sphagnum denticulatum*, *Pinguicula vulgaris*, *Potamogeton polygonifolius* and *Eriophorum angustifolium* are all frequent. [KP]

79. 41877 66170 Rocky M10 flush with frequent *Carex demissa*, *Juncus bulbosus*, *Drepanocladus* sp., *Scorpidium scorpioides*, *Campylium stellatum*, *Carex panicea* and *Schoenus nigricans*. Also noted through this habitat at low frequency are *Bryum pseudotriquetrum*, *Thalictrum alpinum* and *Pinguicula vulgaris*. Photograph 25. [KP]

80. 42523 66085 Stream cuts through wider area of intact blanket bog where there is little or no erosion to the peat. *Sphagnum papillosum* is frequent (M17a) through wetter areas where the water table is closest to the surface, becoming replaced by *Racomitrium lanuginosum* in slightly drier situations. Vegetation in general is made up of a fairly even mixture of *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Trichophorum cespitosum* with scattered *Cladonia uncialis*, *Pleurozia purpurea* and *Cladonia portentosa*. [KP]

81. 43166 66110 Sequence of species poor bog pools (M1) with abundant aquatic *Sphagnum cuspidatum* and marginal *Sphagnum denticulatum.* [KP]

82. 43743 66915 Localised severe peat erosion/hagging to 1m. Rate of erosion is greater than re-vegetation of bare peat. Sparse *Eriophorum angustifolium* does occur through some areas of eroded peat. [KP]

83. 43660 67015 Peat mound. [KP]

84. 43409 66915 Expanse of eroding bare peat and exposed gravel over hilltop. *Calluna vulgaris* and *Juncus squarrosus* are re-vegetating some areas of shallow peat and mineral soil. [KP]

85. 41578 66321 *Schoenus nigricans* dominated stony flush (M10) with *Carex demissa*, *Narthecium ossifragum*, *Carex panicea*, *Trichophorum cespitosum* and *Scorpidium scorpioides*. [KP]

86. 41563 66842 Acid grassland occurs in a mosaic with blanket bog (as a result of historic grazing pressures). Where blanket bog remains it is rich in graminoids and in particular *Eriophorum vaginatum* with occasional *Juncus squarrosus*, *Eriophorum angustifolium*, *Rhytidiadelphus loreus*, *Hylocomium splendens* and *Calluna vulgaris*. The *Sphagnum* carpet remains more or less intact with frequent *Sphagnum capillifolium*, *S. papillosum* and *S. palustre*. [KP]

87. 43938 67402 Bog pools (M1) with abundant aquatic *Sphagnum denticulatum* and *Sphagnum cuspidatum* interspersed with *Sphagnum* rich *Juncus squarrosus* grassland (U6a). These pools occur within a wider area of intact M17a/b/M19a where *Sphagnum* spp. are abundant through the wetter M17a community. [KP]

88. 44249 67657 Degree of hagging varies greatly over this undulating terrain with some area of bog completely intact and others with frequent peat hags to 1m. [KP]

89. 43343 68028 Flat area of blanket bog with frequent *Sphagnum papillosum*, *S. capillifolium*, *S. cuspidatum* and *S. palustre* through areas of M17a, which become more or less replaced by *Racomitrium lanuginosum* over slightly higher ground. Erosion is minimal with hollows all densely re-vegetated by *Sphagna* and *Eriophorum angustifolium*. Photographs 26 & 27. [KP]

90. 42971 67999 Despite the steep gradient here, a good proportion of vegetation is over deep (>0.5m) peat and similar to a grassy M19 with frequent *Juncus squarrosus* and *Nardus stricta*. Cover of *Sphagnum* spp. is still significant through this habitat. This

bog habitat occurs in a mosaic with acid grassland and wet heath (particularly over fence to North East). [KP]

91. 42779 68159 Wet heath over shallow peat with abundant *Calluna vulgaris*, *Juncus squarrosus* and *Sphagnum capillifolium*. At lower cover are occasional *Rhytidiadelphus loreus*, *Sphagnum cuspidatum*, *Aulacomnium palustre*, *Eriophorum vaginatum* and *Empetrum nigrum*. This habitat is short-grazed by sheep. [KP]

92. 42007 67044 *Schoenus nigricans* dominated stony flush with abundant *Carex demissa* and occasional *Campylium stellatum.* There are similar flushes scattered over these slopes. [KP]

93. 44505 69106 Sequence of pools (M1) forming hummock/hollow structure in association with M17b & a. Pools are vegetated by *Sphagnum cuspidatum* and *Sphagnum denticulatum* with *Eriophorum angustifolium*. There is also scattered *Potamogeton polygonifolius*. Photographs 28 & 29. [KP]

94. 45267 68714 Sequence of pools/small lochans surrounded by good condition blanket bog (M17a) with a high cover of *Sphagnum papillosum* and minimal erosion. *Eriophorum angustifolium* is colonising bare peat where it exists and a small area of past erosion has become re-vegetated by *Calluna vulgaris* and *Juncus squarrosus*. Photographs 30 & 31. [KP]

95. 43803 63848 Hummock-hollow topography with the topes drying out and hummocks of *Racomitrium lanuginosum*. Also *Cladonia portentosa*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Calluna vulgaris* and wetter hollows with very poor vegetation, little *Sphagnum* and trampled by sheep. There are also patches of M17a with more extensive *Sphagnum papillosum*, *Sphagnum capillifolium* and *Pleurozia purpurea*. *Sphagnum magellanicum* is also present. This is A5 but declining and on the verge of being classed as A4. [TR]

96. 44242 64664 *Juncus squarrosus* forming mounds as if it has colonised an old small block of remnant peat within eroded blanket bog. Photograph 34. [TR]

97. 44086 65393 Eroding blanket bog with hags to 1.5m high. The blanket bog is mainly M17b composed of *Racomitrium lanuginosum*, *Calluna vulgaris*, *Hypnum sp*, *Cladonia portentosa*). Very heavily grazed with much bare peat and trampling. Other communities present are U6a *Juncus squarrosus* and *Sphagnum* grassland/mire also with *Sphagnum cuspidatum*, *Scapania gracilis* and *Calluna vulgaris*. Photograph 35. [TR]

98. 44189 65976 Area of flat intact blanket bog is M17a with extensive *Sphagnum papillosum* carpets along with *Sphagnum capillifolium* and *Calluna vulgaris*, *Eriophorum angustifolium* and *Eriophorum vaginatum*. There is an occasional M1 hollow/pool with *Sphagnum cuspidatum* and *Sphagnum denticulatum*. Photograph 36 and 37. [TR]

99. 43321 65184 Looking south – continuous blanket bog classed as A5. M17b has much *Racomitrium lanuginosum* with *Cladonia portentosa*, *Calluna vulgaris*, *Eriophorum angustifolium*, *Eriophorum vaginatum* and some *Trichophorum*

cespitosum. There is also some *Sphagnum capillifolium* and patchy *Erica cinerea* amongst the *Calluna vulgaris*. There is an occasional small patch of M3 bare peat and U6 *Juncus squarrosus* acid grassland with *Nardus stricta* and *Calluna vulgaris*. [TR]

100. 43475 64258 Looking east down onto a patch of A3 eroding blanket bog with intact A5 beyond in the background and A4-5 in the foreground. [TR]

101. 42398 63641 Flat area of blanket bog intact (A5) consisting of mainly M17a and M17b with M1 hollows. There are areas with more erosion (A4) within it and these have bare peat/M3 at around 5-10% coverage. The M17 has *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Sphagnum capillifolium*, *Racomitrium lanuginosum*, *Hypnum jutlandicum*, *Cladonia portentosa* and *Sphagnum papillosum*. The M1 hollows have *Sphagnum cuspidatum* but they are very poor and quite bare being trampled badly by sheep. [TR]

102. 42758 63665 Area of blanket bog classed as A4 and A3. There is very frequent erosion and hags with areas of bare peat up to 1m wide every 5m. The area is also heavily grazed by sheep. [TR]

103. 42849 63440 Very wet area on broad hollow with a gull colony. Consists of much standing shallow water and M1/M17a vegetation. Photograph 38. [TR]

104. 43203 63584 Steeper slope are very much like dry heath but on deep and firm peat. *Calluna vulgaris* is abundant along with *Racomitrium lanuginosum*, *Cladonia portentosa*, *Empetrum nigrum*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Hylocomium splendens* and patches of *Sphagnum capillifolium*. [TR]

105. 42184 64289 Large expanse of intact blanket bog with very hags and erosion. Some areas within this have more frequent hags though. The vegetation is mainly M17a and M17b with frequent large cushion and carpets of *Sphagnum capillifolium*, *Racomitrium lanuginosum* and *Cladonia portentosa*. *Sphagnum papillosum* and *Pleurozia purpurea* are more frequent on wetter ground and there are also hollows where *Sphagnum cuspidatum* predominates. Photograph 39 [TR]

106. 42196 63699 5 photos showing effect of grazing levels on blanket bog surface vegetation on either side of a fence. LH side is more heavily trampled than RH side. LH has more bare peat and no *Sphagnum cuspidatum* in hollows whereas RH side has mainly vegetated hollows with much *Sphagnum cuspidatum*. Photograph 40, 41, 42. [TR]

107. 44630 63791 M10 flush with much *Scorpidium scorpioides*, *Carex viridula ssp. oedocarpa*, *Juncus bulbosus*, *Blindia acuta*, *Campylium stellatum* and *Ctenidium molluscum*. There are many such flushes along this hillside, some with much *Schoenus nigricans*. [TR]

108. 44890 64889 Large summit area of very eroded blanket bog (A2 and A1). There is widespread bare peat along with shallow peat U6 acid grassland and heath. Main species are *Juncus squarrosus*, *Calluna vulgaris*, *Rhytidiadelphus loreus*, *Hypnum*

sp, *Dicranum scoparium*, and *Barbilophozia sp. Juncus squarrosus* colonises old bits of broken off peat and forms tight mono-dominant hummocks. Photograph 43. [TR]

109. 44722 65817 *Juncus squarrosus* appears to be a prime builder of vegetation blocking up eroded peat channels within area of eroding blanket bog (A3) M17 at about 60% U6/M3 around 40%. Photograph 44. [TR]

110. 44882 64109 Big area has much revegetation and active peat build-up in hollows which have much *Sphagnum.* Again *Juncus squarrosus* appears to play and important role in forming a peat surface resistant to erosion. [TR]

111. 45427 65912 Tronister Club – widespread erosion of blanket bog with much bare peat (M3) and U6 acid grassland, bare substrate and heath. There are remnant small isolated blocks of blanket peat (M17). Photograph 45. [TR]

112. 45140 65521 A3 area of remaining blanket bog to shallow and bare peat vegetation is around 50:50 Photograph 46. [TR]

113. 44883 64086 Area in fenced part seems to be recovering – eroded blanket bog with extensive shallow peat but now active build up with much *Sphagnum capillifolium*, *Calluna vulgaris*, *Juncus squarrosus*, *Sphagnum papillosum*, *Cladonia portentosa*, *Empetrum nigrum*. *Juncus squarrosus* being overgrown by *Sphagnum*. There is also an occasional M1 pool with *Sphagnum cuspidatum*. Very little actual bare peat and much U6/M17a/M17b/M1. [TR]

Delting

114. 38819 66577 Wide expanse of blanket bog which varies greatly in condition between more or less intact bog with wet hollows (M17a/b/M1) through to deeply hagged M17b/M3. Past eroded peat tends to be revegetating with wet grassy heath (M15d/U6) vegetation. Bare peat is frequent but not extensive. [KP]

115. 37247 66567 Area of peat cuttings to North-east of here. Over this area blanket bog has been modified by this activity with some areas of bare peat and other parts revegetated by acid grassland. [KP]

116. 37682 65886 Fly tipping of agricultural (manure and straw) and commercial/domestic rubbish (exhausts, oil cans, chairs etc) over this area. [KP]

117. 39119 65433 Continuous intact blanket bog mainly. Flats and depressions have a higher cover of *Sphagnum papillosum* along with *Sphagnum capillifolium*, *Cladonia portentosa*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Calluna vulgaris* and *Erica tetralix*. Drier hummocks and better drained peat surfaces have less *Sphagnum*, more *Racomitrium lanuginosum* and *Cladonia portentosa* and also *Calluna vulgaris*, *Empetrum nigrum*, *Eriophorum vaginatum*, *Cladonia arbuscula* and *Cladonia uncialis*. Pools are scarce and have a little *Sphagnum cuspidatum* at edges with little else. Photo 48. [TR]

118. 39119 65414 Pool with standing water which is unvegetated apart from a little *Carex rostrata* and *Sphagnum denticulatum* at the edges [TR]

119. 39767 65666 Mainly shallow peat with grassy wet heath and patches of blanket bog. *Trichophorum cespitosum*, *Racomitrium lanuginosum*, *Calluna vulgaris*, *Cladonia portentosa*, *Cladonia uncialis*, *Nardus stricta*, *Huperzia selago* and *Carex panicea.* Photo 49. [TR]

120. 39608 66836 Around Souther Hill there is eroded blanket bog supporting wet heath and acid grassland. Much of the shallow peat though has very good covers of *Sphagnum papillosum* and *Sphagnum capillifolium* with *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Calluna vulgaris*, *Empetrum nigrum* and *Racomitrium lanuginosum* (U6a->M17a). It has therefore been upgraded in activity ranking from 3 to 4 to reflect this. [TR]

121. 37150 69138 Narrow gorge with steep rocky sides supporting a mosaic of H10a/H10c/U6 with occasional tall herb ledges (U16): *Luzula sylvatica*, *Lonicera periclymenum*, *Solidago virgaurea*, *Thymus polytrichus*, *Jasione montana*, *Erica cinerea*, *Blechnum spicant*, *Hypericum pulchrum*, *Galium verum*, *Prunella vulgaris*, *Succisa pratensis*, *Angelica sylvestris*, *Festuca vivipara*, *Lotus corniculatus*. There are also small fragments of CG10a immediately below ledges. [KP]

122. 37328 68276 Hummock/hollow bog structure over ridge which is in relatively good condition. The drier M17b occurs of the hummocks with M1/M3 hollows. [KP]

123. 37706 68779 Small area adjacent to eroding hagg which is heavily vegetated by *Juncus squarrosus* (U6) with associated shallower substrate. There are similar small areas over this hill. To south-east there are more extensive areas of thin peat vegetated by *Racomitrium lanuginosum*/*Calluna vulgaris* heath (H14a) with occasional *Empetrum nigrum*, *Erica cinerea* and *Cladonia* spp. interspersed with fragments of *Juncus squarrosus* dominated vegetation (U6). [KP]

124. 37755 69351 Localised hagging over ridge of mire. Individual haggs are a maximum of 1m high with limited associated peat erosion. [KP]

125. 37816 68446 Area of wetter, lower lying blanket bog with fragments of M17a and frequent M1 pools. Hagging and erosion localised and minimal. [KP]

126. 38025 67101 Areas of H14/U6 over summit with *Racomitrium lanuginosum* and *Calluna vulgaris* co-dominating the short, wind-clipped vegetation with scattered *Nardus Stricta* and locally abundant *Juncus squarrosus*. Over these areas peat depth is less than 0.5m and in parts there is bare, exposed gravely substrate. Where the peat thickens vegetation is mainly of the M17b blanket bog community with some M19a. [KP]

127. 38654 67069 Eroding hagg system at edge of extensive area of haggs to the south and south-east. [KP]

128. 39719 67227 More extensive area of *Juncus squarrosus* dominated vegetation (U6) with a frequently broken peat surface leaving areas of bare gravel. Pockets of deeper peat support M19a/M17b. [KP]

129. 39746 67574 Small areas of *Juncus squarrosus* dominated vegetation with associated thin substrate within wider area of deep peat. There are also localised eroding peat haggs over this summit area which are mainly 1m high although increasing to 1.5m occasionally. [KP]

130. 40838 68577 Area of salt-marsh composed mainly of mono-dominant stands of *Plantago maritima* with occasional *Triglochin maritima*, *Glaux maritima* and *Armeria maritima*. There are also smaller fragments of *Glaux maritima*, *Juncus gerardii*, *Armeria maritima*, *Triglochin maritima*, *Plantago maritima* and *Festuca rubra* forming a typically taller sward. [KP]

131. 40947 68433 Stand of *Phragmites australis* at head of salt marsh adjacent to small stream. Associated species include *Juncus gerardii*, *Glaux maritima* and *Triglochin maritima*. [KP]

132. 42126 71663 Occasional scattered small peat haggs over Hill of Neegarth which are 1-1.5m high. Photograph 95. [KP]

133. 42468 71337 Eroding peat hagg approximately 1-1.5m high. At base of hagg is exposed gravely substrate and small fragments of *Juncus squarrosus* dominated vegetation (U6c). There are more haggs to immediate west of here. Photograph 94. [KP]

134. 42505 71200 Summit ridge is a mixture of *Calluna vulgaris*, *Nardus Stricta*, *Racomitrium lanuginosum* and *Juncus squarrosus* with varying levels of dominance. Substrate is quite stony and vegetation most similar in NVC terms to U6c/H14a. [KP]

135. 42993 72952 Peat cuttings through area of marginal blanket bog adjacent to minor road. Mire is locally modified with associated surface drying as a result. Vegetation superficially resembles dry heath in parts. [KP]

136. 43197 71848 Small area of vegetation over shallow substrate. Vegetation most closely resembles a mosaic of heathy *Juncus squarrosus* grassland (U6c) and *Calluna vulgaris-Racomitrium lanuginosum* heath (H14a) and is frequently transitional between the two. Vegetation tends to be made up of a mixture of *Calluna vulgaris*, *Nardus Stricta*, *Racomitrium lanuginosum* and *Juncus squarrosus* with occasional *Carex bigelowii*. Dominance between these species varies. [KP]

137. 43309 72134 Small fragments of *Juncus squarrosus* dominate vegetation (U6c) with shallow substrate here and to the north-east over this ridge. [KP]

138. 43433 71326 Short grazed flush (*Carex flacca*, *Succisa pratensis*, *Plantago maritima*, *Prunella vulgaris*, *Thymus polytrichus*, *Selaginella selaginoides*, *Danthonia decumbens*, *Potentilla erecta*, *Thalictrum alpinum*, *Calluna vulgaris*, *Nardus Stricta*, *Festuca ovina*, *Bellis perennis*, *Rhytidiadelphus squarrosus*, *Pseudoscleropodium purum*). To south-west of here is Schoenus nigricans flush with *Carex echinata*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Hylocomium splendens*, *Plantago lanceolata*, *Plantago maritima* and *Calliergon cuspidatum*. [KP]

139. 42043 70357 These slopes look like dry heath being *Calluna vulgaris*-dominated but there is plentiful *Erica tetralix* and frequent patches of *Sphagnum capillifolium*, *Sphagnum papillosum* with sparse *Eriophorum angustifolium* and has therefore been classed as M15b. Drier parts have less *Erica tetralix* and *Sphagnum* and there is then an increase in *Erica cinerea* along with *Hypnum* sp., *Hylocomium splendens*, *Potentilla erecta* and *Rhytidiadelphus loreus* – this has been classed as H10a. *Juncus squarrosus* is frequent throughout and *Calluna vulgaris* is grazed to a height of about 15cm. [TR]

140. 40591 69737 Large parts of the broad ridge below the summit of the Hill of Dale have shallow peat and M15c (see quadrat). *Vaccinium vitis-idaea* is also present here and there are areas of *Juncus squarrosus* and *Nardus stricta* acid grassland U6/U5. There are a few intact peat blocks but these are relatively small with most of the deeper peat over the brow of the hill to the south-east. [TR]

141. 40431 69550 A large area of deep waterlogged peat with an abundance of *Sphagnum papillosum* and *Sphagnum capillifolium* (M17a) along with wet hollows having *Sphagnum cuspidatum* and *Sphagnum denticulatum* (M1). Avoid developing here. Also highest part of Hill of Dale has fairly intact blanket mire. [TR]

142. 40569 69974 An area of relatively intact peat to 3m deep as seen at various hagg locations. The blanket bog is in good condition with typical species composition for M17b, M17a, M19a and M1 where they occur. Avoid developing. [TR]

143. 41645 71524 More erosion here with haggs to 3m high and a bare peat network to 3m wide. There are some very wet areas though, up to 200m across, with M17a and M1 in depressions and these should be avoided. [TR]

144. 41874 70746 An area of largely shallow peats (M15c/U6 – *Juncus squarrosus*, *Calluna vulgaris*, *Erica cinerea*, *Cladonia portentosa*, *Cladonia uncialis*, *Racomitrium lanuginosum*, *Empetrum nigrum*) with few blocks of deeper peat with some M17a-c and M1. There are also bare stony patches. [TR]

145. 38845 69656 Small hill has eroded blanket mire with haggs to 2m and a high cover of *Juncus squarrosus* acid grassland (U6 – *Juncus squarrosus*, *Nardus stricta*, *Polytrichum commune*, *Calluna vulgaris*, *Racomitrium lanuginosum*, patchy *Sphagnum palustre* and *Sphagnum capillifolium*) and scattered deeper peat blocks. [TR]

146. 40062 69042 Here the mire is quite flat and wet with a high cover of *Sphagnum capillifolium* along with *Trichophorum cespitosum*, *Calluna vulgaris*, *Empetrum nigrum*, *Juncus squarrosus*, *Cladonia portentosa*. There are shallow pools with *Sphagnum cuspidatum* and *Sphagnum denticulatum*. There is small amount of shallower peat and bare ground around the summit of Bonnet Knowe. [TR]

147. 39473 68998 This long ridge has blanket mire variably hagged to 3m deep. It has M17b on deep intact peat blocks and a network of M3 bare peat and *Eriophorum angustifolium* to 10m across and there are also wetter areas of mire. There are patches of U6/U5 acid grassland to 50m across which are the preferable areas for development and all deep peat should be avoided. [TR]

148. 39159 68971 Blanket mire here more intact with very few haggs. There area areas of wetter peat with carpets of *Sphagnum papillosum* and *Sphagnum capillifolium* in good condition. [TR]

149. 38885 68762 Dynascord Hill has many large areas of bare stony ground and shallow peat with acid grassland (U6) and is suitable for development although the remaining intact peat blocks should be avoided, especially where there is some active formation. [TR]

150. 38472 67995 Summit of Riding Hill has eroded blanket mire consisting of deep blocks of peat amid shallow peats (M15c – *Calluna vulgaris*, *Racomitrium lanuginosum*, *Juncus squarrosus*, *Erica cinerea*, *Empetrum nigrum*, *Cladonia portentosa*, *Hypnum* sp. and bare peat and stony ground. Suitable for turbines but avoid intact peats. [TR]

151. 39381 68177 Button Hills – there is a very large area of intact blanket mire which is generally very wet with abundant *Sphagnum papillosum* in carpets with *Sphagnum capillifolium* and *Cladonia portentosa*, *Calluna vulgaris*, *Empetrum nigrum*,

Eriophorum vaginatum, *Eriophorum angustifolium*, *Trichophorum cespitosum* and *Juncus squarrosus*. [TR]

Kergord

152. 35509 59676 Badly eroded ridge of former blanket peat which has frequently been eroded down to the gravely substrate. [KP]

153. 35597 55048 *Calluna vulgaris* heavily browsed and exhibiting topiary growth form. [KP]

154. 36152 54732 Small area of eroding peat haggs (1m high) with some *Eriophorum angustifolium* re-colonising bare peat along with more established *Juncus squarrosus* dominated vegetation (U6c). To north of here M17b/M3 vegetation is typical of much of the survey area with *Racomitrium lanuginosum* dominated vegetation interspersed with peaty hollows and runnels. [KP]

155. 36292 59693 Large area of eroding bare peat. Some parts have re-vegetated with grassland species and *Juncus squarrosus* with *Eriophorum angustifolium* colonising areas with no other vegetation. Photograph 78. Similar, smaller scale areas occur to the east of here, nearer the road. Areas of surrounding M17b are fairly typical of the survey area as a whole with occasional peaty pools/hollows (M1/M3) and some degree of erosion throughout, varying from small scale to deep actively eroding haggs where there is exposed gravely substrate. [KP]

156. 36527 56144 This extensive area of blanket bog is partially modified and moderately grazed. Impact on the surface, in the form of bare peat, is frequent from trampling (sheep). There is also a population of mountain hares across this area. Vegetation is mainly of the M17b sub-community with patchy peaty hollows (M3). Photographs 71 & 72. [KP]

157. 36739 55464 *Carex*-rich flush with abundant *Carex panicea* and *Carex viridula* ssp. *oedocarpa*, *Danthonia decumbens*, *Juncus bulbosus*, *Thalictrum alpinum*, *Calluna vulgaris*, *Potentilla erecta*, *Nardus Stricta* and *Carex echinata*. Bryophytes are more or less absent except for some localised *Sphagnum denticulatum*. Flush is approximately 10m wide and linear down hillside. Further up-slope vegetation becomes more *Nardus Stricta* dominated and most similar to U5c in terms of NVC. Photograph 73. [KP]

158. 36842 56375 Soligenous flush (M6bii) with *Trichophorum cespitosum*, *Carex echinata*, *Juncus bulbosus*, *Nardus Stricta*, *Calluna vulgaris*, *Sphagnum denticulatum*, *Potentilla erecta* and *Eriophorum angustifolium*. Similar flushes are frequent over this area. Immediately adjacent mire is quite grassy with frequent *Nardus Stricta* and *Sphagnum palustre* as well as occasional *Sphagnum papillosum.* [KP]

159. 37010 57267 Expanse of blanket bog. Some localised poaching and *Sphagnum* disturbance with increased *Racomitrium lanuginosum*. Areas of M19a/M17b with

smaller fragments of the wetter M17a and peaty M3 hollows. Moderate grazing by sheep over the area has led to some areas of vegetation more closely resembling wet heath although still over deep peat. [KP]

160. 37237 55479 Hagging over North Mid Hill. Vegetation is mainly of the M17b blanket bog community with scattered peaty hollows/haggs (M3). Photographs 74 (to north) & 75 (to south). [KP]

161. 37385 57215 Immediately adjacent to stream are fragments of acid grassland (U4b) which are preferentially grazed. Adjacent areas of dry heath exhibit carpet/topiary growth forms and have an obvious browse line. This dry heath is tussocky *Calluna vulgaris* with grassy pathways between. Photograph 64. [KP]

162. 37438 57223 M30 soakway with *Potamogeton polygonifolius*, *Sphagnum cuspidatum* and *Ranunculus flammula*. This low-lying ground also supports frequent soligenous *Carex* spp. flushes (M6bii) with frequent *Nardus Stricta*, *Sphagnum denticulatum* and *Carex panicea*. *Danthonia decumbens* becomes frequent at flush margins where vegetation is transitional to acid grassland. [KP]

163. 37500 54500 Scattered *Rhynchospora alba* in transitional zone between M17b and M1. [KP]

164. 37698 55573 Large, linear bog-pool (M1) which is mainly deep standing water with abundant aquatic *Sphagnum cuspidatum*. Marginal vegetation includes a mixture of *Sphagnum cuspidatum*, *S. palustre*, *S. denticulatum*, *Drosera rotundifolia*, *Eriophorum angustifolium*, *Empetrum nigrum*, *Pinguicula vulgaris*, *Trichophorum cespitosum* and *Erica tetralix*. Photograph 76. [KP]

165. 37698 53469 Large area of frequent peat haggs (1-2m) and associated erosion which is frequently severe. Photograph 90 taken from 37509 53622 looking east. [KP]

166. 37805 57121 Localised, small-scale peat erosion and hagging with evidence of trampling by sheep. Photograph 65. [KP]

167. 37950 56900 Large stand of emergent *Equisetum fluviatile* at south end of Loch of Lunklet. Photograph 66. [KP]

168. 38153 57025 Partially modified vegetation over hillside. Where the slope is least there are pockets of *Calluna vulgaris*/*Eriophorum vaginatum* blanket bog (M19a) similar to vegetation seen over large expanses of the survey area. Where the gradient increases wet heath (M15) vegetation is quite grassy and often transitional to acid grassland where there is a higher cover of graminoids. Locally there are also stands of flushed *Nardus Stricta* grassland and *Juncus squarrosus* dominated vegetation (U6). There are small eroding peat haggs (mainly in grassier areas) and evidence of a history of high grazing pressure. [KP]

169. 38503 53581 Exposed bedrock over summit interspersed with *Juncus squarrosus* dominated vegetation (U6c). Any turbines proposed over this higher ground should be micro-sited on such vegetation/exposed rock, avoiding deeper peats. [KP]

170. 38583 54757 Large sequence of M1 bog-pools, over hilltop area of blanket bog, with some water movement between pools. Vegetation is mainly a mixture of *Sphagnum cuspidatum*, *S. denticulatum*, *Eriophorum angustifolium* and *E. vaginatum*. Much of the wetter M17a sub-community found over this hilltop is in good condition with semi-continuous *Sphagnum papillosum* and spongy surface. Eroding peat haggs are frequent but limited in extent and levels of peat loss. Peat mainly 1-2m deep. [KP]

171. 38589 57502 Carpet of *Sphagnum papillosum* frequently remains intact over this area of watershed blanket bog. There is some tracking and trampling by sheep. Here peat surface has become partially dried vegetation is more similar to M17b sub-community with frequent *Rhytidiadelphus loreus*, *Sphagnum capillifolium* and *Racomitrium lanuginosum*. M19a is generally less frequent here than to the west. [KP]

172. 38620 54667 Sequence of M1 pools over summit/ridge. Pools are mainly intact with no trampled margins and generally surrounded by wetter vegetation (M17a) than to the south of here. M17b and M19a also occur through this polygon on slightly higher, and correspondingly drier ground. Haggs are frequent away from the pools with erosion locally down to gravely bedrock in parts. Photograph 85. [KP]

173. 38687 55783 Stream flowing through centre of blanket bog is vegetated by *Carex rostrata* with marginal *Sphagnum denticulatum*. This area of wet valley mire (M17a) has a high cover of *Sphagnum palustre* with locally abundant *Sphagnum papillosum*. *Sphagnum* is completely absent in parts and there is also patchy *Molinia caerulea*. [KP]

174. 38766 57580 Small-scale peat haggs with some re-colonising *Eriophorum angustifolium*, although mainly bare eroding peat. Photograph 67. [KP]

175. 38819 61932 Vehicle tracking through peat surface with associated erosion. Locally the mire is drying/modified to *Juncus squarrosus* dominated vegetation (U6) with some areas of bare gravel. [KP]

176. 38639 63634 Badly poached area of blanket bog (M17b, M3, M17a, M1). Photographs 79 & 80. Within peaty hollows (M3) there is some *Menyanthes trifoliata* and *Potamogeton polygonifolius* in addition to the usual frequency of *Eriophorum angustifolium*. Adjacent drier ground is mainly *Juncus squarrosus* dominated modified bog (U6). [KP]

177. 38848 63415 Frequent eroding peat haggs (M3) over hillside of modified bog which appears mainly grassy although frequently over deep peat. Areas of eroding peat are greater than those being re-colonised by *Eriophorum angustifolium*. [KP]

178. 38877 56571 Large acid flush (M6bii) which is dominated by *Carex echinata* over *Sphagnum denticulatum*. Associated species include *Sphagnum palustre*, *Viola*

palustris, *Festuca vivipara*, *Potentilla erecta*, *Polytrichum commune*, *Sphagnum cuspidatum*, *Agrostis canina* and locally abundant *Eriophorum angustifolium*. Within this stand there are a few open pools and some localised *Juncus effusus* (M6cii). Area of mire to the east of here has quite extensive hagging with some exposed bedrock in parts. Areas of bog which are not presently eroding tend to be in good condition. [KP]

179. 38888 62960 Expanse of bare rock/gravel over the summit of Sneugie with scattered hags at edge. Gavel is being re-colonised by Nardus *Stricta* and *Deschampsia flexuosa* where there is some soil accumulation. Photograph 81. [KP]

180. 38919 53588 Some of the *Nardus Stricta* dominated vegetation (U5) over these slopes is quite wet and derived from former, modified mire. *Nardus Stricta* dominates with *Festuca vivipara*, Narthecium *ossifragum, Potentilla erecta, Juncus squarrosus, Rhytidiadelphus loreus, Hylocomium* splendens, *Thuidium tamariscinum*, *Polygala serpyllifolia*, *Rhytidiadelphus squarrosus*, *Sphagnum palustre*, *Anthoxanthum odoratum*, *Viola palustris* and *Eriophorum angustifolium*. [KP]

181. 38932 57267 Area of eroding bare peat greater than 100m² immediately around Scalla Field trig cairn. No re-colonisation evident. Over this summit there are localised areas of shallower peat with a high cover of *Juncus squarrosus* (U6c). Blanket bog is generally in good condition with a semi-constant *Sphagnum* carpet through areas of wetter, M17a, mire. Some pools are vegetated by *Sphagnum cuspidatum* and *Sphagnum denticulatum* (M1) whilst others have become eroded and mainly bare peat with scattered *Eriophorum angustifolium*. [KP]

182. 38941 57451 Flushed grassy slopes supporting abundant *Nardus Stricta* with *Sphagnum palustre*, *S. capillifolium*, *S. papillosum*, *Juncus squarrosus*, *J. acutiflorus*, *Eriophorum angustifolium*, *Carex panicea*, *C. echinata*, *Thalictrum alpinum*, *Empetrum nigrum* and *Calluna vulgaris*. Vegetation most closely resembles a mosaic or transition between U5c/U6c with a possible transition towards M10 in parts where there is a little *Pinguicula vulgaris*. [KP]

183. 38959 54727 Area of erosion with small associated peat haggs (<1m). There is some exposed rock and gravely substrate as well as fragments of *Juncus squarrosus* dominated vegetation (U6). Most surrounding mire vegetation is mainly good condition M19a/M17b. Photographs 86 – 89. [KP]

184. 38965 57396 Steep craggy slopes/ledges supporting fragments of *Luzula sylvatica* dominated tall-herb vegetation (U16). Associates include *Polypodium vulgare*, *Galium saxatile*, *Rumex acetosa*, *Rhytidiadelphus loreus* and *Polytrichum commune*. Non-documented for this community is frequent *Salix herbacea*. Photograph 68. [KP]

185. 38993 55597 Steep rocky outcrop supporting grassy dry heath (H10c). *Salix herbacea* grows with *Nardus Stricta*, *Carex bigelowii*, *Potentilla erecta*, *Huperzia selago*, *Galium saxatile*, *Racomitrium lanuginosum*, *Vaccinium myrtillus* and *Hymenophyllum wilsonii*. *Salix herbacea* and *Hymenophyllum wilsonii* are both frequent over these rocks. Photograph 77. [KP]

186. 39023 60930 Eroded ridge of M15c vegetation dominated by *Racomitrium lanuginosum*, *Erica cinerea*, *Calluna vulgaris* and *Nardus Stricta* with occasional *Trichophorum cespitosum* and much bare gravel/rock. Locally this vegetation becomes transitional to M10 where there is some soligenous influence. [KP]

187. 39125 54713 Peat haggs at break of slope, approximately 1m high with limited re-vegetation by *Eriophorum angustifolium*. [KP]

188. 39215 55587 Stony flush with *Juncus articulatus*, *Carex viridula* ssp. *oedocarpa*, *Triglochin palustre*, *Potamogeton polygonifolius*, *Campylium stellatum*, *Scorpidium scorpioides*, *Juncus bulbosus*, *Narthecium ossifragum*, *Carex panicea*, *Eriophorum angustifolium* and *Carex dioica*. Photographs 91 & 92. [KP]

189. 39268 55296 Area of modified bog with various communities forming a fine-grained mosaic. Small fragments of fairly typical M19a are interspersed with vegetation transitional towards acid grassland. Stony flushes are occasional and similar to photographs 91 & 92. [KP]

190. 39289 63449 Frequent wax cap fungi along slopes of semi-improved acid grassland above ruined buildings. [KP]

191. 39368 57311 Eroding peat haggs to 1m. Photographs 69 & 70. [KP]

192. 39467 63201 M10 basic flushes along steeper ground supporting a mixture of *Carex viridula* ssp. *oedocarpa*, *C. panicea*, *C. echinata*, *C. pulicaris*, *Sphagnum denticulatum*, *S. palustre*, *Thalictrum alpinum*, *Galium saxatile*, *Nardus Stricta*, *Potentilla erecta*, *Taraxacum* agg., *Juncus squarrosus*, *Breutelia chrysocoma*, *Plantago lanceolata*, *Cirsium palustre*, *Campylium stellatum*, *Hylocomium splendens*, *Scorpidium revolvens*, *S. scorpioides*, *Rhytidiadelphus loreus*, *Pinguicula vulgaris* and *Prunella vulgaris*. These, often stony, M10 flushes are frequent all along slopes to north-west of here. Surrounding vegetation is mainly *Juncus squarrosus* grassland (U6) which is frequently transitional to *Nardus Stricta* grassland (U5) or less modified blanket bog (M17/M19). [KP]

193. 39535 55267 Small flush with *Schoenus nigricans* and *Carex dioica* at margins. [KP]

194. 39578 56861 Continuous *Sphagnum papillosum*/*palustre* carpet through area of good condition blanket bog (M17a). [KP]

195. 39638 61108 Start of drain (0.5m deep) which flows north from here through modified mire and acid grassland mosaic. Photograph 83. [KP]

196. 39690 61119 Straight drain cut through mire with drier peat and associated vegetation immediately either side of it. Drain is approximately 1.5m deep and very active at time of survey. If this drain were blocked it would improve overall condition/value of this valley mire. Photograph 82 taken from 39499 61111. [KP]

197. 39758 55242 New drain approximately 0.5m deep. Photograph 93. [KP]

198. 39988 59876 Area of eroding peat haggs forming a mosaic of the drier M17b blanket mire and bare peat (M3) over watershed. *Racomitrium lanuginosum* hummocks are conspicuous through this area of mire and expanses of bare peat with scattered *Eriophorum angustifolium* localised. [KP]

199. 40128 60371 Large stand of vegetation which is not typical of documented NVC communities although most similar to M6bii. *Nardus Stricta* is abundant with frequent *Carex panicea*, *Carex echinata*, *Ranunculus flammula* and *Juncus bulbosus*. Occasional through the sward are *Pedicularis sylvatica*, *Potamogeton polygonifolius*, *Juncus effusus*, *Bryum pseudotriquetrum*, *Sphagnum denticulatum*, *Carex nigra*, *Prunella vulgaris*, *Potentilla erecta*, *Cirsium palustre* and *Polytrichum commune*. Small stands of M17a have frequent *Sphagnum palustre* and are often transitional to M19a with conspicuous *Eriophorum vaginatum* tussocks forming. Where there is increased soligenous influence *Potamogeton polygonifolius* becomes more prominent with *Ranunculus flammula*, *Taraxacum* agg., *Sphagnum denticulatum* and *Carex panicea* (M30). [KP]

200. 40314 55646 Steep banks along stream side are mainly short grazed mesotrophic grassland (*Cynosurus cristatus*, *Plantago lanceolata*, *Prunella vulgaris*, *Nardus Stricta*, *Juncus effusus*, *Anthoxanthum odoratum*, *Holcus lanatus*, *Cirsium arvense*, *Mnium hornum*). Wax cap fungi are locally frequent. [KP]

201. 40325 60431 Very wet area of mainly inaccessible mire with frequent dead sheep. Where there is some soligenous influence there are linear stands of *Juncus effusus* (M6) or *Potamogeton polygonifolius* soakways (M30) with *Cardamine pratensis*, *Ranunculus flammula* and *Carex nigra*. In adjacent blanket bog (M17a) there is occasional *Nardus Stricta* through a semi-continuous *Sphagnum* carpet of *Sphagnum papillosum* and *Sphagnum palustre*. [KP]

202. 40398 57109 Shallow drain cut through bog is vegetated by *Sphagnum denticulatum*. Immediately adjacent vegetation is more grassy (*Nardus Stricta*) with frequent *Juncus squarrosus*. Small fragments of U6 and U5 grassland occur throughout this polygon where the blanket mire is modified, increasing in frequency closer to semi-improved fields to the south. Elsewhere there is good *Sphagnum*/*Eriophorum vaginatum*/*Calluna vulgaris* cover. [KP]

203. 40670 56475 Deep drain at base of slope with increase in cover of U6 down-slope. There are further drains over the slopes to the south of here. [KP]

204. 40765 60051 Large expanse of bare eroding peat over hill summit and ridge which to some extent is associated with overhead cables and poles. Photograph 84. [KP]

205. 40893 60842 Frequent haggs over this area and abundant sheep dung. Some re-colonisation by *Eriophorum angustifolium* (M3) and *Juncus squarrosus* grassland (U6). [KP]

206. 41041 57053 Localised severe peat erosion in parts along this ridge becoming less severe to the south. Photograph 19a. [KP]

207. 41225 56973 Vegetation over these steeper east-facing slopes is heavily dominated by *Calluna vulgaris* and most closely resembles H10a dry heath although locally transitional to H10c where there is an increase in graminoids. Occasionally *Eriophorum angustifolium* and *E. vaginatum* or *Juncus effusus* and *Juncus squarrosus* are present at low cover. *Calluna vulgaris* is heavily browsed by sheep with carpet/topiarised growth forms evident and frequent dung conspicuous. [KP]

208. 41344 60901 Area of modified bog with former peat cuttings and high grazing impacts adjacent to main road. Conspicuous sheep dung throughout. [KP]

209. 41345 56015 There is some tracking and trampling across this bog but *Sphagnum* carpet largely intact. A shallow drain bisects the bog here. [KP]

210. 41531 56043 Pool/soakway vegetated by *Potamogeton polygonifolius*/*Ranunculus flammula*/*Callitriche* agg./*Sphagnum denticulatum*, *Glyceria fluitans*, *Myosotis scorpioides*, *Juncus bulbosus*, *Polytrichum commune*, *Eriophorum angustifolium*, *Sphagnum palustre* and *Caltha palustris*. Here the vegetation most closely resembles an M30 soakway in NVC terms. Further into the bog the vegetation becomes more like a soligenous M1 bog-pool. Along the main Burn of Pettawater in this area are quite extensive stands of *Iris pseudacorus* with occasional *Angelica sylvestris*. [KP]

211. 41676 57140 Valley mire with hummock/hollow structure. M17b typically dominates the slightly higher and drier peats with the hollows mainly trampled bare peat (M3) with some standing water. Re-colonisation by *Eriophorum angustifolium* is frequent and, where peat is drier, *Carex panicea* indicating a history of high grazing pressures. There is also some localised disturbance to *Racomitrium lanuginosum* hummocks and occasional intact M1 pools. [KP]

212. 41908 55204 Peat cuttings approximately 1m deep and related drying to adjacent peat surface. *Calluna vulgaris* is frequently topiarised by heavy grazing pressures in areas adjacent to the road such as this. [KP]

213. 42390 56766 Frequent areas of trampling by sheep leaving small fragments of bare peat (M3). *Juncus squarrosus* dominated vegetation (U6) tends to occur in hollows adjacent to small runnels/burns. [KP]

214. 36974 57359 Steep sides of Lunklet Burn are fenced off, bryophyte-rich heath (H21a) is prominent here consisting of a high cover of *Calluna vulgaris* with *Erica cinerea*, *Erica tetralix*, *Empetrum nigrum*, *Potentilla erecta*, *Blechnum spicant*, *Carex binervis*, *Succisa pratensis*, *Salix aurita*, *Luzula sylvatica*, *Lonicera periclymenum*, *Hypnum jutlandicum*, *Dicranum scoparium*, *Sphagnum subnitens*, *Sphagnum papillosum*, *Thuidium tamariscinum*, *Rhytidiadelphus loreus*. There are also acid flushes along the banks consisting of *Juncus effusus*, *Juncus articulatus*, *Cirsium palustre*, *Ranunculus flammula*, *Holcus lanatus*, *Sphagnum palustre*, *Polytrichum commune* (M6c). [TR]

215. 37082 57611 Dry heath on steeper slopes with drier shallower peat and a dominant *Calluna vulgaris* cover. It is heavily grazed by sheep here into tight bushes and an

occasional small patch of acid grassland or sheep scar. There is sparse *Danthonia decumbens* with *Deschampsia flexuosa* and *Festuca vivipara*, *Potentilla erecta*, *Juncus squarrosus*, *Rhytidiadelphus squarrosus*, *Hypnum jutlandicum*, *Thuidium tamariscinum* and *Rhytidiadelphus loreus*. [TR]

216. 38620 58284 Here below Gruti Hill there are deep haggs to 3m high. The dried out peat surfaces have an abundance of *Calluna vulgaris* and *Racomitrium lanuginosum* with sparser *Empetrum nigrum*, *Eriophorum angustifolium*, *Eriophorum vaginatum* and *Rhytidiadelphus loreus* and *Cladonia portentosa* (M17b). Bare peat generally only has sparse *Eriophorum angustifolium* (typical M3) with some U6 (*Juncus squarrosus*, *Empetrum nigrum*, *Sphagnum palustre*, *Lophocolea bidentata*) in bottoms of haggs. No M1 hollows seen. Photograph 63. [TR]

217. 37195 57815 Eroding blanket mire here. On drier surfaces there is abundant *Calluna vulgaris* with *Empetrum nigrum*, *Juncus squarrosus* and much *Racomitrium lanuginosum* with *Rhytidiadelphus loreus*, *Cladonia portentosa*, *Cladonia uncialis* (M17b). In wetter depressions there is some *Sphagnum cuspidatum* and *Sphagnum denticulatum* (M1). On shallower peats the vegetation verges towards wet heath with patchy *Sphagnum capillifolium* and *Scapania gracilis*. [TR]

218. 37451 57921 Along the sides of the burn is variable with some dry heath which has been mapped as H10a although lacking in *Erica cinerea* generally (*Calluna vulgaris*, *Empetrum nigrum*, *Galium saxatile*, *Blechnum spicant*, *Thuidium tamariscinum*, *Rhytidiadelphus loreus*, *Hylocomium splendens*, *Diplophyllum albicans*) and U6 acid grassland (*Juncus squarrosus*, *Potentilla erecta*, Luzula multiflora, *Agrostis canina*, *Galium saxatile*, *Rhytidiadelphus squarrosus*, *Dicranum scoparium*). U4b in more mesotrophic nutrient-enriched patches. [TR]

219. 37644 57935 Lower flat mire is intact with many wet depressions having abundant *Sphagnum cuspidatum*, *Sphagnum papillosum* and very little bare peat except at trampled edges of wet hollows. [TR]

220. 38399 58120 A fairly intact area of blanket mire within overall eroding mire. Here *Sphagnum papillosum* is of high cover with *Calluna vulgaris*, *Empetrum nigrum*, *Eriophorum vaginatum* and *Sphagnum capillifolium* all very visually prominent. There is an occasional pool with *Sphagnum cuspidatum* (M1) and occasional hags (M17b/M3) with some *Juncus squarrosus* acid grassland forming on the shallow peats. [TR]

221. 38677 58248 Where the blanket peat has eroded down to expose the stony substrate there are visible calcareous influences in the presence of bryophytes not otherwise seen in this acid terrain. Prominent are *Scorpidium scorpioides* with *Scorpidium revolvens*, *Blindia acuta*, *Scapania undulata*, *Campylium stellatum, Dicranella palustris,* and the sedges *Carex pulicaris*, *Carex viridula ssp. oedocarpa* and *Carex panicea*. Such areas have with affinities with M10/M11 mountain flushes and are frequent on the west side of the hill forming a valuable and probably increasing element in the general diversity. [TR]

222. 38996 58108 Blanket mire here is relatively intact with few haggs. It is mainly M19a with wetter patches having M17a marked out by increased *Sphagnum* cover. [TR]

223. 39251 58391 There are some linear down-slope haggs here but not extensive. Again, where eroded to the substrate basic influences are visible in the presence of *Scorpidium revolvens*. [TR]

224. 39000 59060 M10 type flushes with many sedges – *Carex panicea*, *Carex viridula ssp. oedocarpa*, *Carex pulicaris, Ranunculus flammula* and the moss *Campylium stellatum*. [TR]

225. 39174 59241 Some very wet areas on the flatter ground here are not as hagged and consist of areas of wet hollows (M1) with abundant *Sphagnum cuspidatum*, *Sphagnum denticulatum* and *Potamogeton polygonifolius*. These often occur within extensive carpets of *Sphagnum papillosum* with *Calluna vulgaris* and *Eriophorum vaginatum* growing amidst. [TR]

226. 37299 59149 Wet area now very eroded with much wet bare peat (M3) and drier hummocks of *Calluna vulgaris*, *Erica cinerea*, *Racomitrium lanuginosum* (M17b). [TR]

227. 37358 58869 Area of low-lying flat bog a high cover of *Sphagnum papillosum* and *Sphagnum capillifolium*. There is also some *Rhynchospora alba,* which is generally scarce in the area, and *Eriophorum vaginatum*, *Erica tetralix*, *Calluna vulgaris*, *Trichophorum cespitosum*, *Narthecium ossifragum*, *Eriophorum angustifolium*, *Cladonia portentosa*, *Cladonia uncialis* (M17a). [TR]

228. 37122 58590 East-facing dry heath (H21a) has a high cover of *Calluna vulgaris* with some *Carex binervis*, *Juncus squarrosus*, *Potentilla erecta*, sparse *Nardus stricta* and a luxuriance of the bryophytes *Sphagnum capillifolium*, *Sphagnum papillosum*, *Dicranum scoparium*, *Hylocomium splendens* and *Rhytidiadelphus loreus*. (16) [TR]

229. 37380 59747 Wet flat area with some erosion and bare peat but also intact blocks of peat varying from wet (*Sphagnum papillosum* and *Sphagnum capillifolium* abundant, M17a) to drier (*Racomitrium lanuginosum* abundant, M17b). Also prominent here are *Calluna vulgaris*, *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Erica tetralix*, *Cladonia portentosa*, *Aulacomnium palustre* and hollows of *Sphagnum cuspidatum* (M1) where not so trampled and bare. [TR]

230. 37980 59742 Bratta Field summit area is generally well eroded to a stony substrate with some plates of remnant blanket peat to 30m across. The remaining mire is mainly M19a (*Calluna vulgaris*, *Eriophorum vaginatum*, *Empetrum nigrum*, *Vaccinium myrtillus* and hypnoid mosses) but there are drier peat surfaces with abundant *Racomitrium lanuginosum* (M17b) and some large areas where the peat remains intact and waterlogged to about 200m across (*Sphagnum papillosum*, *Sphagnum capillifolium*, *Juncus squarrosus*, *Eriophorum vaginatum*, *Eriophorum angustifolium*). Avoid developing on wetter areas and any intact peat blocks. Photograph 62. [TR]

231. 39048 60124 Summit of Marro Field is mainly shallow peat with stony substrate and acid grassland (U6 - *Juncus squarrosus*, *Nardus stricta*, *Racomitrium lanuginosum*). On remaining intact peat blocks there is M17b. [TR]

232. 38841 60727 A large area where peat is generally shallow or bare stony substrate with only small blocks of deeper peat (M19a, M17b) to 1m deep. The grassy tundra-like vegetation is dominated by either *Nardus stricta* or *Juncus squarrosus* with *Racomitrium lanuginosum* generally abundant and variable amounts of *Calluna vulgaris*, *Erica cinerea Carex panicea* (U5/U6/M15c). Photograph 61. [TR]

233. 37791 60994 Snelda Hill summit quite stony or shallow peat – generally resembling an acid grassland dominated by *Juncus squarrosus* and *Nardus stricta* with some heath species, *Calluna vulgaris*, *Empetrum nigrum* and *Cladonia portentosa*, *Eriophorum angustifolium* and here more like M15c-M17b with only a little deeper peat. [TR]

234. 41867 57742 Patta Dale has deep peat with variable blanket mire. Here there is a central band of M19a (*Eriophorum vaginatum*, *Empetrum nigrum*, *Calluna vulgaris*, *Eriophorum angustifolium*, hypnoid mosses) and is generally greener looking from a distance. Mostly the lower ground is more like M17b (*Racomitrium lanuginosum*, *Trichophorum cespitosum*, *Erica tetralix*, *Sphagnum capillifolium*, *Cladonia portentosa*) with some wetter areas of M17a/M1. The central narrow channel has M23b rush-pasture (*Juncus effusus*, *Viola palustris*, *Ranunculus repens*, *Cardamine pratensis*) and areas of *Potamogeton polygonifolius* over *Sphagnum denticulatum* and *Calliergonella cuspidata*. Photographs 59 & 60. [TR]

235. 41637 58358 The mire here is much more eroded with much heavily trampled bare peat. Gullies up to 4m deep and generally a lot poorer than the blanket mire to the south of here. Photograph 58. [TR]

236. 40900 58830 To the north of here are areas of bare peat to 20m across and there is hagging to 2m deep. There are however also some more intact areas of blanket peat (M19a) though the area too and these should be avoided if possible. Photograph 57. [TR]

237. 40041 59188 Flat valley bottom blanket mire is mainly intact with few haggs. Mainly M17b consisting of *Calluna vulgaris*, *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Erica tetralix*, *Racomitrium lanuginosum*, *Sphagnum capillifolium*, *Cladonia portentosa* and *Rhytidiadelphus loreus*. Steeper banks, e.g. alongside channels have U6 *Juncus squarrosus*-dominated acid grassland. There is an occasional acid flush with *Juncus effusus* over *Sphagnum palustre*, *Polytrichum commune* and *Sphagnum fallax* (M6ci). [TR]

238. 36143 60426 Hill of Voxter is mainly eroding and drying blanket mire, hence much M17b – *Calluna vulgaris*, *Erica cinerea*, *Racomitrium lanuginosum*, *Cladonia portentosa*, *Cladonia uncialis*, *Eriophorum vaginatum*, *Eriophorum angustifolium* and spares *Hypnum* sp. There are frequent patches of *Juncus squarrosus* acid grassland within this (U6) where the peat is eroded and there may also be bare substrate associated with these areas, no basic influences noted here. Photograph 56. [TR]

239. 38156 62303 Blanket mire here is eroded with haggs through much of the area and there is wet and dry heath over shallow peats on knolls (H10a/M15c – *Racomitrium lanuginosum*, *Erica cinerea*, *Calluna vulgaris*, sparse *Trichophorum cespitosum*, *Cladonia portentosa*, patchy *Sphagnum capillifolium*). Flushed zones on substrate within the mire have some indicators of base enrichment in the bryophytes *Scorpidium revolvens*, *Scorpidium scorpioides* which occur with *Sphagnum denticulatum*, *Potamogeton polygonifolius* and *Trichophorum cespitosum* (M11/M1). [TR]

240. 38692 62978 Eroded blanket mire with large patches of bare stony ground which has high covers of *Juncus squarrosus* and *Nardus stricta* acid grassland and would be a suitable target area for turbines (U6). The remaining blanket mire has many bare eroding peat faces (M3) but there are some remaining active wet depressions which have *Sphagnum cuspidatum*, *Sphagnum denticulatum* and *Eriophorum angustifolium* (M1) and these should be avoided. [TR]

241. 37953 63745 Mainly *Juncus squarrosus* and/or *Nardus stricta* acid grassland on these slopes (U6/U5) but there are also some basic (M10a) flushes marked out by the sedges *Carex viridula ssp. oedocarpa*, *Carex panicea*, *Carex dioica*, *Carex echinata* with *Juncus bulbosus*, *Thalictrum alpinum*, *Drosera rotundifolia*, *Potamogeton polygonifolius* and the bryophytes *Ctenidium molluscum*, *Scorpidium revolvens*, *Campylium stellatum* and *Breutelia chrysocoma*. [TR]

242. 36884 63856 Grobs Ness headland is almost entirely semi-improved acid grassland varying from smooth U4b grassland to less enriched U5d *Nardus stricta* grassland. [TR]

243. 37104 63359 Here the acid grassland here is dominated by *Festuca vivipara*, *Anthoxanthum odoratum*, *Nardus stricta* and *Deschampsia flexuosa* with well-browsed *Calluna vulgaris* and some enrichment in the form of *Carex flacca*, *Viola palustris*, *Succisa pratensis*, *Pedicularis sylvatica*, *Erica cinerea*, *Narthecium ossifragum*, *Potentilla erecta*, *Sphagnum denticulatum*, *Thuidium tamariscinum*, *Rhytidiadelphus loreus*, *Hylocomium splendens* and *Sphagnum capillifolium*. More generally on the slopes above there is also an occasional patch of grassy dry heath (H10c). [TR]

244. 27170 62145 Enclosed fields are variably improved. In leys *Lolium perenne* is mono-dominant with some *Trifolium repens* and sparse *Holcus lanatus*, *Ranunculus repens* and *Rumex acetosa*. Where less improved there is usually more *Holcus lanatus* and a diversity of species which moves towards MG6b/U4b. [TR]

245. 37204 61105 The Hoddins blanket mire has a fence-line here. To the south-west it is less grazed and *Trichophorum cespitosum* and *Cladonia portentosa* are visibly much more prominent. On the other side *Calluna vulgaris* is increased amongst shorter vegetation which has a high cover of *Juncus squarrosus*. There are also occasional pools with *Sphagnum cuspidatum* and *Sphagnum denticulatum* (M1). Hagging is rather infrequent here and low. Much of the blanket mire has M17b with *Racomitrium*

lanuginosum abundant and *Empetrum nigrum*, *Erica cinerea*, *Rhytidiadelphus loreus*, *Hylocomium splendens* and patches of *Sphagnum capillifolium*. [TR]

246. 35460 61973 Cole Ness has a very bland acid grassland vegetation dominated by *Juncus squarrosus* and *Nardus stricta* with *Racomitrium lanuginosum*, *Diplophyllum albicans*, *Polytrichum commune*, *Dicranum scoparium* and *Carex panicea* (U6/U5). [TR]

247. 35492 61192 Here the peat is generally shallow with short-grazed wet heath consisting of *Calluna vulgaris*, *Erica cinerea*, *Carex panicea*, *Trichophorum cespitosum*, *Erica tetralix*, *Racomitrium lanuginosum*, *Sphagnum capillifolium*, *Cladonia portentosa*, *Cladonia uncialis*, *Hylocomium splendens* (M15c). Where there is no peat the vegetation resembles a tundra-like grassland dominated by *Juncus squarrosus* and *Nardus stricta* (U6). Photograph 55. [TR]

248. 35427 58385 Wet heath consisting of *Calluna vulgaris*, *Erica cinerea*, *Erica tetralix*, *Racomitrium lanuginosum*, *Juncus squarrosus*, *Cladonia portentosa* with stony basic flushes (M10a) which have *Pinguicula vulgaris*, *Scorpidium scorpioides*, *Carex viridula ssp. oedocarpa*, *Campylium stellatum*, *Juncus bulbosus*, *Carex panicea*, *Carex pulicaris*, *Sphagnum denticulatum* and *Philonotis fontana*. [TR]

249. 35274 58489 An enriched *Nardus stricta* grassland (CG10a) with *Carex flacca*, *Succisa pratensis*, *Narthecium ossifragum*, *Plantago lanceolata*, *Linum catharticum*, *Thalictrum alpinum*, *Polygala serpyllifolia*, *Festuca vivipara*, *Calluna vulgaris*, *Anthoxanthum odoratum*, *Potentilla erecta*, *Pedicularis sylvatica*, *Hylocomium splendens* and *Dicranum scoparium*. There are also basic M10a flushes in the area. [TR]

250. 35767 53792 Whitelaw Hill has mainly intact blanket mire (M17b and M19a) with some erosion, not severe, to 50cm. The mire is dominated by a mixture of *Calluna vulgaris*, *Erica tetralix*, *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Narthecium ossifragum*, with *Racomitrium lanuginosum*, *Cladonia portentosa*, *Cladonia uncialis*, *Sphagnum capillifolium* and *Hypnum* sp. generally constant. [TR]

251. 35873 52336 Flat summit area of Dudd Hill has areas of active waterlogged blanket mire with an abundance of *Sphagnum papillosum*, *Sphagnum capillifolium*, low *Calluna vulgaris* and *Trichophorum cespitosum*, *Eriophorum vaginatum* (M17a) grading into hummocks and some pools (M1 - *Sphagnum cuspidatum*, *Eriophorum angustifolium*) as well as some haggs (M17b/M3). [TR]

252. 35842 52528 Dudd Hill still M17b but here more eroded than the surrounding blanket mire with haggs to 2m high throughout with much bare peat in a M3 network to 8m wide in parts. Photograph 54. [TR]

253. 36682 53040 Haggs frequent (M17b/M3) but there are also large patches of intact blanket mire (M1a/M17b) in good condition and supporting indicative good amounts of *Sphagnum papillosum*, *Sphagnum capillifolium* and *Cladonia portentosa*. (41) [TR]

254. 36629 52069 Flat area of blanket mire is very hagged to 1.5m with drying peat blocks (M17b) and a network of bare peat (M3). Some hagg bottoms are waterlogged and active with a good build-up of *Sphagnum cuspidatum* grading into carpets of *Sphagnum papillosum* and *Sphagnum capillifolium* (M1/M17a) and these should be completely avoided. Photographs 52 & 53. [TR]

255. 37045 51487 Summit of Smirlee Hill has much eroded blanket mire with haggs to 2m high. There is much bare peat with only *Eriophorum angustifolium* (M3) and there area large areas of bare stony substrate and *Juncus squarrosus* grassland over shallow peat. The area is suitable for turbines but intact areas of peat and their edges should be avoided. Photograph 50. [TR]

256. 37191 51876 Large pools and areas of waterlogged *Sphagnum cuspidatum*, *Sphagnum capillifolium*, *Sphagnum papillosum* with *Juncus squarrosus*, *Eriophorum vaginatum* and *Eriophorum angustifolium*. [TR]

257. 37277 52461 South Mid Field summit has a mixture of intact and eroding mire with a network of bare peat and *Eriophorum angustifolium* (M3) to 5m wide in places. There are also occasional patches of bare soil and shallow peat with U6 but the mire is generally not as eroded as that at Smirlee Hill. [TR]

258. 37652 52763 Intact, good condition typical M17b consisting of a high cover of *Racomitrium lanuginosum* and *Cladonia portentosa* with *Calluna vulgaris*, *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Empetrum nigrum*, *Eriophorum angustifolium*, *Sphagnum capillifolium*, *Pleurozia purpurea*, and only occasional haggs. Photograph 51. [TR]

259. 38132 52429 A large flat area of intact blanket mire with good cover of *Sphagnum papillosum*, *Sphagnum capillifolium* and *Sphagnum cuspidatum* hollows with *Sphagnum denticulatum* and *Rhynchospora alba*. Also present are *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Calluna vulgaris*, *Eriophorum angustifolium* and also areas with a high cover of *Juncus squarrosus*. Avoid developing here. [TR]

APPENDIX 8.2: NVC SURVEY

The information contained within NVC Survey that supported the 2009 ES was seen as relevant and thus was included in the 2018 EIA.

Viking Wind Farm NVC Survey, 2008

A Report for EnviroCentre/SSE

T. Rafferty & K. Proctor, August 2008
Highland Ecology

Highland Ecology
www.highlandecology.com

CONTENTS

NVC Survey for Viking Wind Farm (track & turbine layout)

1 Summary

The area of the proposed Shetland windfarm covers a large area of mainland Shetland between Weisdale in the south, Aith in the west, Vidlin in the east and Sullom Voe to the north. The survey was split into four separate quadrants (Kergord, Nesting, Collafirth and Delting) by the main A970 road running north/south and the minor B9071 east/west.

The majority of the area consists of gently sloping hills with a covering of deep peat which has accumulated since the last ice age. This supports large areas of a range of important blanket bog vegetation types. These generally conform well to the NVC classification system and, being in good condition, support a range of typical species. The majority of this is composed of three main NVC types (M17a, M17b and M19a) depending on the water content of the upper surface layer. The more sensitive and less frequent types of wet hollow and pool vegetation (M1, M30) are usually found within M17a, the most waterlogged of the three main types, and these have been valued relatively high for this reason.

Erosion of the blanket bog is a prominent feature and intensive sheep grazing has led to the acceleration of erosion by maintaining bare un-vegetated surfaces which are then open to the effects of wind, rain, heat etc. This is especially frequent around exposed broad summits and ridges. In these areas water has drained out of the peat and the surface and there is more of the drier M17b type of vegetation. Away from these areas of erosion the blanket bog is generally intact and in good condition. The main areas of erosion occur over the exposed summit ridges although in many areas extensive peat erosion in the past has led to the colonization of bare ground by grassland and heathland characteristic of shallow peats. This vegetation often has a high cover of *Sphagnum* spp. and new peat can be actively forming in some of these areas.

Other vegetation types occurring on shallower peat are wet heath, dry heath and acid grassland. These often occur in mosaics of more than one type, especially in areas of erosion along with remnant deep peat blocks. They are generally more robust and can colonise bare ground and therefore have been valued relatively low compared to blanket bog, which is irreplaceable except over periods of thousands of years.

More scattered and occasional vegetation types include acid and basic flush and, rarely, some rush-pasture and calcareous grassland.

2 Methods

2.1 Field survey

A National Vegetation Classification (NVC) survey was carried out to cover the proposed wind farm site and an additional 100m buffer zone beyond the turbine envelope, both sides of access routes and borrow pits.

Field survey was carried out according to the NVC methodology outlined in Rodwell J. S. British Plant Communities Vols. 1 – 5 (Cambridge University Press, 1990, 1991,1992, 1995) and using the methodology described in the Handbook for Phase 1 Habitat Survey (NCC 1993).

Surveyors walked over the proposed layout in such a way as to see all habitats present within buffer zones. Each vegetation type encountered was mapped with a closed polygon onto field maps at 1:10,000. All areas were mapped to NVC sub-community level wherever possible and at least to community level when the vegetation did not easily fit any of the documented sub-communities. Where it was not possible to map areas as an NVC community (e.g. house and garden, quarry or other habitats not covered by the NVC) then Phase 1 Habitat Survey codes were used instead.

Where two or more vegetation types occurred closely together in a repeating pattern they were mapped as a mosaic with an approximate ratio indicative of the amount of each vegetation type within that polygon. Often communities occur as small fragments, 5% or less, and these were indicated in brackets. e.g. M17a + M17b 7:3 (M3, M1).

Where the vegetation in a mapable area appeared to be transitional between 2 different NVC types, and was not easily classifiable as either, it was mapped as a transitional type, e.g. M6d/M23a, and a target note made.

Target notes, referencing NVC community types, were made of all features of nature conservation interest, including important plant species, condition of the vegetation and management practices. All target notes were referenced using a handheld GPS and given an 8 figure grid reference.

Sufficient supporting data was gathered for the more important vegetation types. This consists of quadrat data sets with a DOMIN rating for each species present.

In addition to the above, notes were made on peat depth, wetness, erosion etc. Depth was measured using a handheld pole. This enabled depths of between 0m and 1.75m to be measured.

Fieldwork was carried out by Tim Rafferty, Kate Proctor and Nikki Dayton at an average rate of 30Ha/day.

2.2 Sources of error and limitations

The following factors influence the accuracy of mapping and classification of vegetation in a walkover survey of this nature:

- Different NVC communities and sub-communities frequently occur in fine-grained repeating patterns of two or more types and only a rough estimate of the composition of these can be made in the field.

- Transitional vegetation is frequent and it is not always possible to confidently assign it to a single NVC community or sub-community.

- Although as much of the survey area was walked as was possible much of the ground was scanned and proportions of various communities were estimated. Errors can occur in viewing sloping 3D surfaces from a low viewpoint.

3. NVC Communities – technical descriptions

3.1 Blanket bog/mire communities

EC Habitats Directive 7130 Blanket bogs, UKBAP Priority Habitat

The major part of the proposed development area is covered by blanket peat of varying depth. This was usually measured to be over 2 metres and often very much deeper, as displayed at various hags. The blanket mire is comprised mainly of three extensive different NVC mire communities or sub-communities (M17a, M17b and M19) with other more localised and patchier mire communities within the overall matrix (M1, M3, M6, M15) along with acid grassland, dry heath and wet heath (U6, H10,M15).

M1 *Sphagnum denticulatum* bog pool

EC Habitats Directive 7150 Depressions on peat substrates of the *Rhynchosporion*

Sphagnum cuspidatum A, *Sphagnum denticulatum* A, *Sphagnum papillosum* O, *Eriophorum angustifolium* F, *Erica tetralix* O, *Calluna vulgaris* F, *Eriophorum vaginatum* F.

This community is one of wet hollows/depressions in the peat surface or the margins of deeper pools. Although widespread through the survey area it is less frequent than the main blanket bog communities, occurring where the water table is at the surface for much of the year. As such it tends to occur mainly within the more waterlogged blanket bog community M17a or sometimes within hag systems where water does not drain away.

The main visual constant here is *Sphagnum cuspidatum,* which can be abundant in vegetated hollows, and there is usually some associated *Sphagnum denticulatum,* which distinguishes this community from M2. As it is generally found in the wetter areas it is more frequently associated with M17a into which it grades via a transitional zone of *Sphagnum cuspidatum*/*Sphagnum denticulatum* to *Sphagnum capillifolium*/*Sphagnum papillosum*.

Vascular associates are typically sparse but there is usually some *Eriophorum angustifolium* and one or more of *Erica tetralix*, *Calluna vulgaris*, *Eriophorum vaginatum* and *Menyanthes trifoliata*.

This community is one of the most sensitive and throughout the survey area it has been much degraded through trampling by sheep. Where grazing is heavy the hollows are maintained as a bare wet peat surface open to further erosion by wind and rain. Where this occurs on gently sloping blanket bog the water is able to drain from the un-vegetated hollows readily, creating a network of bare channels, which continue to erode and deepen over the years. Where sheep numbers are lower the hollows hold standing water and support good covers of *Sphagnum cuspidatum* and/or *Sphagnum denticulatum* and there is little bare peat open to erosion. These two extremes can sometimes be seen closely together at fence-lines between different grazing regimes on the same bit of blanket bog.

As well as occurring through the larger tracts of uneroded blanket mire this community can also be found within the wet hollows of hag systems where it survives or may have re-colonised parts following previous erosion episodes.

M3 *Eriophorum angustifolium* bog pool

EC Habitats Directive 7150 Depressions on peat substrates of the *Rhynchosporion*

Eriophorum angustifolium F, *Sphagnum cuspidatum* O, *Juncus squarrosus* O, *Narthecium ossifragum* R.

This is a community of bare peat surfaces, either wet or dry. It is widespread over the Viking site in areas where blanket bog is being eroded by wind, rain and sheep. It is therefore particularly common over higher summit ground where blanket bog erosion is most severe, but it also occurs within the majority of blanket bog throughout the site to varying degrees.

The most frequent pioneer species which colonises bare peat is *Eriophorum angustifolium* and a few other associates. This habitat is very common where sheep numbers are high and concentrated along the bare peat channels within eroding bog, trampling the peat and churning up the colonising plants and therefore holding back re-vegetation. This holding back of re-vegetation is particularly noticeable on the drier peat surfaces. Where the bare peat is wetter *Eriophorum angustifolium* and subsequent colonisers seem to be able to get a hold more effectively. This may be due to better environmental conditions for colonisation and/or the fact that sheep tend to prefer the drier surfaces.

Another important coloniser of bare peat is *Juncus squarrosus* which appears to be particularly important in forming a tough and erosion-resistant vegetated peat surface around which *Sphagnum* spp. can colonise, eventually forming stands of the U6a *Juncus squarrosus* acid grassland community.

The community is probably on the increase as blanket bog breaks down but in previously eroded areas recolonisation is taking place with succession to M15d/U6 occurring and replacing some of the bare ground.

M17a *Trichophorum cespitosum-Eriophorum vaginatum* blanket mire *Drosera rotundifolia-Sphagnum* spp. sub-community

EC Habitats Directive 7130 Blanket bogs

Eriophorum angustifolium A, *Calluna vulgaris* A, *Eriophorum vaginatum* A, *Trichophorum cespitosum* O, *Erica tetralix* O, *Empetrum nigrum* ssp. *nigrum* O, Narthecium *ossifragum* R, *Potentilla erecta* R, *Drosera rotundifolia* R, *Sphagnum papillosum* A, *Sphagnum capillifolium* A, *Sphagnum tenellum* O, *Pleurozia purpurea* O.

This is a community of more or less permanently waterlogged peat and is characterised by an abundance of *Sphagnum* spp. and *Drosera rotundifolia*. It usually occurs in mosaics with the other two main blanket bog types, M17b and M19, occupying ground where the peat surface is kept more or less waterlogged throughout the year. It also occurs in more extensive stands in its own right on particularly flat ground and in large depressions, wide channels and shallow valley bottoms where water does not drain away.

Over the proposed Viking site this mire type is fairly typical of that described in the NVC with an abundance of *Sphagnum papillosum* and *Sphagnum capillifolium*, often in extensive carpets and forming a peat surface that is soft and spongy underfoot. Amongst these two prominent mosses there can also be some *Sphagnum tenellum, Sphagnum cuspidatum* and *Pleurozia purpurea*.

The hypnaceous bryophyte element of M19a here is absent or much reduced and the lack of prominent *Eriophorum vaginatum* tussocks also marks it out from that community. *Eriophorum vaginatum* still occurs as a constant throughout the vegetation but generally as a sparser smaller amount. M17a differs from the drier M17b in having much more extensive *Sphagnum capillifolium* along with *Sphagnum papillosum,* absent from M17b, and much reduced amount of *Racomitrium lanuginosum* compared to that community.

The bulk of the vascular component here is comprised of *Eriophorum angustifolium*, *Calluna vulgaris*, *Eriophorum vaginatum* and *Narthecium ossifragum*. *Erica tetralix* is notably sparse through most stands compared to the rest of Scotland where it is usually quite a prominent component. Compared to the rest of Scotland *Molinia caerulea*, normally a prominent component species of M17a, is completely absent from this vegetation type.

The condition of this community varies over the site but tends to represent some of the best condition blanket bog where it occurs as intact stands over large areas of flatter or depressed ground. Where it has become modified by management practices it can become the drier M17c community with *Juncus squarrosus* and grasses becoming prominent. Where grazing is heavy the sensitive *Sphagnum* carpet can become very trampled and broken but many of the larger, uniform stands of this community remain in good condition as it is thought that sheep may have a tendency to avoid the wetter spongy conditions.

This vegetation type may have been much more extensive in the past and it has been much reduced in parts by sheep grazing, erosion and drainage, especially so over the exposed broad summits and ridges where the blanket bog cover is much broken down.

M17b *Trichophorum cespitosum-Eriophorum vaginatum* blanket mire *Cladonia* spp. sub-community

EC Habitats Directive 7130 Blanket bogs

Eriophorum angustifolium A, *Calluna vulgaris* A, *Eriophorum vaginatum* A, *Sphagnum capillifolium* A, *Cladonia portentosa* A, *Racomitrium lanuginosum* A, *Erica cinerea* F, *Trichophorum cespitosum* F, *Erica tetralix* O,

This is a community of the drier peat surfaces found within stretches of blanket bog and is present as one of the three main blanket bog types, along with M17a and M19, throughout the whole survey area. It occurs on the driest peat surfaces and it is therefore the main NVC type found in the more eroded areas of blanket bog where water has, over time, drained out of the remaining peat blocks. It also occurs commonly in mosaics with the other two blanket bog communities where it occupies the better drained hummocks or more extensive elevated peat surfaces.

This sub-community is characterised by an abundance of *Racomitrium lanuginosum* and a generally reduced cover of *Sphagnum* compared to the M17a sub-community. *Sphagnum capillifolium* is still very frequent here but it is generally more patchy than in M17a and *Sphagnum papillosum* is virtually absent compared to the wetter M17a. Along with *Racomitrium lanuginosum*, *Hypnum jutlandicum* is usually present here and, also distinctive of the dry surface, *Erica cinerea*, which although not constant, is frequently present, especially around the driest edges of peat hags.

Vascular associates are generally sparse but *Eriophorum vaginatum*, *Calluna vulgaris*, *Trichophorum cespitosum* and *Eriophorum angustifolium* are constant or very frequent. The lack of high cover of tussocky *Eriophorum vaginatum* and carpet of hypnaceous mosses mark this vegetation out from M19 blanket bog.

As this is a community of drier peats it is often associated with erosional complexes and heavily grazed and trampled by sheep, which use the hags as shelter and as convenient head-high grazing. Here it forms mosaics with bare peat and shallow peat acid grassland/heathland (U6/M15d/H10b) which have replaced the former deep peat blanket bog.

M17c *Trichophorum cespitosum-Eriophorum vaginatum* blanket mire
***Juncus squarrosus-Rhytidiadelphus loreus* sub-community**

Calluna vulgaris A, *Sphagnum papillosum* A, *Sphagnum capillifolium* F, *Eriophorum vaginatum* F, *Juncus squarrosus* F, *Eriophorum angustifolium* F, *Anthoxanthum odoratum* O, *Nardus stricta* O, *Trichophorum cespitosum* O.

Intensive grazing results in the scattered occurrence of this sub-community where it is derived from the wetter M17a sub-community. In many instances it occurs around the margins of wetter mire where there is some transition towards drier habitats.

Calluna vulgaris, *Juncus squarrosus*, *Eriophorum vaginatum* and *Eriophorum angustifolium* are the vascular dominants. *J. squarrosus* and various grass species generally attain a higher cover here than in other mire communities and indicate some transitional tendencies (to U6a). *Trichophorum cespitosum* is often at low cover here. In the moss layer *Sphagnum papillosum and Sphagnum capillifolium* cover can be still quite extensive in this sub-community.

M19 *Calluna vulgaris-Eriophorum vaginatum* blanket mire

EC Habitats Directive 7130 Blanket bogs

Eriophorum vaginatum A, *Calluna vulgaris* A, *Erica tetralix* O, *Empetrum nigrum* ssp. *nigrum* F, *Eriophorum angustifolium* F, *Rhytidiadelphus loreus* A, *Hylocomium splendens* A, *Pleurozium schreberi* F, *Hypnum jutlandicum* O, *Sphagnum capillifolium* F, *Sphagnum papillosum* O, *Sphagnum palustre* O.

This is a community of more aerated peat than the M17a community and less subject to waterlogging. It is therefore found in extensive uniform stands on somewhat steeper slopes which shed water more easily. As well as forming stands in its own right this community also occurs in mosaics with the other blanket bog types occupying banks and patches of peat where water table conditions support the prominent growth of *Eriophorum vaginatum*, in its tussock form, and *Calluna vulgaris*.

The peat surface of this community has a firmer feel than M17a and M17b and the prominence of bulky vascular associates, along with much decreased *Sphagnum* and increased hypnaceous moss element, make this type of blanket bog the most tough and resilient of the 3 types. As such it is thought that development on this type of bog might lead to less extensive losses through further fragmentation compared to the more waterlogged and sensitive M17a.

The community is usually at once visually distinguished by a predominance of *Eriophorum vaginatum* which flourishes here in pronounced tussocks, usually co-dominant with pronounced bushy *Calluna vulgaris*. Within the Shetland context the *Eriophorum vaginatum* can often grow in a smoother, less tussocky sward. There is also usually some *Empetrum nigrum* and *Eriophorum angustifolium* growing more sparsely through the predominant species along with some *Trichophorum cespitosum* and a little *Erica tetralix*, although the latter is sparse and much less frequent here than in typical M19a. Although this type of vegetation can be quite confidently classed as M19 it is not easy to place it in a sub-community and it is best to consider it as a Shetland form of M19.

The bryophyte layer in this community is characterised by an abundance of hypnaceous mosses with *Hylocomium splendens* particularly prominent along with very frequent *Rhytidiadelphus loreus* and *Hypnum jutlandicum* and, more occasionally, *Pleurozium schreberi*. Although *Sphagnum* cover in general is much reduced compared to M17a, *Sphagnum capillifolium* is frequent here and there can also be some *Sphagnum palustre* or *Sphagnum papillosum* in wetter parts. *Sphagnum* becomes more pronounced in transitions to the wetter M17a mire where the two occur together in mosaics.

The condition of this community is generally very good, being robust and less prone to erosion than M17a and M17b. The tough character of the peat surface also make it resilient to trampling in areas of heavy grazing, though on the most historically heavily grazed slopes there are much reduced amounts of *Calluna vulgaris* and other dwarf shrubs along with an increase in grasses amongst the tussocks of *Eriophorum vaginatum*. In the most extremely modified cases this type of vegetation could almost be classed as M20 *Eriophorum vaginatum* mire.

3.2 Marshy grassland/rush-pasture

M23b *Juncus effusus/acutiflorus-Galium palustre* mire

Juncus effusus A, *Agrostis canina* O, *Potentilla erecta* O, *Anthoxanthum odoratum*, *Polytrichum commune* O, *Rumex acetosa* O.

This is usually a very common upland community, of wet, peaty mineral soils of acid to neutral pH but it only occurs as small isolated stands over the survey area.

An abundance of the rush *Juncus effusus* with a range of marshy herbs (*Ranunculus ficaria*, *Cirsium palustre*, *Viola palustris*) and grasses (*Agrostis canina*, *Anthoxanthum odoratum*, *Holcus lanatus*) is characteristic, along with a general absence of *Sphagna*.

3.3 Flushes, soakways and springs: acidic and base-rich

Flushes occur throughout the survey area as small, usually linear, stands where there is some associated soligenous influence. These vary greatly between acid *Sphagnum* dominated flushes and soaks and the stony base-rich *Carex* dominated flushes.

M6b *Carex echinata-Sphagnum fallax* mire *Carex nigra-Nardus stricta* sub-community
M6c *Carex echinata-Sphagnum fallax* mire *Juncus effusus* sub-community

Carex echinata F, *Eriophorum angustifolium* F, *Carex nigra* F *Juncus effusus* F, *Sphagnum palustre* F, *Molinia caerulea* F, *Polytrichum commune* F, *Rumex acetosa* F, *Anthoxanthum odoratum* F, *Agrostis canina* F.

This community occurs in zones of flushing where there may be some slight nutrient enrichment but where water chemistry remains acid. The peat can be deep and is usually quite wet. It is common as linear stands in soakways and patchily along the sides of more prominent watercourses.

The soligenous vegetation is distinguished by a high frequency of *Carex echinata* along with several of *Juncus effusus*, *Eriophorum angustifolium*, *Carex nigra*. *Sphagnum* is usually present as *Sphagnum denticulatum* or sometimes *Sphagnum palustre*. *Sphagnum fallax*, usually prominent in this type of vegetation is much reduced in this community over the Viking survey area. *Juncus effusus* and other rushes which are usually very prominent in this type of vegetation are quite patchy and sparse here therefore there is a tendency for it to be recorded as the M6b sub-community due to the frequent presence of *Carex nigra* and *Eriophorum angustifolium.*

M10 *Carex dioica-Pinguicula vulgaris* mire

EC Habitats Directive 7230 Alkaline fens

Scorpidium scorpioides A, *Pinguicula vulgaris* A, *Carex viridula ssp. oedocarpa* A, *Thalictrum alpinum* F, *Carex panicea* F, *Campylium stellatum* F, *Bryum pseudotriquetrum* F, *Blindia acuta* F, *Juncus bulbosus* F, *Scorpidium revolvens* F, *Selaginella selaginoides* F, *Euphrasia officinalis* F, *Juncus articulatus* O, *Ctenidium molluscum* O

This type of flush is irrigated by relatively more base-rich waters and usually it occurs as small linear stands or patches. It can be quite frequent in areas of eroded blanket bog where the substrate has become exposed and shallow surface peats are irrigated by waters which have been subject to influence from rock material.

The most distinctive elements of the vegetation are the frequent presence of the small yellow sedge *Carex viridula* ssp*. oedocarpa* and a wet straggling mass of the dark moss *Scorpidium scorpioides*. Amongst the vascular component *Pinguicula vulgaris* is usually also present and characteristic along with some *Carex panicea*, *Thalictrum alpinum*, *Juncus bulbosus* and sometimes some *Juncus articulatus*. Other distinctive bryophytes flourish here such as *Scorpidium revolvens*, *Campylium stellatum*, *Blindia acuta, Bryum pseudotriquetrum*. Rarely there can even be a little *Plantago maritima*.

Generally this type of vegetation does not support as many species as elsewhere in Scotland but there are some richer stands which have *Carex dioica*, *Carex pulicaris* and the mosses *Fissidens adianthoides* and *Ctenidium molluscum*.

M30 Related vegetation of seasonally-inundated habitats

This is a rather poorly described vegetation type in the NVC. It is similar to M29 *Hypericum elodes-Potamogeton polygonifolius* but it lacks *Hypericum elodes*.

This is a type of vegetation found in narrow soakways within areas of blanket bog over gently sloping ground. It is therefore often associated with M6 flushes from which it is marked out by an abundance of *Potamogeton polygonifolius* and slowly flowing water.

There is frequently *Sphagnum denticulatum, Carex rostrata* and *Menyanthes trifoliata*, making it transitional to M1 wet hollow or bog pool vegetation from which it differs in the *Potamogeton polygonifolius* and in being long/linear with flowing water. In some stands there is often a fair amount of *Eleocharis multicaulis*. Other frequent associates are *Juncus bulbosus, Eriophorum angustifolium, Sphagnum papillosum, Myosotis scorpioides, Ranunculus flammula, Equisetum palustre* and *Carex nigra*.

M32 *Philonotis fontana-Saxifraga stellaris* spring

Philonotis fontana A, *Bryum pseudotriquetrum* A, *Calliergon cuspidatum* F, *Agrostis capillaris* O, *Cardamine pratensis* O, *Carex nigra* O, *Sphagnum denticulatum* O, *Ranunculus flammula* O, *Rhytidiadelphus loreus* O.

Springs of this kind are a rare habitat over the Viking survey area and only noted from isolated locations in Nesting and Delting. The spring head itself is usually heavily bryophyte dominated forming a bright mat within the surrounding vegetation. Through the moss carpet tend to grow scattered grasses and small herbs but never attaining anything more than low cover.

These springs are often intimately associated with flushes (M6 or M10) which occur down-slope as a direct result of increased water movement.

A feature of Shetland are springs formed by mono-dominant *Pseudobryum cinclidioides*, which is a moss of very scattered Scottish distribution but which is concentrated on mainland Shetland. Such springs were found occasionally throughout the survey area.

3.4 Dry Heath communities

EC Habitats Directive 4030 European dry heaths

Dry heath occurs on well-drained, shallow peats and is usually restricted to the steepest slopes. It can also occur around knolls within the blanket peat and along steeper banks, often adjacent to watercourses. It is also common in areas of eroded blanket bog on broad summits where it often resembles alpine *Calluna vulgaris-Racomitrium lanuginosum* heath.

H10a *Calluna vulgaris-Erica cinerea* heath
Typical sub-community

EC Habitats Directive 4030 European dry heaths

Calluna vulgaris D, *Hypnum jutlandicum* A, *Hylocomium splendens* A, *Dicranum scoparium* F, *Pleurozium schreberi* F, *Rhytidiadelphus loreus* F, *Potentilla erecta* O, *Juncus squarrosus* O, *Rhytidiadelphus squarrosus* O.

Much of the dry heath on steep slopes and shallow free-draining peats proved difficult to classify in NVC terms. It is usually entirely dominated by *Calluna vulgaris* with a carpet of *Hylocomium splendens* and *Hypnum jutlandicum*. As it usually does not contain any great amount or frequency of *Erica cinerea* or *Vaccinium myrtillus* it does not easily fit within either H10 or H12. By default it was decided therefore to map it as H10a. Later in the season *Vaccinium myrtillus* did become more prominent in some stands and it is thought therefore that H12 may have been under-recorded, although this is not critical as both heath types are very similar.

As it is found on the steepest slopes large stands of this habitat are very rare in the survey area. It is however quite widespread occurring as small patches over rock outcrops or along the steep sides of watercourses where shallow peat overhangs and freely drains.

H10b *Calluna vulgaris-Erica cinerea* heath
***Racomitrium lanuginosum* sub-community**

EC Habitats Directive 4030 European dry heaths

Calluna vulgaris A, *Racomitrium lanuginosum* A, *Empetrum nigrum* A, *Hypnum jutlandicum* A, *Hylocomium splendens* A, *Deschampsia flexuosa* A, *Nardus stricta* A, *Vaccinium myrtillus* F, *Erica cinerea* F, *Agrostis capillaris* F

This is normally an alpine heath community of high summits on mainland Scotland. On Shetland it occurs on broad summits at lower elevations and is frequently found in areas of previous blanket bog which has completely or partially eroded away to shallow peat or substrate. Here it usually forms a mosaic with grassy wet heath (M15d), acid grassland (U6), remnant blanket bog (M17b) and bare peat (M3).

It is characterised by the dominance of *Calluna vulgaris* and abundance of *Racomitrium lanuginosum*. Also making it similar to the alpine heath is the frequent presence of *Empetrum nigrum* and *Cladonia uncialis*. Also constant or frequent here are *Nardus stricta* and the mosses *Hylocomium splendens* and *Hypnum jutlandicum*. Other frequent associates are *Festuca vivipara*, *Potentilla erecta*, *Erica cinerea*, *Carex bigelowii*, *Deschampsia flexuosa*, *Vaccinium myrtillus* and *Agrostis capillaris*.

Although these areas are heavily grazed this community is resistant to trampling. Due to ongoing heavy grazing of areas of eroding blanket bog the community is thought to be probably slowly increasing.

H10c *Calluna vulgaris-Erica cinerea* heath
***Festuca ovina-Anthoxanthum odoratum* sub-community**

EC Habitats Directive 4030 European dry heaths

This community was not recorded very often or over any great extents but occasionally drier heaths with some grasses growing through it were recorded as H10c. The H10c sub-community can often resemble a very fine-grained mosaic of acid grassland and heathland giving the vegetation a quite patchy appearance. This vegetation type tends to occur where there is increased pressure from herbivores

H12a *Calluna vulgaris-Vaccinium myrtillus* heath
***Calluna vulgaris* sub-community**

EC Habitats Directive 4030 European dry heaths

Calluna vulgaris D, *Vaccinium myrtillus* F, *Hypnum jutlandicum* A, *Hylocomium splendens* F, *Rhytidiadelphus loreus* F

This community was recorded more frequently towards the end of the survey and it is thought that it may have been under-recorded during the early part due mainly to the much less prominent growth of *Vaccinium myrtillus* at that time of year. The *Vaccinium myrtillus* in this type of heath is very sparse indeed becoming more detectable when the longer leafier shoots have grown.

H12c *Calluna vulgaris-Vaccinium myrtillus* heath
***Galium saxatile-Festuca ovina* sub-community**

EC Habitats Directive 4030 European dry heaths

Calluna vulgaris D, *Vaccinium myrtillus* F, *Hypnum jutlandicum* A, *Hylocomium splendens* F, *Rhytidiadelphus loreus* F, *Anthoxanthum odoratum* F, *Nardus stricta* F, *Luzula multiflora* F

Very similar to H12a, this sub-community was recorded very infrequently within dry heath where grasses become more prominent through the *Calluna vulgaris* canopy.

3.5 Wet Heath communities

EC Habitats Directive 4010 Northern Atlantic wet heaths with *Erica tetralix*.

Wet heath vegetation occurs on less well-drained, shallow, acid peats (less than 50cm) thus it is found on sloping banks and around knolls. It is found throughout the survey area on gently to moderately sloping ground in addition to areas which are becoming re-vegetated following peat erosion.

M15a *Trichophorum cespitosum-Erica tetralix* wet heath
***Carex panicea* sub-community**

EC Habitats Directive 4010 Northern Atlantic wet heaths with *Erica tetralix*.

Thalictrum alpinum F, *Calluna vulgaris* F, *Erica tetralix* O, *Trichophorum cespitosum* O, *Deschampsia flexuosa* O, *Prunella vulgaris* O, *Potentilla erecta* O, *Pinguicula vulgaris* O, *Selaginella selaginoides* O, *Viola riviniana* O, *Carex panicea* O, *Polygala serpyllifolia* O, *Nardus stricta* O*, Huperzia selago* O, *Deschampsia flexuosa* O*, Fissidens* sp. O, *Hylocomium splendens* O, *Pleurozium schreberi* O, *Ctenidium molluscum* O, *Breutelia chrysocoma* F, *Racomitrium lanuginosum* O, *Hypnum jutlandicum* O.

This type of wet heath is not widespread but occurs on the southern slopes below Riding Hill in the Delting Quadrant. Here the wet heath is subject to flushing resulting in the occurrence of this, the richest, most floristically diverse sub-community (M15a).

There is no particular vascular dominant as is seen in the other wet heath sub-communities but instead a more open and varied mixture of species. *Calluna vulgaris* attains quite high cover, interspersed by low growing *Thalictrum alpinum*. *Breutelia chrysocoma*, an M15a indicator species, forms a large proportion of the bryophyte cover, although the range of bryophytes present is also greater than that found in the more common wet heath communities over the site. These include *Racomitrium lanuginosum*, *Hylocomium splendens*, *Pleurozium schreberi*, *Ctenidium molluscum*, *Hypnum jutlandicum* and *Fissidens adianthoides.*

M15b *Trichophorum cespitosum-Erica tetralix* wet heath
Typical sub-community

EC Habitats Directive 4010 Northern Atlantic wet heaths with *Erica tetralix*.

Trichophorum cespitosum A, *Calluna vulgaris* A, *Eriophorum angustifolium* A, *Juncus squarrosus* F, *Erica tetralix* F, *Sphagnum capillifolium* F

This sub-community is found on shallow peats with more impeded drainage compared to those supporting dry heath. It is less frequent over the survey area than the grassy M15d.

Calluna vulgaris, *Eriophorum angustifolium* and *Trichophorum cespitosum* are the main vascular species here and, along with frequent patchy *Sphagnum capillifolium* this habitat can grade into and look very much like blanket bog vegetation except that it is found on shallower peat. It differs from M15c in lacking *Erica cinerea* and much *Racomitrium lanuginosum* and from M15d by the reduced grasses, hypnaceous mosses and J*uncus squarrosus*.

In areas of heavy grazing the *Sphagnum* component can suffer damage and it is thought that the overall proliferation of M15d over M15b in the survey area is a result of long-term heavy grazing by sheep.

M15c *Trichophorum cespitosum-Erica tetralix* wet heath
***Cladonia spp.* sub-community**

EC Habitats Directive 4010 Northern Atlantic wet heaths with *Erica tetralix*.

Calluna vulgaris A, *Trichophorum cespitosum* A, *Erica cinerea* A, *Racomitrium lanuginosum* A, *Eriophorum angustifolium* A, *Cladonia portentosa* F, *Hypnum jutlandicum* F

Although not widespread and common in the survey area this sub-community was recorded at several locations in the Kergord quadrant. Here it is found on thin wet peats on somewhat steeper slopes where there is often some exposed rock or mineral substrate.

Marking this type of wet heath out is the presence of *Erica cinerea* and *Racomitrium lanuginosum* as constants along with the main species found in the other sub-communities, i.e. *Calluna vulgaris*, *Trichophorum cespitosum*, *Eriophorum angustifolium* and *Hypnum jutlandicum*. As in M15d there is a lack of *Sphagnum* cover. In parts this vegetation type is transitional towards H10b and in such situations is only separated from that community by the frequency of *Trichophorum cespitosum* and presence of scattered *Sphagnum capillifolium*.

M15d *Trichophorum cespitosum-Erica tetralix* wet heath
***Vaccinium myrtillus* sub-community**

EC Habitats Directive 4010 Northern Atlantic wet heaths with *Erica tetralix*.

Calluna vulgaris A, *Juncus squarrosus* A, *Hylocomium splendens* A, *Rhytidiadelphus loreus* A, *Hypnum jutlandicum* A, *Nardus stricta* F, *Empetrum nigrum* F

This is the most widespread type of wet heath recorded on the survey. It is frequently found in areas of eroding blanket bog where it gains a hold, along with acid grassland, on the shallow peats there. With the grasslands it forms a patchy mosaic and the two vegetation types do grade into each other. The heath though supports a much greater cover of ericoids.

Calluna vulgaris is the most frequent and visually prominent dwarf shrub here but there is usually also some *Empetrum nigrum*. *Juncus squarrosus* and *Nardus stricta* are prominent and together they form a continuity with the acid grassland communities (U6) with which it forms mosaics. *Sphagnum capillifolium* is generally present here, although of reduced frequency compared to M15b, with frequent hypnaceous mosses, particularly *Hylocomium splendens*, *Rhytidiadelphus loreus* and *Hypnum jutlandicum* forming the bulk of the bryophyte layer.

This is a tough community that is resistant to trampling damage by sheep although its further spread on shallow bare peat and mineral substrate within eroding blanket bog may be being held back somewhat by the effects of trampling.

3.6 Acid Grassland communities

U4a *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland
Typical sub-community

U4b *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland
***Holcus lanatus-Trifolium repens* sub-community**

Semi-improved U4 acid grasslands are not a widespread feature but can occur around the edges of the survey area in marginal pastures. It also occurs in areas of blanket bog erosion around broad summits and ridges where it forms a very short and heavily grazed species-poor turf of *Festuca ovina* or *Festuca vivipara* sometimes with *Aira praecox,* and can often be found forming mosaics with the other main type of acid grassland, U6, from which it is distinguished by the lack of *Juncus squarrosus*.

In the more improved parts, around the edges of the survey area it is more typical and variably improved leading to both sub-communities, U4a and U4b, with the latter containing more species of nutrient-rich conditions. Thus it is often comprised of a number of grassy sward species such as *Nardus stricta*, *Luzula campestris*, *Plantago lanceolata*, *Juncus squarrosus*, *Festuca rubra*, *Prunella vulgaris*, *Carex panicea*, *Narthecium ossifragum, Potentilla erecta*, *Rhytidiadelphus squarrosus*, *Anthoxanthum odoratum*, *Agrostis capillaris*, *Holcus lanatus*, *Holcus mollis*, *Rumex acetosa*, *Cirsium palustre*, *Deschampsia flexuosa* and *Cardamine pratensis*. In the moss layer can be found an abundance of calcifugous hypnoid mosses such as *Dicranum scoparium*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Dicranum scoparium*, *Mnium hornum*, *Frullania sp.* and *Polytrichum commune*.

In richer areas there may be a little *Thalictrum alpinum* which indicates some degree of base enrichment and a transition towards CG10.

U5b *Nardus stricta-Galium saxatile* grassland
***Agrostis canina-Polytrichum commune* sub-community**

This *Nardus stricta*-dominated community was not recorded much on the current survey as most of the acid grassland containing *Nardus stricta* is thought to fall more easily within U6 *Juncus squarrosus* grassland as *Juncus squarrosus* is usually present in all of the acid grassland found. Within grassland/heath mosaics though there are localised patches where *Nardus stricta* increases in cover and in some instances these could be categorised as U5.

U6 *Juncus squarrosus-Festuca ovina* grassland

This type of *Juncus squarrosus*-dominated acid grassland is common throughout the survey area, especially within erosional complexes, where it is found in mosaics with dwarf shrub heath, on the shallower peats amid remnant deep peat blocks of blanket bog. It is also found as patches within more intact blanket bog.

Juncus squarrosus appears to be one of the early colonisers of bare peat and broken down blanket bog. Where it gets a hold it can often form a dense mass of tight rosettes which bind the peat surface together forming a very tough surface resistant to trampling by sheep and erosion by wind and rain and providing a matrix for Sphagnum to regain a hold. It is therefore thought to be of some importance in the regeneration of blanket bog and also in forming dams and banks which hold back erosion and water runoff and thereby protect or create pools and wet hollows within eroding blanket bog.

Two sub-communities were recorded.

U6a *Juncus squarrosus-Festuca ovina* grassland
***Sphagnum* spp. sub-community**

Juncus squarrosus D, *Sphagnum papillosum* A, *Sphagnum capillifolium* F, *Nardus stricta* F, *Eriophorum angustifolium* F, *Sphagnum palustre* F, *Calluna vulgaris* O, *Festuca vivipara* O, *Potentilla erecta* O, *Polytrichum commune* O.

This sub-community is identified by the dominance of *Juncus squarrosus* and the frequency and cover of Sphagnum. This is mainly *Sphagnum capillifolium* and *Sphagnum papillosum* and not *Sphagnum fallax* as in the documented NVC tables. It is transitional in nature to wet heath and blanket bog and usually contains more *Eriophorum angustifolium* and *Calluna vulgaris*. Although generally less grassy in appearance than U6d it usually has *Nardus stricta* and occasionally a little *Agrostis canina*.

It is thought that this community can form on areas of previously bare peat where *Juncus squarrosus* gets a hold and around which further mire species can re-colonise, especially *Sphagnum* spp. It also occurs as patches within more intact mire.

U6d *Juncus squarrosus-Festuca ovina* grassland
***Agrostis capillaris-Luzula multiflora* sub-community**

Juncus squarrosus D, *Hylocomium splendens* F, *Rhytidiadelphus loreus* F, *Nardus stricta* F, *Anthoxanthum odoratum* F, *Potentilla erecta* F, *Rhytidiadelphus squarrosus* O, *Empetrum nigrum* O, *Polytrichum commune* O, *Agrostis capillaris* O.

This sub-community is visually more grassy in appearance and *Sphagnum* is generally absent here. It occurs within eroding blanket bog and also on steeper slopes with a covering of shallow peat.

Juncus squarrosus is the most prominent vascular constant here along with a range of grasses such as *Anthoxanthum odoratum*, *Nardus stricta*, *Festuca ovina*, *Agrostis capillaris* and, more occasionally, *Agrostis canina* and *Deschampsia flexuosa*. *Potentilla erecta* and *Galium saxatile* are also prominent here. Although *Calluna vulgaris* and *Eriophorum angustifolium* can still be present the appearance here is less like a heath than U6a and more like a grassland. Instead of an abundance of *Sphagnum* in the bryophyte layer there are usually good covers of the hypnaceous mosses *Hylocomium splendens*, *Rhytidiadelphus loreus, Rhytidiadelphus squarrosus* and *Pleurozium schreberi* as well as frequent *Polytrichum commune* and occasional *Dicranum scoparium* and *Mnium hornum*.

Both these sub-communities have no doubt increased over the years as blanket bog has eroded and broken up along with widespread heavy grazing management practices.

Also noted frequently are patches of vegetation composed almost entirely of dense *Juncus squarrosus* which seem to form on small mounds of remnant peat creating very tight *Juncus squarrosus* hummocks. Vegetation such as this could form a valuable resource in the process of mitigation, through creation of new habitat and protection of existing habitat, by providing tough erosion-resistant vegetated peat surfaces to work with.

3.7 Calcareous Grassland communities

CG10a *Festuca ovina*-*Agrostis capillaris*-*Thymus polytrichus* grassland *Trifolium repens*-*Luzula campestris* sub-community

Agrostis capillaris, Campanula rotundifolia, Festuca ovina, F. rubra, Plantago lanceolata, Potentilla erecta, Prunella vulgaris, Thymus praecox, Viola riviniana, Hylocomium splendens.

Calcareous grassland is a rare vegetation type over the survey area and as such was only recorded from one location as the CG10a sub-community. It occurs where there is some base enrichment from underlying bedrock.

A rather open grassy sward tends to be dominated by the community constants *Festuca ovina* and *Thymus polytrichus* with frequent *Deschampsia flexuosa, Euphrasia* agg., *Alchemilla alpina, Anthoxanthum odoratum, Potentilla erecta, Plantago lanceolata, Nardus stricta, Galium saxatile, Rhytidiadelphus squarrosus, Pleurozium schreberi* and *Pseudoscleropodium purum.*

Thymus polytrichus is generally slow growing and easily shaded out by more vigorous herbs. Moderate/high grazing pressures appear to benefit this vegetation type keeping the sward fairly open and diverse with *T. polytrichus* generally avoided by herbivores. A lowering of current high domestic stock levels may therefore have an adverse effect on this flora.

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APPENDIX 1: TARGET NOTES

Collafirth NVC Target Notes

146. 41377 65963 Hillside is moderate to heavily grazed by sheep. The majority of vegetation is a bryophyte dominated M19 with abundant *Hylocomium splendens*, *Rhytidiadelphus loreus* and *Calluna vulgaris* and frequent *Eriophorum vaginatum*, interspersed with fragments of acid grassland (U6). [KP]

147. 41530 66063 High cover of *Eriophorum vaginatum* and *Eriophorum angustifolium* over this hillside gives the vegetation a distinctive, grassy appearance. *Calluna vulgaris* is much reduced in cover and *Empetrum nigrum* spp. *nigrum* scattered. Peat depth is greater than 0.5m and *Sphagnum* spp. locally frequent. Where *Calluna vulgaris* becomes more frequent it tends to be low growing and fairly inconspicuous. [KP]

148. 41770 66124 Stony flush (M10) with parts *Sphagnum denticulatum* dominated (M6). The open sward is composed of *Potamogeton polygonifolius*, *Carex panicea*, *Carex viridula* ssp. *Oedocarpa*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Scorpidium scorpioides*, *Nardus stricta*, *Narthecium ossifragum*, *Equisetum palustre*, *Campylium stellatum*, *Pinguicula vulgaris* and *Juncus bulbosus*. Photograph C1. [KP]

149. 41784 66146 Flush/soakway (photographs C2 & C3) vegetated by *Bryum pseudotriquetrum*, *Calliergon cuspidatum*, *Potamogeton polygonifolius*, *Ranunculus flammula*, *Anthoxanthum odoratum*, *Agrostis capillaris*, *Cardamine pratensis*, *Montia fontana*, *Cerastium fontanum*, *Carex nigra*, *Equisetum palustre*, *Glyceria fluitans*, *Myosotis scorpioides*, *Carex rostrata*. This vegetated soakway/channel continues eastwards to 41922 66101 (upstream) and is approximately 1-4m wide over this area of good condition wet/intact blanket bog (M17a). There are also further acid flushes through the peat surface with *Potamogeton polygonifolius*, *Scorpidium scorpioides*, *Carex* spp. and *Sphagnum denticulatum*. [KP]

150. 41747 66428 Area of active/intact blanket bog with a notably reduced cover of *Calluna vulgaris* compared to vegetation on the East side of stock fence. *Calluna vulgaris* is in fact still frequent but greatly reduced in stature as a result of long term grazing pressures. Cover of *Sphagnum papillosum, S. capillifolium* and *S. palustre* is generally high through areas of M17a and grasses infrequent. Photograph C4. [KP]

151. 41870 66199 Stony M10 flush (photograph C5) with *Carex viridula* ssp. *Oedocarpa*, *Carex nigra*, *Pinguicula vulgaris*, *Eriophorum angustifolium*, *Juncus bulbosus*, *Equisetum palustre*, *Scorpidium scorpioides*, *Trichophorum cespitosum*, *Carex panicea*, *Campylium stellatum*, *Potamogeton polygonifolius*, *Drosera rotundifolia*, *Campylopus* atrovirens, *Narthecium ossifragum*, *Schoenus nigricans* and *Juncus articulatus*. Towards the flush margins there are also *Thalictrum alpinum*, *Plantago maritima*, *Prunella vulgaris* and *Ctenidium molluscum.* Photograph C6 from 41860 66166 upslope. [KP]

152. 41833 66213 Stony (M10) flush similar to above. There are 2 or 3 similar flushes between here and stock fence to the West. [KP]

153. 41721 66213 Over this mainly grassy hillside there are occasional patches of *Sphagnum papillosum* interspersed with graminoids (*Anthoxanthum odoratum*, *Carex nigra*) over deep peat. [KP]

154. 41659 66215 Small, species-rich, grassy flush with *Nardus stricta*, *Juncus squarrosus*, *Narthecium ossifragum*, *Taraxacum* agg., *Prunella vulgaris*, *Plantago lanceolata*, *Equisetum palustre*, *Potentilla erecta*, *Trifolium repens*, *Eriophorum angustifolium*, *Anthoxanthum odoratum*, *Trollius europaeus*? and *Cirsium palustre*. [KP]

155. 41624 66222 M10 flush (*Carex viridula* ssp. *oedocarpa*, *Pinguicula vulgaris*, *Trichophorum cespitosum*, *Pedicularis sylvatica*, *Potamogeton polygonifolius*, *Schoenus nigricans* and *Scorpidium scorpioides*. Blanket bog communities over these slopes were found to be transitional towards grassland although retaining a high cover of peat building *Sphagnum papillosum*. [KP]

156. 41679 66146 Vigorously growing channel vegetation (*Cardamine pratensis*, *Eriophorum angustifolium*, *Juncus effusus*, *Myosotis scorpioides*, *Ranunculus flammula*, *Anthoxanthum odoratum*, *Equisetum palustre*, *Rhytidiadelphus squarrosus*, *Calliergon cuspidatum*, *Carex nigra*, *Sphagnum denticulatum*). Photograph C7. [KP]

157. 42374 66235 Approximate turbine location (#36) within wide area of intact blanket bog which was mainly of the drier M17b NVC sub-community (*Calluna vulgaris*, *Racomitrium lanuginosum*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Erica tetralix*, *Trichophorum cespitosum*, *Cladonia portentosa*, *Sphagnum capillifolium*) interspersed with smaller areas of the wetter M17a sub-community with *Sphagnum capillifolium* generally replacing *Sphagnum papillosum*. There were also small fragments of M19 vegetation. Photographs C8 & C9. [KP]

158. 42774 66209 Although there is frequent small-scale erosion over this area of blanket bog it is generally active with frequent *Sphagnum* filled hollows (M1) and *Eriophorum angustifolium* colonising bare peat (M3). Photographs C10 & C11. [KP]

159. 42901 66261 Approximate turbine location (#38) within area of intact M17b with virtually no erosion and interspersed with wetter M17a vegetation (mainly *Sphagnum capillifolium*). There is some hagging to the East but this is small scale. Photographs C12, C13 & C14. [KP]

160. 42740 65536 Peat greater than 3m deep here (photograph C15). Blanket bog over this area varies greatly in terms of the degree of erosion/hagging with some areas completely intact and others deeply hagged. [KP]

161. 42686 65242 Approximate turbine location #41 in area of intact M17b/a blanket bog with little or no erosion channels (photographs C16 & C17). To the West of here at the bottom of slope there was some erosion but here eroded hollows have become *Sphagnum* filled. [KP]

162. 42740 65760 Approximate turbine location #39 (photographs C18, C19 & C20) within area of M17b with some erosion/hagging (M3). Re-vegetation of bare peat was frequent and generally at a faster rate than erosion. There was also some *Juncus squarrosus* grassland (U6a) where peat is shallow as a result of past erosion and *Sphagnum cuspidatum*/*Sphagnum denticulatum* hollows (M1). [KP]

163. 42138 65041 A wide flush dominated by *Sphagnum denticulatum* with sparse *Juncus effusus* and *Carex nigra* along the centre and *Juncus bulbosus* at the margins, somewhat poached (M6aii). [ND]

164. 42262 64947 An extensive valley mire supporting a mosaic of M17a, M17b, generally smooth, not hagged and in good condition with frequent depressions (M1) (photo C21). More or less constant *Sphagna*, though *Sphagnum capillifolium* more frequent than *Sphagnum papillosum* which is occasional to frequent. The track along the valley to turbine 42 should be moved 150m west to avoid this basin mire. There are also frequent sink holes with pockets of *Juncus effusus* and flushed grassland at the bases. [ND]

165. 42067 64679 Site of turbine 45. This turbine is sited within the extensive valley mire in a particularly good area dominated by *Eriophorum angustifolium, Sphagnum papillosum* and *Calluna vulgaris* (photo C22 close-up, photo C23 S across mire system) in very good condition, the *Sphagna* forming a deep and continuous carpet. Move the turbine and access tracks to either side 100m west onto the slope above to avoid this system. [ND]

166. 42161 64544 A hag system with quite abundant erosion but fenced all around and apparently less heavily grazed (photo C24). Active revegetation of hags and *Sphagna* abundant on hag tops. [ND]

167. 42444 64578 A large pool at the edge of the 100m strip with some *Sphagnum denticulatum* and *Eriophorum angustifolium* at the margins. [ND]

168. 42561 64734 Site of turbine 46. Sited on smooth peat (M17b) adjacent to a hagged area. The vegetation here is in reasonable condition though *Sphagna* are not frequent on dry hag tops. Occasional pools and depressions (M1) (photo C25 N). [ND]

169. 43023 64815 Site of turbine 44. Turbine sited on a small mound near to the burn at the bottom of the valley (photo C26 N, photo C27 SW). [ND]

170. 42857 64847 *Potamogeton polygonifolius* flushes (M30) through blanket bog in good condition with: *Potamogeton polygonifolius, Sphagnum denticulatum,*

Ranunculus flammula, Juncus bulbosus, Eriophorum angustifolium, Carex nigra, Narthecium ossifragum (photo C28). [ND]

171. 42208 65401 Site of turbine 42 in an extensive valley mire (photos C29 N, C30 E, C31, C32). predominantly blanket bog (M17a) in good condition on very deep peat with scattered pools and depressions and abundant *Sphagna* including *Sphagnum papillosum.* If possible move the turbine and tracks 100m west to avoid this system. [ND]

172. 42265 65427 M1/M6aii flush in good condition supporting: *Sphagnum cuspidatum, Sphagnum denticulatum, Juncus bulbosus, Trichophorum cespitosum, Narthecium ossifragum* and *Eriophorum angustifolium.* [ND]

173. 42309 65953 *Potamogeton polygonifolius* flush (M30) through a large area of species-rich, flushed grassland (photo C33, C34) from which the following species have been recorded: *Ranunculus flammula, Trifolium repens, Ranunculus ficaria, Juncus bulbosus, Callitriche stagnalis, Myosotis secunda, Viola palustris, Leontodon autumnalis, Caltha palustris, Nardus stricta, Agrostis capillaris, Anthoxanthum odoratum, Festuca ovina, Carex panicea, Carex viridula ssp. oedocarpa, Carex flacca, Sphagnum denticulatum, Dicranella palustris, Pseudobryum cinclidioides, Bryum pseudotriquetrum, Calliergon cuspidatum.* [ND]

174. 41912 66099 *Potamogeton polygonifolius* flush through blanket bog (M17a) in good condition. Flush supports a rich flora including *Sphagnum denticulatum, Juncus bulbosus, Carex panicea, Eriophorum angustifolium, Ranunculus flammula, Aneura pinguis* and other herbs as yet too small to identify (photo C35). Avoid if possible. Base-enrichment of these flushes from soaks flowing down from the hills to the south and north. [ND]

175. 41770 66105 M10a flush at the base of the slope on stony substrate (photo C36). *Carex viridula ssp. oedocarpa, Carex panicea, Pinguicula vulgaris, Potamogeton polygonifolius, Juncus bulbosus, Narthecium ossifragum, Scorpidium scorpioides, Sphagnum denticulatum, Equisetum palustre, Carex dioica, Dicranella palustris, Calliergon cuspidatum.* Avoid by micro-siting. [ND]

176. 41685 66049 M10a flush as above, avoid by micro-siting. [ND]

Delting NVC Target Notes

177. 43056 72548 Fragments of vegetation similar to grassy dry heath (H10c) where *Calluna vulgaris* is heavily grazed by sheep and occurs in a fine-grained mosaic with *Rhytidiadelphus loreus*, *Hylocomium splendens* and *Deschampsia flexuosa.* This habitat is over deep peat (>0.5m) and most likely derived from M19 through long term grazing and drying of peat surface. [KP]

178. 43615 72940 Very wet flush/soakway (M30) with abundant *Potamogeton polygonifolius*, *Montia fontana* and *Sphagnum denticulatum*. Also present at

varying frequencies are *Ranunculus flammula*, *Juncus bulbosus*, *Eriophorum angustifolium* and *Myosotis scorpioides* (photograph D30). [KP]

179. 44368 73045 Expanse of *Sphagnum papillosum* dominated mire with constant *Eriophorum vaginatum* and *Eriophorum angustifolium*. *Calluna vulgaris* is fairly constant although at low cover and predominantly pioneer making it inconspicuous beneath cotton grasses. *Sphagnum palustre* and *Polytrichum commune* are quite localised in occurrence and the bog here is modified to some degree. However, the bog remains active with high cover of peat building *Sphagna* and *Eriophorum* spp. Consider moving track to grassy slopes just north of here. Photograph D31 at 44330 73049. [KP]

180. 42950 72320 Small area of peat hags (photograph D32) within wider area of more-or-less completely intact blanket bog (photograph D33). Here re-vegetation of eroded surfaces is frequent and generally occurring at a greater rate than associated erosion. Species present in these hollows are mainly *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Calluna vulgaris*, *Sphagnum papillosum*, *Sphagnum cuspidatum* and *Sphagnum capillifolium*. [KP]

181. 40543 72274 Turbine location number 170. Large area of intact blanket bog. *Sphagnum capillifolium* largely replaces *Sphagnum papillosum* through areas mapped as M17a and is interspersed with areas of the drier *Racomitrium lanuginosum* dominated M17b sub-community and M1 hollows (*Sphagnum cuspidatum*, *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Eriophorum vaginatum*). Photographs D34 & D35. [KP]

182. 40721 72183 Small area of peat erosion and re-vegetation, with erosion appearing to be occurring at a slower rate than re-vegetation. M17a here has a greater percentage of *Sphagnum papillosum* than seen over the slopes immediately to the North. [KP]

183. 40505 71467 Turbine location number 6. Small scale peat erosion, within wider area of mainly intact blanket bog, with frequent *Eriophorum angustifolium* and *Sphagnum cuspidatum* colonising the peat surface (M3). Photographs D36, D37 & D38. [KP]

184. 40439 71651 Small open water pool at proposed track junction within area of mainly intact blanket bog (photograph D39). In contrast, most areas with a similar exposed ridge or hilltop topography over the site tend to be badly eroded. Track movement. [KP]

185. 40367 71641 M1 pools (*Sphagnum cuspidatum*, *Sphagnum denticulatum*, *Eriophorum angustifolium*) within area of wetter blanket bog (M17a) are starting to dry out due to lack of rain. *Sphagnum papillosum* is particularly abundant around pool margins. Photograph D40. [KP]

186. 40468 71699 Partially re-vegetated pools within small scale hag system (photograph D41). This is a potentially fragile habitat which should be avoided by track route. [KP]

187. 40750 71938 Turbine location number 2. Small fragment of wet heath (M15d) where peat has eroded/slipped in the past and subsequently become re-vegetated, within wider area of intact blanket bog (M19/M17) with little or no erosion. Photographs D42 & D43. [KP]

188. 39859 72756 Sequence of M1 bog-pools (photograph D44). Re-route track to avoid this habitat. [KP]

189. 39812 72817 Flush/soakway on proposed track route vegetated by *Potamogeton polygonifolius*, *Carex nigra*, *Sphagnum denticulatum*, *Equisetum palustre*, *Hydrocotyle vulgaris*, *Bryum pseudotriquetrum* and *Carex dioica*. [KP]

190. 40056 71322 M1 pool (*Sphagnum cuspidatum*, *Sphagnum denticulatum*, *Juncus bulbosus*) which is drying out and poached by sheep. Associated flush/soakway (M6b) is vegetated by *Sphagnum denticulatum*, *Carex nigra*, *Juncus bulbosus*, *Agrostis capillaris* and *Sphagnum cuspidatum*. [KP]

191. 39534 71194 Bog surface is more structurally diverse, than to North-east, with small-scale hagging and associated vegetation of hollows (M1/M3) becoming flushed in parts (M6aii). Re-vegetation is generally occurring at a faster rate than erosion. Photograph D45. Difficult to choose a suitable track route through this habitat. [KP]

192. 39375 70736 Wet heath (M15d) vegetation occurs where peat has slipped or been eroded away in the past and ground subsequently becomes re-vegetated. *Calluna vulgaris* dominates with abundant *Juncus squarrosus*. Associates include frequent *Sphagnum capillifolium*, *Sphagnum papillosum*, *Eriophorum angustifolium* and occasional *Racomitrium lanuginosum.* Some intact peat blocks of M17b/M19 remain and current erosion is at a low level. Photograph D46. [KP]

193. 39385 70695 Photographs D47, D48 & D49 show area of intact mire around the Burn of Laxobigging to the South-east. [KP]

194. 39452 70700 This steeper slope is mainly a mosaic of atypical wet heath vegetation (M15d) which is dominated by *Calluna vulgaris* with *Juncus squarrosus*, *Hylocomium splendens*, *Potentilla erecta* and *Galium saxatile* over deep peat. The top of the slope supports more typical blanket bog vegetation (M19) from which the rest of the slope is probably derived through modification. Photograph D50. [KP]

195. 39460 70486 Flush vegetation through channel is mainly *Juncus effusus* and *Sphagna* (M6ci). Where there is very slow flowing water visible aquatic flora becomes more diverse and includes *Ranunculus flammula*, *Cardamine pratensis*, *Myosotis scorpioides*, *Montia fontana*, *Drepanocladus* sp., marginal *Sphagnum denticulatum* and *Juncus effusus*. Photograph D60. [KP]

196. 39402 70442 Continuation of soakway described above (39460 70486). Additional species here include *Juncus bulbosus* and *Potamogeton polygonifolius*. Photograph D61. Surrounding mire is active and intact with a good cover of *Sphagnum* species. [KP]

197. 39486 71199 Small pool of standing water surrounded by *Sphagnum papillosum* dominated M17a mire on proposed track line. This track may be better situated along Mid field ridge, although this was not surveyed. [KP]

198. 38754 70575 Turbine location number 11 (photographs D62, D63 & D64). Area of mainly intact blanket bog (M17b/a) with some fragments of wet heath (M15d) over shallower peats between small re-vegetating hags. Current rate of erosion appears to be minimal. *Sphagnum papillosum* is locally abundant through wet heath vegetation which is floristically closer to M17a despite occurring over less than 50cm of peat. [KP]

199. 38829 70184 Small pools vegetated around the margins by *Sphagnum denticulatum* and *Sphagnum cuspidatum* (photographs D65 & D66). Blanket bog varies between active, good condition M17a with a high cover of *Sphagnum papillosum* which forms a carpet over the surface, and areas of erosion where M17 forms a mosaic with M3. Some areas which have been eroded away in the past have become re-vegetated by M15d. [KP]

200. 38897 69906 Area of hagging and associated erosion. There is some re-vegetation of bare peat by *Eriophorum angustifolium* but in general rate of erosion is greater than that of re-vegetation. Remaining peat blocks support mainly M17b. Photograph D67. [KP]

201. 39042 69917 Soakway/flush with *Potamogeton polygonifolius*, *Carex nigra*, *Carex viridula* ssp. *oedocarpa*, *Eriophorum angustifolium*, *Sphagnum cuspidatum*, *Deschampsia flexuosa* and *Juncus squarrosus*. [KP]

202. 39142 69870 Flush/soakway with *Potamogeton polygonifolius*, *Ranunculus flammula*, *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Carex viridula* ssp. *oedocarpa* and *Carex* spp. There are frequent similar flushes scattered over this area. [KP]

203. 39232 69768 Fragments of H14 typically have high cover of *Racomitrium lanuginosum* and *Calluna vulgaris*. Associates include *Nardus stricta*, *Carex bigelowii*, *Juncus squarrosus*, *Cladonia uncialis*, *Huperzia selago*, *Potentilla erecta*, *Trichophorum cespitosum* and *Hypnum jutlandicum* (photograph 7). Floristically this vegetation is quite similar to H10b recorded elsewhere over the site. [KP]

204. 39016 69378 Large open water bog pool within an area of *Sphagnum papillosum* dominated (M17a) blanket bog (photograph D69). Margins of pool have frequent *Sphagnum cuspidatum* and *Sphagnum denticulatum.* [KP]

205. 39130 69388 Turbine location number 29. Small scale hagging within wider area of largely intact blanket bog (photographs D70, D71 & D72). Where the peat depth decreases to less than 0.5m in there are small patches of U6d and M15d. Open water bog-pools occur scattered over this area. Degree of erosion varies over area. [KP]

206. 39095 69734 Frequent acid flushes (M6a) and M30 soakways (*Potamogeton polygonifolius*, *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Carex* spp., *Narthecium ossifragum*) over this area in general.

207. 38977 69815 Bryophyte dominated flush/spring with *Potamogeton polygonifolius*, *Ranunculus flammula*, *Carex echinata*, *Carex nigra*, *Bryum pseudotriquetrum*, *Drepanocladus* sp. etc. [KP]

208. 38792 70104 Turbine location number 15 within area of predominantly shallow peat (M15d) with scattered peat blocks (M17b) and occasional bare ground. Blanket bog here is not particularly active but vegetation as a whole appears to be in a state of recovery (photographs D86 & D87). [KP]

209. 38672 70494 Open water pools and M1 hollows (*Sphagnum cuspidatum*) within area of fairly intact blanket bog (photograph D73). [KP]

210. 36650 66182 Enclosed field with vegetation intermediate between mire and acid grassland. *Calluna vulgaris* and *Erica tetralix* are generally present through the acid grassland (U5d) although at low cover and quite inconspicuous. In parts *Carex panicea* becomes quite frequent and the vegetation more similar to the *Carex panicea-Viola riviniana* sub-community (U5c). [KP]

211. 36712 66190 Flush/soakway with abundant *Carex nigra* and frequent *Potamogeton polygonifolius*, *Ranunculus flammula* and *Eriophorum angustifolium*. Also present at lower cover area mixture of *Carex dioica*, *Pinguicula vulgaris*, *Menyanthes trifoliata*, *Drosera rotundifolia*, *Erica tetralix*, *Sphagnum denticulatum*, *Racomitrium lanuginosum* and *Sphagnum papillosum*. [KP]

212. 36771 66188 Small hollow of *Sphagnum papillosum* dominated blanket bog (M17a) with usual associates (*Eriophorum angustifolium*, *Erica tetralix*, *Potentilla erecta*, *Calluna vulgaris*, *Narthecium ossifragum*, *Sphagnum capillifolium*, *Racomitrium lanuginosum*) and scattered *Carex panicea*/*Nardus stricta*. There are frequent pools and soakways (*Potamogeton polygonifolius*, *Eriophorum angustifolium*, *Sphagnum denticulatum*, marginal *Pinguicula vulgaris*) through this habitat. Photograph D88. [KP]

213. 36851 66282 Very wet flush with *Juncus effusus*, *Rumex acetosa*, *Cardamine pratensis*, *Eriophorum angustifolium*, *Equisetum palustre*, *Calliergon* sp., *Ranunculus flammula*, *Montia fontana*, *Agrostis stolonifera*, *Anthoxanthum odoratum*, *Carex* spp., *Carex nigra* and open water. In parts the flush becomes bryophyte dominated (*Philonotis fontana*, *Calliergon cuspidatum*, *Bryum*

pseudotriquetrum, Aulacomnium palustre and *Sphagnum* spp. towards margins. [KP]

214. 37391 66588 Frequent peat cuttings through blanket bog. Some areas are also eroded away to bare mineral substrate. The bog itself is quite heavily grazed in parts and lightly hagged. [KP]

215. 37522 67177 Steep slopes supporting dry heath have become a fine-grained mosaic of heath and acid grassland (H10c) through heavy grazing by sheep (photograph D89). [KP]

216. 37521 67032 Scattered species poor flushes (*Carex viridula* ssp. *oedocarpa*, *Carex panicea*, *Nardus stricta*, *Sphagnum denticulatum*, *Campylopus atrovirens*, *Erica tetralix*, *Calluna vulgaris*, *Eriophorum angustifolium*). [KP]

217. 37294 66697 Frequent peat cuttings (up to 1m) through blanket bog with associated access tracks and areas of bare ground, wet heath and acid grassland (U6). [KP]

218. 40021 69840 Spring/flush between peat hags vegetated by *Drepanocladus* sp., *Cardamine pratensis*, *Scapania* sp., *Carex echinata*, *Juncus squarrosus*, *Juncus bulbosus* and *Eriophorum angustifolium* (photograph D90). [KP]

219. 39897 69532 Turbine location number 18. These gentle slopes support extensive, intact blanket bog with abundant *Sphagnum papillosum* and *Sphagnum capillifolium*. Where there is some small scale erosion there is also a good rate of re-vegetation by *Eriophorum angustifolium* and *Sphagnum* spp. (photographs D91, D92 & D93). [KP]

220. 39489 69130 Location of turbine number 21. Ridge of blanket mire (M17a/b) with hagging either side. The actual ridge here is of fairly intact M17a (photographs D94, D95 & D96). Within this polygon the condition and activeness off the blanket bog varies greatly between eroding hags and deep carpets of *Sphagnum papillosum* (M17a). [KP]

221. 39377 68785 Deep spongy *Sphagnum papillosum* dominated M17a mire. Constants include *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Calluna vulgaris*, *Trichophorum cespitosum*, *Empetrum nigrum* and *Sphagnum capillifolium* (photograph D97). This vegetation type occurs in a mosaic with drier M17b and M19 with scattered peat hags (M3). [KP]

222. 39392 68656 Summit vegetation which is predominantly a mixture of *Racomitrium lanuginosum*, *Calluna vulgaris*, *Juncus squarrosus* and *Eriophorum angustifolium* with scattered *Cladonia portentosa*, *Eriophorum vaginatum*, *Hypnum jutlandicum*, *Cladonia uncialis*, *Rhytidiadelphus loreus*, *Dicranum majus* and *Trichophorum cespitosum* over shallow peat. This vegetation was mapped as *Calluna vulgaris-Racomitrium lanuginosum* heath (H14) although due to the presence of mire species such as *Eriophorum angustifolium* and *Eriophorum vaginatum* it is not typical of the documentation for this community and exhibits a

transition towards the *Trichophorum cespitosum-Erica tetralix* wet heath (M15d). [KP]

223. 38783 67242 Flush with abundant *Carex limosa* and *Potamogeton polygonifolius* co-dominating the vegetation with margins vegetated by frequent *Sphagnum denticulatum*, *Nardus stricta* and *Carex echinata* (photograph D98). Upslope the flush becomes quite stony with sparse *Carex viridula* ssp. *oedocarpa*, *Eriophorum angustifolium* and *Carex echinata*. Also noted within the flush as a whole were *Carex dioica* and *Drepanocladus revolvens*. Top end (38836 67212) of flush becomes quite grassy looking with *Nardus stricta*, *Trichophorum cespitosum*, *Carex limosa*, *Carex viridula* ssp. *oedocarpa*, *Narthecium ossifragum*, *Eriophorum angustifolium* and *Sphagnum denticulatum* making up the bulk of cover. KP]

224. 39194 67471 Eroding bank of peat where subterranean stream reappears (photograph D99). [KP]

225. 38976 67954 Scattered M10 flushes across hillside with *Carex viridula* ssp. *oedocarpa*, *Potamogeton polygonifolius*, *Pinguicula vulgaris*, *Drosera rotundifolia*, *Erica tetralix*, *Trichophorum cespitosum* and *Narthecium ossifragum*. Towards the margins there is also frequent *Scorpidium scorpioides* and *Sphagnum denticulatum*. Adjacent wet heath is most similar to M15a (see quadrat 21). [KP]

226. 38570 67799 Location of turbine number 28 (photographs D100, D101, D102 & D103) within a wider area of fairly intact and active blanket bog which is mainly M17b with M3 hollows/hagging. In parts there is also some wetter (M17a) mire with frequent *Sphagnum papillosum* and M19. Proportions of the various NVC types are quite difficult to assess here. Eroded hollows are generally re-vegetating (*Sphagnum cuspidatum*/*Eriophorum angustifolium*) and habitat appears to be in a stable condition. [KP]

227. 38246 68094 Location of turbine number 26 (photographs D104, D105, D106 & D107) towards edge of area with frequent hagging/erosion where M17b dominates. *Eriophorum angustifolium* is frequent through areas of bare peat. Where erosion has occurred in the past *Juncus squarrosus* and *Calluna vulgaris* dominate shallow peat (M15d) with frequent *Sphagnum papillosum*/*capillifolium*. [KP]

228. 38224 68031 Frequent M1 pools across area of active saddle mire (M17a). Pools are mainly vegetated by aquatic *Sphagnum cuspidatum* (photograph D108). Track movement to East to avoid negatively impacting on this habitat is recommended. [KP]

229. 38592 68132 Continuous carpet of *Sphagnum papillosum*/*capillifolium* with an even mix of the usual M17a constants (*Eriophorum angustifolium*, *Eriophorum vaginatum*, *Calluna vulgaris*). Photograph D109 from 38548 68089 of saddle mire and associated pools. This area of blanket bog is intact, active and in good

condition. Towards the edges of the polygon *Juncus squarrosus* begins to appear and becomes quite frequent in parts. [KP]

230. 38722 68285 Location of turbine number 25 (photographs D110, D111 & D112). Varying degrees of hagging/erosion over these slopes in general with re-vegetation generally equal to erosion. [KP]

231. 39138 68585 Location of turbine number 24 (photographs D113, D114, D115, D116) at edge of *Sphagnum papillosum* dominated mire. Immediately to the south vegetation is over shallow peat/mineral soil. Avoid *Sphagnum papillosum* dominated mire and pools when micrositing turbine and tracks. [KP]

232. 38868 68866 Location of turbine number 22 (photographs D117, D118 & D119) is within an area of intact M17a with deep/spongy more-or-less continuous *Sphagnum papillosum*. To the East of here and elsewhere along this ridge vegetation tends to be over shallower peat/mineral soil as a result of past erosion processes and subsequent re-vegetation. It would be preferable here to microsite turbine and move track to the East so as to avoid deeper peat and active bog. [KP]

233. 42361 71577 Site of turbine 171, Hill of Neegarth (photo D51 S, D52 SW, close-up). Relatively smooth bog with vegetated flushes and very little bare peat and abundant *Sphagna* in hollows and pools. Not approached closely due to nesting birds. Move track and turbine 50m to the south-east, downhill from an area of good condition hilltop saddle-mire (see 42265 71540). [ND].

234. 42265 71540 Hilltop saddle mire with blanket bog (M17a) in good condition with abundant *Sphagnum papillosum* and frequent pools (M1). Some hags but good revegetation of bare peat evident (photo D53). [ND]

235. 41833 71324 Spur mire around the site of turbine 35. the mire is dominated by M17a with frequent pools (photo D54). Some low hags but good revegetation (photo D55 N). [ND]

236. 41554 71859 Site of turbine 4. Relatively smooth habitat (M17b) to the south-west (photo D56 SW) but the mire breaks up into hags downhill of the turbine as the mire steepens towards the burn (photo D57 NE). The habitat is generally in good condition, some hagging but good revegetation of bare peat areas, abundant *Sphagnum denticulatum* in depressions, though few real pools. [ND]

237. 41988 71895 Site of turbine 1. M1 depression in the fore and relatively smooth peat behind (photo D58). Mire in good condition, some hags but these are low and evidently revegetating, few defined pools (photo D59). Hags are larger to the east. [ND]

238. 41525 70937 Site of turbine 8 at the corner of two fence-lines and an extensive area of bare peat in good condition just breaking up into hags down-slope. The M17 polygon is good habitat with abundant *Sphagnum papillosum* and should be retained undamaged. The track and turbines will be better run along the top

of Oxnabool where they are more eroded. (Photo D74 S, Hill of Oxnabool, photo D75 NE of good condition M17a, photo D76 across the hags). [ND]

239. 41249 71325 Site of turbine 5, on smooth gentle peat with occasional, low hags. The habitat is predominantly M17b with pockets of U6a in places. (photo D77 across the peat to the south-east, photo D78 N towards the burn). [ND]

240. 40983 71305 Species-rich flush across this slope (photo D79) with *Cardamine flexuosa, Aulacomnium palustre, Carex panicea, Trifolium repens, Caltha palustris, Pseudobryum cinclidioides, Cirsium palustre, Galium saxatile, Agrostis capillaris, Anthoxanthum odoratum, Carex viridula ssp. oedocarpa, Thalictrum alpinum, Ranunculus flammula, Sphagnum denticulatum. Philonotis fontana* springs are also present above. Avoid these features. [ND]

241. 41083 70932 Flushed grassland with a herb-rich spring-head (photo D80): *Callitriche stagnalis, Juncus effusus, Agrostis capillaris, Calliergon cuspidatum, Cardamine flexuosa, Juncus bulbosus, Juncus squarrosus, Rhytidiadelphus squarrosus, Sphagnum denticulatum.* [ND]

242. 41035 70864 Site of turbine 10. (photo D81 SE across M17b slope, D82 NW along burn channel with frequent base-rich soak communities immediately below the turbine). Turbine located on lightly hagged blanket bog M17b but is immediately above a burn channel with base-flushed grassland and flush communities. May require a relook at track and turbine positioning to avoid damage to these features through changes to run-off, surface-flow and potential pollution hazards. [ND]

243. 40967 70938 Springhead (photo D83) dominated by *Sphagnum denticulatum,* with frequent *Juncus bulbosus, Eriophorum angustifolium, Ranunculus flammula, Caltha palustris, Cardamine flexuosa* and algae, immediately below turbine 10 (see above).

244. 40529 70788 Site of turbine 32 (photo D84 SW over M17a blanket bog, photo D85 NW towards burn). This turbine is located within an extensive valley mire with extensive areas of active M17a blanket bog, on deep peat and in good condition, with frequent *Sphagnum papillosum, Sphagnum capillifolium* and *Pleurozia purpurea.* Suggest moving turbine and tracks away from this valley system, possibly south-east onto the slopes or removing them from the project. [ND]

245. 39154 70460 A large pool (M1) in good condition c. 50m from the turbine 13 (photo D1): *Juncus bulbosus, Sphagnum denticulatum, Narthecium ossifragum, Potamogeton polygonifolius, Eriophorum angustifolium, Sphagnum papillosum, Drosera rotundifolia,* quite scummy with algae in the deepest part. Avoid. [ND]

246. 39358 70385 A soakway through a flat valley mire dominated by M17a. The soak is dominated by *Sphagnum denticulatum* and *Juncus bulbosus* in its upper reaches winding down from hags and pools above. At this point it becomes richer, first with *Ranunculus flammula* and *Potamogeton polygonifolius* and then

with *Myosotis secunda, Callitriche stagnalis, Cardamine flexuosa* and *Juncus effusus.* Avoid. [ND]

247. 39211 70439 Site of turbine 13 (photo D2 W, photo D3 S across hags and photo D4 of the extensive valley mire). Turbine sited within hags just at the head of an intact and important valley mire system. The hags are generally low with little bare peat which is re-vegetating well. Keep turbine and tracks away from valley bottom – could move west onto hillside. [ND]

248. 39409 70312 Grassy flats on the banks of a burn with an interesting mix of species (photo D5). The moss layer is 90% *Sphagnum papillosum* with *Polytrichum commune* scattered through and the herb layer is: *Juncus effusus, Anthoxanthum odoratum, Agrostis capillaris, Luzula multiflora, Carex nigra, Carex echinata, Galium saxatile, Potentilla erecta, Viola palustris, Caltha palustris, Mnium hornum, Aulacomnium palustre.* There are also grips through this area, though largely blocked. [ND]

249. 39713 70420 Site of turbine 77. Sited in the middle of an extensive valley mire supporting abundant M17a in good condition. The turbine itself is located within a small group of hags but the surrounding mire would be affected. This is an inappropriate location for development (photo D6 SE, photo D7 NW). [ND]

250. 40182 70417 Site of turbine 14 (photo D8 down the burn of Oxnabool towards grassy areas, photo D9 E across a gentle slope of mostly smooth blanket bog M19/M17). Gentle slope with some light hagging in places but in good condition and part of valley system (see turbine 77 above), to be avoided. [ND]

251. 39974 70024 To the south-east of the fence-line, the vegetation is evidently more heavily grazed than in the valley mire and there are signs of long-term impacts such as the replacement of blanket bog by *Juncus squarrosus* grassland U6. [ND]

252. 39885 70030 Species-rich flushes (photo D10) by the fence and close to turbine 27, *Ranunculus flammula, Callitriche stagnalis, Juncus bulbosus, Carex nigra, Carex echinata, Juncus effusus* and *Sphagnum denticulatum* DOMIN 9-10. [ND]

253. 39867 70007 Site of turbine 27 (photo D11 E over adjacent grassland and flushes, photo D12 S over M19b bog). Turbine is sited on a smooth area of M19b bog, not hagged but with signs of long-term heavy grazing. [ND]

254. 39811 70062 *Potamogeton polygonifolius* flush (M30) extending from the flush at the fence line by turbine 27 several hundred metres down the burn. Locally species-rich (photo D13). [ND]

255. 39195 69924 Site of turbine 17 (photo D14 N along the eroded ridge, photo D15 W a small area of very eroded ground A1, near the turbine site). The eroded ridge extends all along the top of the hill with lots of bare peat and slumped ground, though largely revegetated. [ND]

256. 39131 70431 *Philonotis fontana* spring (M32) on the hillside above turbine 13, *Sphagnum denticulatum* and *Philonotis fontana* above and Carex viridula ssp. oedocarpa and *Carex panicea* below tending to M10 (photo D16). *Pseudobryum cinclidioides* also present. Avoid this feature, especially if moving track and turbines west to avoid the valley mire. [ND]

257. 41140 70197 A broad saddle mire between three summits. This large area of M17a mire is in very good condition with abundant *Sphagnum papillosum* and deep active pools (photo D17). Avoid this area. [ND]

258. 41105 70249 A large flush M6aii with M30 at the head of this burn and extending some way down (photo D18): *Carex nigra, Potamogeton polygonifolius, Cardamine flexuosa, Sphagnum denticulatum* (9), *Ranunculus flammula, Cardamine pratensis, Eriophorum angustifolium, Hylocomium splendens, Calliergon cuspidatum, Plantago lanceolata, Anthoxanthum odoratum, Pseudobryum cinclidioides, Campylium stellatum.* Avoid this area. [ND]

259. 41073 70160 A broad, flushed area extending into M6c soaks downhill. *Sphagnum denticulatum* is dominant with abundant *Eriophorum angustifolium* and local *Sphagnum cuspidatum* and other species (photo D19). Avoid. [ND]

260. 40920 70042 An M30 flush, well developed with abundant *Narthecium ossifragum.* [ND]

261. 40787 70141 A large pool with the saddle mire system with *Sphagnum cuspidatum, Sphagnum denticulatum, Juncus bulbosus* (photo D20, D21). [ND]

262. 40697 70412 Site of turbine 12 (photo D22 E to *Sphagnum denticulatum* depression and D23 S across blanket bog 0.8m deep. Bog in good condition with occasional low hags, constant *Sphagna* and active revegetation of bare peat areas. [ND]

263. 40287 70347 Mossy bank on the burn of Oxnabool with *Fontinalis antipyretica* in the stream and *Ranunculus flammula, Callitriche stagnalis* and *Persicaria amphibian* (new hectad record for this species). On the bank are *Dicranella palustris, Aneura pinguis, Scapania* spp., *Sphagnum palustre, Viola palustris, Rumex acetosa* and *Mnium hornum.* [ND]

264. 40361 69936 Site of Turbine 16 (photo D25 E along track line and D26 N hags, M17a and pools). This turbine is situated at the base of a gentle hillside with regular low hags but some good re-vegetation. Some underground burns and sink-holes present so micro-location of turbines necessary if placed here, although this area is in good condition with pool features present so better to avoid. Turbine and tracks could be located along the ridge to the south. [ND]

265. 40529 69675 The peat is all slumped away from this hilltop. Occasional mounds are left supporting wet heath type vegetation (M15d) and *Juncus squarrosus* grassland (U6) but the majority of the vegetation is dry heath with frequent *Racomitrium lanuginosum* (H10b) and open stony ground. (photo D27). [ND]

266. 40583 69650 Blanket bog M17a/M15b on relatively shallow peat 50-70cm deep on top of the hill, apparently actively building following a past erosion event (photos D28, D29). [ND]

267. 37885 67419 *Listera cordata* in blanket bog (photo D127). [ND]

268. 37984 67375 M30 stony *Potamogeton polygonifolius* flush running down the hillside, tending to M10 in places: *Potamogeton polygonifolius, Sphagnum denticulatum, Scorpidium scorpioides, Carex panicea, Juncus bulbosus, Carex viridula ssp. oedocarpa, Narthecium ossifragum, Ranunculus flammula, Pinguicula vulgaris, Schoenus nigricans, Aneura pinguis, Scorpidium revolvens* and *Carex dioica.* Avoid this feature [ND]

269. 37894 67133 Site of turbine 31 (photo D128 E and D129 N) along the stony plateau. The peat has slumped away from the summit in this area due to past erosion but active revegetation is evident. Abundant *Sphagna* including *Sphagnum papillosum* are present in M15 and U6 communities in mosaic with dry heath H10b, some open stony patches and some relics of blanket bog (M17b). [ND]

270. 38378 66791 A deep pool on the hilltop in an area where deep hagging is frequent but similar pools are still occasional (photo D130). *Sphagnum denticulatum* at the margins, *Sphagnum cuspidatum* with some emergent *Juncus bulbosus.* Very vulnerable to any increase in erosion here, e.g. through development. [ND]

271. 38378 66690 Site of turbine 33 (photo D131 NE and D132 SW across blanket bog in good condition). In a saddle between two hilltops is an area of M17a mire in good condition with some pools, deep peat and abundant *Sphagnum papillosum.* The turbine location should be moved onto higher ground, e.g. 20m north onto Duddin Hill. The track should also go across the top of Duddin Hill. [ND]

272. 38524 67072 a small stand of flushed grassland on the hillside with M6c and M6b at the base of the slope and some U4 grassland, *Philonotis fontana* springs M32 and base-rich flushes M30 at the top (photo D133). Avoid this feature. [ND]

273. 38421 67127 Site of turbine 30 (photo D134 E) A gentle slope, lightly hagged but re-vegetating at the same rate. Occasional flushes suggest some local base enrichment. [ND]

274. 38090 67383 A narrow M10 flush, one of several along this part of the slope where steeper (photo D135). It is dominated by *Carex viridula ssp. oedocarpa* with *Carex dioica, Juncus bulbosus, Potamogeton polygonifolius, Ranunculus flammula, Pinguicula vulgaris, Deschampsia* spp (? *setacea*), *Scorpidium scorpioides, Aneura pinguis, Campylium stellatum, Drosera rotundifolia.* Avoid these flushes. [ND]

275. 38537 68594 Much of the *Calluna vulgaris* over this hillside is dead. Heather beetle? Photograph D120. [KP]

276. 38463 69034 Turbine location number 20 at edge of small-scale peat hagging within otherwise fairly intact mire (photographs D121, D122 & D123). [KP]

277. 38424 68580 Turbine location number 23 within wide expanse of uniform M19/M17 which exhibits very little variation in surface structure. Areas of light erosion/hagging to the NW should be avoided as naturally eroding and re-vegetating. There are small fragments of *Juncus squarrosus* grassland (U6) here and *Calluna vulgaris* mainly dead. Photographs D124, D125 & D126. [KP]

Kergord NVC Target Notes

278. 41023 55493 For the most part steeper slope support dry heath vegetation (*Calluna vulgaris*, *Hylocomium splendens*, *Rhytidiadelphus loreus*) over peat depths of 50-70cm which comes closest in NVC terms to H10a. *Juncus squarrosus* occurs as discrete patches and *Empetrum nigrum* ssp. *nigrum* locally scattered through the heath. Due to the peat depth this vegetation will have been derived from past blanket bog. Photograph K1. [KP]

279. 41015 55769 Unvegetated open water bog pool within ridge of intact mire. Photograph K2. [KP]

280. 40963 55996 Approximate turbine location number 141. Small fragment of M15d/H10b (*Calluna vulgaris*, *Juncus squarrosus*, *Sphagnum capillifolium*, *Hylocomium splendens*, *Empetrum nigrum*, *Racomitrium lanuginosum*) within largely intact blanket bog (mainly M19) along ridge. *Sphagnum* spp. are frequent through blanket mire. Photographs K3 & K4. [KP]

281. 40977 56216 Proposed track route is through an area of wetter M17a blanket bog between two main pools (marked on map) and scattered smaller pools. Re-route track to the west of fence here. [KP]

282. 40992 56441 Two M1 bog-pools with abundant aquatic *Sphagna* and open water (Photograph K5). Surrounding mire habitat is quite varied and ranges between localised hagging/quite severe erosion and wet areas with abundant *Sphagnum* spp. [KP]

283. 41008 56501 Approximate turbine location number 128 within area of degraded/eroding summit mire. Re-vegetation is abundant, and mainly of *Juncus squarrosus* (U6d) and wet heath (M15d) where the peat has mainly been eroded away to leave a shallow layer. Peat blocks still remain, creating a mosaic with above vegetation. Photographs K6 & K7. Immediately off the ridge the mire vegetation is more or less intact. Bog pool immediately to the north of here. [KP]

284. 40833 55057 Sedge-rich flush (*Carex panicea*, *C. viridula* ssp. *oedocarpa*, *C. dioica*, *C. nigra*) with frequent *Pinguicula vulgaris*, *Eriophorum angustifolium* and *Potamogeton polygonifolius* as well as occasional *Selaginella selaginoides*, *Nardus stricta*, *Potentilla erecta*, *Calluna vulgaris* and *Erica tetralix*. Unusually here, bryophytes are dominated by *Fissidens* sp. with *Calliergon* sp., *Campylium stellatum*, *Scorpidium scorpioides*, *Drepanocladus* sp., *Scapania* sp., *Bryum pseudotriquetrum* and *Sphagnum denticulatum*. This flush continues downslope to road at 40847 54999. As this flush is in close proximity to the proposed track it is recommended that disturbance to the flush is avoided. [KP]

285. 40955 58593 Small bog pool, on proposed track line, which is vegetated by aquatic *Sphagnum cuspidatum* in association with small area of M17a/c to 40961 58563 where there is a further pool. It is recommended that the track line be moved slightly either east or west to avoid these standing water habitats. [KP]

286. 40988 58453 Location of turbine number 88. Extensive erosion and associated bare peat along ridge of Mid Kame. Rate of eroding peat appears greater than subsequent re-vegetation. In parts the peat erosion is complete, leaving exposed gravel substrate, which in parts has become colonised by *Juncus squarrosus* and/or *Calluna vulgaris* (U6d/M15d). Remaining peat blocks are mainly present towards the break of slope meaning that the proposed track route is predominantly through bare peat or vegetation associated with shallow peat or mineral substrate. Photographs K8, K9 & K10. [KP]

287. 41033 57979 Location of turbine number 95. Extensive bare gravel and peat (M3) forming a mosaic with remaining peat blocks and areas which have become re-vegetated by *Juncus squarrosus* (U6d). Similar habitat to that described at turbine number 88. Photographs K11, K12, K13 & K14. [KP]

288. 41078 57497 Location of turbine number 107. Area of eroding peat bog which is mainly M3 and M19. Rate of erosion appears greater than that of re-vegetation. Photographs K15, K16 & K17. [KP]

289. 41056 56999 Location of turbine number 119 (photographs K18, K19, K20 & K21). Fairly intact blanket bog (M17a/b/M19) with some minimal erosion and re-vegetation. In some parts erosion rate is greater than re-vegetation and in others the opposite is occurring. Close to the proposed turbine location is a pool with *Juncus squarrosus*, *Sphagnum cuspidatum*, *Sphagnum denticulatum*, *Eriophorum vaginatum* and *Calluna vulgaris* re-vegetating ground that is assumed to have been previously bare peat (photograph K22). This ridge is currently heavily impacted by sheep grazing with high quantities of dung within the shelter of hags in particular and frequent hoof prints/poaching. [KP]

290. 40964 58164 Shallow pool (17m x 10m in size) which is approximately 45m from proposed track and vegetated by aquatic *Sphagnum denticulatum* around its margins. Banks on 3 sides are of abundant *Juncus squarrosus* and associated sphagnum which appears to be increasing. This combination provides support and rigidity to the bank structure. The remaining side is of eroding bare peat. Photograph K23. [KP]

291. 40932 58936 Location of turbine number 81 (photographs K24, K25 & K26). Area of relatively intact M17a blanket bog (*Eriophorum vaginatum*, *Calluna vulgaris*, *Sphagnum papillosum*, *Sphagnum capillifolium*) with scattered *Juncus squarrosus* where it becomes transitional to the M17c sub-community. These fairly wet blanket bog communities form a mosaic with M19 over this area. Hags and associated erosion are present along the ridge to the North and South of here. There are also small bog-pools to the South and West of here. [KP]

292. 40902 59427 Location of turbine number 74. Bare peat with locally frequent *Eriophorum angustifolium* scattered over the surface and forming a mosaic in general with bare gravel, *Juncus squarrosus* dominated acid grassland (U6d) and wet heath, all of which are interspersed with remaining small peat blocks. This polygon in general is re-vegetating (U6/M15) through the centre where past erosion has resulted in minimal depths of peat remaining and eroding at the margins towards the break of slope (M19/M3). Photographs K27, K28 & K29. [KP]

293. 40853 59913 Location of turbine number 69 (photographs K30, K31 & K32). Fairly intact/active blanket bog (M19) over marginal ground between eroding ridge top vegetation and slopes to the East. [KP]

294. 40750 60129 Area of eroding and eroded bare ground with some colonisation of peat by *Eriophorum angustifolium* (M3) and bare ground by *Juncus squarrosus* (U6d). Move track away from more fragile eroding blanket bog margins to pass though centre of bare ground. Photograph K33. [KP]

295. 40491 60643 Peaty flush vegetated by *Potamogeton polygonifolius*, *Trichophorum cespitosum*, *Juncus bulbosus*, *Juncus squarrosus*, *Carex viridula* ssp. *oedocarpa*, *Carex panicea*, *Narthecium ossifragum*, *Pinguicula vulgaris* and *Sphagnum denticulatum*. Flushes are frequent in general through wet and dry heath which occurs between acid grassland on the steeper slopes above and blanket bog on the flatter ground below. Constant species include *Potamogeton polygonifolius*, *Carex viridula* ssp. *oedocarpa* and *Pinguicula vulgaris*. Through adjacent wet heath there is also some *Thalictrum alpinum* and *Succisa pratensis*. [KP]

296. 40485 60694 Heath vegetation (H10) on these lower slopes is relatively quite species rich. Species present and noted at the time of survey include *Calluna vulgaris*, *Juncus squarrosus*, *Thalictrum alpinum*, *Potentilla erecta*, *Selaginella selaginoides*, *Polygala serpyllifolia*, *Carex panicea*, *Carex nigra*, *Pleurozium schreberi*, *Hylocomium splendens*, *Viola riviniana*, *Leontodon autumnalis*, *Leontodon autumnalis*, *Galium saxatile*, *Rhytidiadelphus loreus* and *Anthoxanthum odoratum*. [KP]

297. 40768 60385 Location of turbine number 65. Habitat here is between severely eroded bare ground and a mosaic of M17/M3 which is hagged and eroding. If possible micro-site turbine slightly to the west in centre of bare peat. Photographs K34, K35 & K36. [KP]

298. 37682 50950 Slopes here are very uniform and heavily grazed area of acid grassland conforming to U6 and composed of abundant *Juncus squarrosus* with *Nardus stricta*, *Anthoxanthum odoratum*, *Agrostis canina*, *Galium saxatile*, *Luzula campestris*, and *Cladonia uncialis*, *Polytrichum commune*, *Mnium hornum*, *Hylocomium splendens* and *Dicranum scoparium*. There are also small clumps less than 50cm across, of heavily browsed *Calluna vulgaris* scattered about indicating former dwarf shrub heath. Also, mainly higher up the slope, there is an occasional patch of modified M19 blanket bog which is very grassy but still has visually prominent tussocks of *Eriophorum vaginatum*. [TR]

299. 37635 51495 Spring above M6c flush has abundant *Pseudobryum cinclinatum* in a lush wet carpet (Photograph K90, K91, K92). Also growing here are *Cardamine pratensis*, *Carex nigra*, *Montia fontana* and *Calliergonella cuspidata*. [TR]

300. 37351 52817 Turbine 167 situated on blanket bog with frequent but not severe erosion (A4) so mainly intact but with bare peat channels 50-200cm across. The blanket bog is mainly the drier M17b with *Calluna vulgaris*, abundant *Racomitrium lanuginosum*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Trichophorum cespitosum* and *Hypnum jutlandicum*. Photograph K93-K96 [TR]

301. 37556 52564 Track here crosses a water-holding saddle with wet hollows/pools supporting *Sphagnum cuspidatum* (M1) *Sphagnum capillifolium* and *Sphagnum papillosum* carpets (M17a) U6a *Juncus squarrosus* acid grassland and fragments of drier deep peat M17b blanket bog. [TR]

302. 37815 52758 Turbine 168 located on a large, intact and active area of blanket bog with extensive *Sphagnum capillifolium* and *Sphagnum papillosum*. There is also abundant *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Calluna vulgaris* with sparser *Empetrum nigrum*, *Trichophorum cespitosum* and in the moss layer *Cladonia portentosa*, *Pleurozia purpurea* and *Scapania gracilis*. Some parts have more hypnoid mosses (mainly *Rhytidiadelphus loreus* and *Hylocomium splendens*) like M19 and there is also some drier M17b blanket bog, especially where hagged, marked out abundant *Racomitrium lanuginosum* cover. Hags are generally infrequent and low, up to 1m. On slope above there is firmer but just as intact M19 in good natural condition. The track north and south of this turbine also runs over intact blanket bog (A5). Photograph K97-100 [TR]

303. 38015 53127 Track runs over an area with large intact blocks of blanket bog broken by frequent large hags to around 2m high and several metres across. [TR]

304. 37904 53626 Turbine 165 and access track will adversely affect an area of largely intact and active blanket bog which is mainly M17a and M17b. There is an area of more eroded bog (A3) to the west and south consisting of the drier M17b type and bare peat (M3). Re-locate turbine and track to minimise impacts. Photograph K101-K104 [TR]

305. 37485 53782 Turbine 161 Located on more or less intact blanket bog but with frequent areas of bare peat up to about 2m wide and with hags 1m high. This is mainly M17b with a high cover of *Racomitrium lanuginosum* with *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Calluna vulgaris*. There are patches with more *Sphagnum capillifolium* and *Sphagnum papillosum* (M17a) but these are not extensive. Photograph K105-K108 [TR]

306. 36856 54185 Turbine 159 located on blanket bog with widespread but small-scale erosion where bare peat channels are usually less than 1m wide and less than 50cm deep. The vegetation is mainly the drier M17b type with abundant *Racomitrium lanuginosum* along with *Calluna vulgaris*, *Eriophorum vaginatum*, *Trichophorum cespitosum* and *Eriophorum angustifolium* as the main dominants and scattered *Cladonia portentosa*, *Dicranum scoparium*, *Hypnum jutlandicum* and some sparse *Erica tetralix*. There is a little patchy *Sphagnum capillifolium* but no great extents. The vegetation is heavily grazed and trampled and occasional M1 hollows with *Sphagnum cuspidatum* are in poor condition. There are patches of M17a where *Sphagnum papillosum* and *Sphagnum capillifolium* are more extensive on waterlogged peat surfaces. Photograph K109-112 [TR]

307. 36870 54645 Turbine 157 located on partly eroding blanket bog with bare peat channels generally less than 1m wide but also with some older deeper hags 1-2m high and with acid grassland and heath in the hag bottoms (U6, M15d). The blanket bog is mainly the drier M17b with abundant *Racomitrium lanuginosum*. There is some *Sphagnum* but it is heavily trampled and struggling Photograph K113-K116 [TR]

308. 36789 55358 Turbine 155 located on blanket bog mainly of the drier M17b type (*Calluna vulgaris*, *Eriophorum vaginatum*, *Racomitrium lanuginosum*, *Eriophorum angustifolium*) which has frequent bare peat channels less than 1m wide and 50cm deep. Some hollows are vegetated with active *Sphagnum cuspidatum* and *Sphagnum papillosum* but they are not in good condition due to heavy grazing and trampling. Much of the track to the south of here goes over more intact blanket bog with extensive *Sphagnum* in places. Photograph K117-K120 [TR]

309. 37260 55273 Turbine 151 located on the boundary between intact (A5) blanket bog to the south-east and more fragmented blanket bog (A3-A4) to the north and west. The eroded bog fragments are mainly drier M17b and the intact bog to SE has more extensive *Sphagnum capillifolium* and *Sphagnum papillosum* (M17a) on the wetter peat surfaces and there is also the occasional hollow with *Sphagnum cuspidatum* (M1). Photograph K121-124 [TR]

310. 37335 56341 Turbine 134 located on partially eroded blanket bog and consisting of deep peat blocks several metres across and bare peat covering areas of several metres. Hags are generally less than a metre high and there is some vegetation in the hag bottoms resembling acid heath and grassland (M15d, U6). Photograph K125-K128 [TR]

311. 37598 55963 Turbine 149 located within intact blanket bog which is mainly the drier M17b type. This is close to an area of blanket bog that is more fragmented and bare peat areas up to 2m across and with hags up to 1.5m high. Photograph K129-K132 [TR]

312. 37163 55852 Turbine 144 located blanket bog of M17b. Hollows have virtually no *Sphagnum* and consisting of bare peat channels up to 1m wide, which are heavily trampled. *Sphagnum capillifolium* occurs as patchy carpets but these are not usually extensive and well-developed enough to call M17a. Photograph K133-K136 [TR]

313. 36869 55174 Turbine 142 on intact (A5) blanket bog with only small-scale erosion channels which are quite sparse. There is U4 grassland nearby. Mainly M17b with patchy *Sphagnum capillifolium* and *Sphagnum cuspidatum* in hollows but these are well trampled. Photograph K137-K140. [TR]

314. 40001 55011 Blanket bog here is very rich in species due to soligenous influences. There can be abundant *Sphagnum papillosum* and other species not normally found in grazed blanket bog such as *Carex dioica*, *Plantago lanceolata*, *Festuca rubra* and *Equisetum palustre*. [TR]

315. 40098 55253 Track runs through intact A5 blanket bog. Not easily classed. There is no *Sphagnum papillosum* but extensive *Sphagnum capillifolium* and no *Racomitrium lanuginosum*. *Erica tetralix* seems to be more predominant than usual for bog in this area and there is also a high cover of *Eriophorum angustifolium* along with *Eriophorum vaginatum*, *Trichophorum cespitosum*, *Narthecium ossifragum*, *Calluna vulgaris* and *Cladonia portentosa*. [TR]

316. 39833 56117 There is deep peat here but blanket bog is very grassy due to history of heavy grazing. There is also less and heavily trampled *Sphagnum*. Amongst the grasses *Anthoxanthum odoratum* is of high cover. (M17c and grassy M19) [TR]

317. 40148 55038 Vegetated islands and banks of burn have *Primula vulgaris*, *Cardamine pratensis*, *Anthoxanthum odoratum*, *Plantago lanceolata*, *Euphrasia officinalis*, *Trifolium repens*, *Carex nigra*, *Caltha palustris*, *Bellis perennis* and the stream bed has the moss *Fontinalis antipyretica*. [TR]

318. 39492 56743 Turbine 122 on very intact, extensive and active blanket bog which has carpets of *Sphagnum papillosum* and *Sphagnum capillifolium* on wetter peat surfaces and the drier M17b and M19 types where the peat surface is drier and drained. Bare peat is virtually absent. Photograph K141-K144 [TR]

319. 39167 56732 Very wet area of blanket bog with pools. Track runs close to this and maybe re-locate further away so as to avoid any damaging effects. [TR]

320. 38995 56343 Turbine 132 located on eroded blanket bog with remaining fragments of deep peat 10s of metres across- this is largely M17b and M19. Shallow peat between these blocks had acid grassland and heath (U6 and

M15d). There is also bare peat and stony substrate it is not that extensive. Photograph K145-K148 [TR]

321. 39802 57098 This is on deep peat but is so modified that it has been classed as H12a. There is virtually no *Eriophorum vaginatum* or *Eriophorum angustifolium* and *Calluna vulgaris* is the dominant vascular species. Amongst this there is sparse *Vaccinium myrtillus*, *Potentilla erecta*, *Anthoxanthum odoratum* and *Deschampsia flexuosa*. The moss layer is made up of much *Hylocomium splendens* with *Rhytidiadelphus loreus*. There are also patches of *Juncus squarrosus* grassland and *Festuca ovina*/*Festuca vivipara* grassland (U6 and U4). [TR]

322. 39546 57210 Turbine 111 on very intact blanket bog which is active (A5). M19 (*Calluna vulgaris*, *Eriophorum vaginatum*, *Vaccinium myrtillus*, *Hylocomium splendens*, *Rhytidiadelphus loreus*), M17a (*Sphagnum papillosum*, *Eriophorum vaginatum*, *Calluna vulgaris*, *Sphagnum papillosum*, *Empetrum nigrum*) and M17b (*Racomitrium lanuginosum*) all occur and intergrade. Bare peat and shallow peat are only occasional here in small patches. Photograph K149-K152. [TR]

323. 39107 57314 Turbine 110 located on relatively intact blanket bog with occasional bare and shallow peat. Carpets of abundant *Sphagnum papillosum* and *Sphagnum capillifolium* indicate the active nature here and there is also plentiful *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Calluna vulgaris*, *Juncus squarrosus* and *Cladonia portentosa*. Wetter hollows support standing water and *Sphagnum cuspidatum*. Photograph K153-K156. [TR]

324. 38955 56848 Turbine 121 on intact blanket bog with some localised erosion but overall this has been classed A5 as any hag bottoms are pretty well-vegetated. M19 and M17 types occur with extensive *Sphagnum papillosum* and *Sphagnum capillifolium* (M17a) on flatter more waterlogged peat surfaces and M17b where the surface is much drier. This turbine could be re-located to more fragmented and less active blanket bog to the east. Photograph K157-K160. [TR]

325. 39383 56208 Turbine 136 – track to this turbine runs along a ridge of fragmented blanket bog. Turbine at end of ridge borders on more intact blanket bog with extensive M17a *Sphagnum papillosum*/*Sphagnum capillifolium* along with M17b and M19. Photograph K161-K164. [TR]

326. 39191 62052 Blanket bog on this side of the fence is transitional towards grassland (*Eriophorum vaginatum* A, *Rhytidiadelphus loreus* A, *Anthoxanthum odoratum* F, *Galium saxatile* F, *Eriophorum angustifolium* F). *Calluna vulgaris* and *Erica tetralix* are absent from the sward. There are high quantities of sheep dung. Photograph K37. [KP]

327. 39076 61741 Large area of grassland (modified bog) which is over deep peat. *Anthoxanthum odoratum* dominates with frequent *Trifolium repens* and occasional *Cerastium fontanum*, *Cardamine pratensis*, *Viola riviniana*, *Luzula*

campestris, *Carex nigra* and *Cirsium palustre*. *Rhytidiadelphus loreus* is locally abundant. Fragments of degraded M19/M20 are scattered across the area with some *Calluna vulgaris* at very low cover in parts. [KP]

328. 39128 61570 M30 soakway/flush dominated by *Potamogeton polygonifolius* with *Ranunculus flammula*, *Myosotis scorpioides*, *Cardamine pratensis* and *Calliergon cuspidatum*. [KP]

329. 38119 57909 Small M10 flush (*Carex viridula* ssp. *oedocarpa*, *Narthecium ossifragum*, *Trichophorum cespitosum*, *Sphagnum denticulatum*, *Campylopus atrovirens*, *Carex panicea*, *Potamogeton polygonifolius*, *Ranunculus flammula*). [KP]

330. 38301 58565 Turbine location number 82 within area of mainly blanket bog interspersed with fragments of acid grassland and wet heath. Blanket bog is more-or-less intact (photographs K38, K39, K40). Upslope from here there are frequent exposed rocks and associated shallower peat around which fragments of M15c occur. [KP]

331. 38309 57785 Turbine location number 99 with area of fairly intact M19. There is some small-scale hagging immediately upslope (North-east). Photographs K41, K42 & K43. [KP]

332. 39028 61325 M30/M1 soakway/pool (*Sphagnum denticulatum*, *Potamogeton polygonifolius*, *Equisetum palustre*, *Sphagnum cuspidatum*, *Eriophorum angustifolium*, *Carex nigra*). [KP]

333. 38928 61176 Through this polygon vegetation is frequently over shallow peat/mineral soil with exposed gravel etc. Vegetation which is mapped as H10b and M15c here tend to be very similar and frequently transitional between the two. M15c, however, tends to have at least some *Trichophorum cespitosum* and *Eriophorum angustifolium* in addition to occasional *Sphagnum* spp. whereas the drier H10b does not (photograph K44). [KP]

334. 38933 60993 Scattered stony flushes (mainly M10 although transitional to M6bii and M30 in parts) with *Carex viridula* ssp. *oedocarpa*, *Carex panicea*, *Trichophorum cespitosum*, *Narthecium ossifragum*, *Nardus stricta*, *Eriophorum angustifolium* and *Potamogeton polygonifolius*. [KP]

335. 39016 60804 Scattered *Salix herbacea* through H10b (*Calluna vulgaris* F, *Erica cinerea* F, *Racomitrium lanuginosum* A, *Cladonia uncialis* O, *Juncus squarrosus*, *Agrostis canina*, *Festuca vivipara*, *Carex bigelowii*) which is transitional towards more alpine heath (i.e. H14). Over these slopes habitats of shallow soils are very similar and often differentiated by one or two species. Photographs K45 & K46. [KP]

336. 39012 60642 Stony species-poor M10 flush (*Carex viridula* ssp. *oedocarpa*, *Carex panicea*, *Nardus stricta*, *Juncus squarrosus*). Mainly bare ground/gravel/rock. There are frequent similar flushes scattered over this area.

Adjacent to the flush acid grassland has scattered *Thalictrum alpinum* and *Breutelia chrysocoma* indicating some base-enrichment. [KP]

337. 40932 60794 Eroding peat hags (M17b/M3). Lower lying ground between the hags which has been eroded/slipped in the past has become re-vegetated by *Juncus squarrosus*, *Calluna vulgaris*, *Sphagnum* spp. occurring in fine-grained mosaic (U6d/U6a/M15d). Current rate of erosion appears ≥ re-vegetation (photograph K47). [KP]

338. 40775 60883 Turbine location number 60 in hollow of M17a/M6bii. Blanket bog is intact/active A5 with acid flushes through it. Erosion is minimal, with high rates of re-vegetation where it does occur. Track/turbine move. Photographs K48, K49 & K50. M30 soakways nearby with *Potamogeton polygonifolius*, *Carex panicea*, *Carex viridula* ssp. *oedocarpa*, *Sphagnum denticulatum*, *Narthecium ossifragum* and *Eriophorum angustifolium*. These are frequent and transitional to M6bii with *Carex echinata*, *Sphagnum denticulatum*, *Potamogeton polygonifolius*, *Carex nigra*, *Juncus bulbosus*, *Eriophorum angustifolium* etc. [KP]

339. 40657 60823 Large stony M10 flush within mainly M19 (photograph K51). [KP]

340. 39290 57498 Blanket bog communities over this hilltop are generally fairly typical (M17/M19) although occasionally occurring over <0.5m peat. Approximately 10% of vegetation appears to be over shallower peats although difficult to assess. [KP]

341. 39211 57494 Fragments of wind-clipped summit heath (H14) over more exposed areas of ground which is dominated by a fairly even mix of *Calluna vulgaris*, *Racomitrium lanuginosum* and *Juncus squarrosus*. Occasional through the vegetation are the sub-shrubs *Vaccinium myrtillus*, *Empetrum nigrum* and, undocumented for this community, *Salix herbacea* and *Vaccinium vitis-idaea*. Lower plants are represented by a mix of *Hylocomium splendens*, *Sphagnum capillifolium*, *Hypnum jutlandicum* and *Cladonia arbuscula*. *Listera cordata* is also frequent through this vegetation. Photographs K52 & K53. [KP]

342. 38984 57401 Tall-herb ledges outwith survey area which were noted because of there rare occurrence of the area. *Salix herbacea* F, *Luzula sylvatica* A, *Rumex acetosa* O, *Drypoteris dilatata* O, *Cerastium fontanum* O, *Vaccinium myrtillus* O, *Rhytidiadelphus loreus* F, *Plagiothecium undulatum* O, *Hymenophyllum wilsonii* O, *Dicranum scoparium* O. Photographs K54, K55, K56 & K57. [KP]

343. 39159 57575 Ridge of rock outcrop with some fragments of tall herb vegetation (photograph K58). A wide range of species occur over this small habitat which is at least partially grazed: *Deschampsia flexuosa*, *Luzula sylvatica*, *Empetrum nigrum*, *Anthoxanthum odoratum*, *Vaccinium myrtillus*, *Viola riviniana*, *Salix herbacea*, *Drypoteris dilatata*, *Potentilla erecta*, *Carex binervis*, *Carex echinata*, *Agrostis stolonifera*, *Carex bigelowii*, *Euphrasia officinalis*, *Selaginella selaginoides*, *Diplophyllum albicans*, *Dicranum scoparium*, *Sphagnum capillifolium*, *Sphagnum palustre*, *Sphagnum papillosum*, *Campylopus atrovirens*, *Ctenidium molluscum*, *Scapania gracilis*, *Drepanocladus revolvens*,

Hymenophyllum wilsonii. Photograph K58. Immediately adjacent to this outcrop are a sequence of M10 flushes. [KP]

344. 39179 57674 Scattered rocky outcrops in close proximity to one another. These support a mixture of *Salix herbacea*, *Polypodium vulgare*, *Poa alpina*, *Hymenophyllum wilsonii*, *Polytrichum commune*, *Festuca vivipara*, *Deschampsia flexuosa*, *Nardus stricta*, *Rhytidiadelphus loreus*, *Galium saxatile*, *Luzula sylvatica*, *Agrostis capillaris* and *Drypoteris dilatata*. Photographs K59, K60 & K61. [KP]

345. 38898 57768 Very wet valley mire (M17a) with central stand of *Carex rostrata* over *Sphagnum denticulatum* (M4) with scattered *Narthecium ossifragum* and much standing water. [KP]

346. 38759 57856 Location of turbine number 98 within mainly intact M17b/a with some minimal erosion. There is scattered *Erica cinerea* through edges of M17b. Eroding edges give way to re-vegetating shallow gullies with abundant *Sphagnum papillosum* and *Eriophorum angustifolium* in addition to scattered *Narthecium ossifragum*, *Erica cinerea*, *Erica tetralix*, *Sphagnum cuspidatum*, *Trichophorum cespitosum* and *Drosera rotundifolia*. Photographs K62, K63 & K64. [KP]

347. 38564 58231 Area of M17b with some erosion (M3) and obvious trampling by sheep through bare peat. To North and West are areas of intact bog. Photographs K68, K69 & K70. [KP]

348. 39404 58005 Location of turbine number 91 within expanse of intact M19. Minimal localised erosion. Photographs K65, K66 & K67. [KP]

349. 39058 58288 Turbine number 98 within mosaic of deep peat and shallow peat vegetation. M19 is interspersed with M17 and M15d. There are also some patches of summit heath (H14) which is transitional towards wet heath (M15). Of equal abundance are *Juncus squarrosus*, *Calluna vulgaris*, *Racomitrium lanuginosum* and *Sphagnum capillifolium*. There is also scattered *Empetrum nigrum*, *Eriophorum angustifolium*, *Cladonia portentosa* and *Vaccinium myrtillus*. Photographs K71, K72 & K73. [KP]

350. 39040 58318 Small pools through intact bog (photograph K74). [KP]

351. 38868 58557 Large pool which has been partly drained is mainly vegetated by *Sphagnum* spp, *Juncus squarrosus* and *Eriophorum angustifolium*. [KP]

352. 38968 58745 Proposed track route here corresponds to line of watercourse through bog with associated linear hag system (photographs K75 & K76). [KP]

353. 38877 58772 Location of turbine number 83 is a mosaic of wind-clipped heath (H14) and M15d with M17 at the edge of the main area of blanket bog. Vegetation is partially fragmented by exposed rocks where there is some water movement across these shallow peats. Photographs K77, K78, K79 & K80. [KP]

354. 38728 58600 Scattered larger bog pools with *Sphagnum cuspidatum* and *Eriophorum angustifolium* within area of intact blanket bog. [KP]

355. 39183 59087 Tall herb/fern community with *Luzula sylvatica* A, *Drypoteris dilatata* A, *Anthoxanthum odoratum* F, *Deschampsia flexuosa* F, *Galium saxatile* F, *Potentilla erecta* F, *Vaccinium myrtillus* F and *Rhytidiadelphus loreus* O (photograph K81). [KP]

356. 39176 59197 *Potamogeton polygonifolius* soakway (M30) with frequent *Juncus bulbosus*, *Sphagnum denticulatum* and *Callitriche* sp. [KP]

357. 39203 59667 Location of turbine number 72 within wide expanse of semi-intact blanket bog. Any hags present are generally small. Photographs K82 & K83. [KP]

358. 39197 60332 Over this flat area of mire with frequent peat hags there is also a high level of re-vegetation (*Eriophorum angustifolium*, *Sphagnum cuspidatum*, *Juncus squarrosus*) within hollows. Erosion appears to be at an equal rate to re-vegetation. [KP]

359. 39380 59222 Location of turbine number 78 at edge of fragmented blanket bog (to North and West). Over this area the peat depth varies between 0 and >1m. To the south there are more frequent areas of exposed bedrock and mineral substrate. Photographs K84, K85 & K86. [KP]

360. 39332 58727 Location of turbine number 85 within wider area of fairly intact blanket bog (M17a/M19). Areas of erosion tend to be localised over this area. Photographs K87, K88 & K89. [KP]

361. 38467 56263 Borrow pit area. Lower slopes have some rock outcrops from which moss samples were gathered to check. Maybe base enrichment here as there are also M10a flushes in this area which appear to be richer than usual (see quadrat at same location). Also found here *Vaccinium uliginosum* not seen elsewhere on survey. [TR}

362. 38660 57343 xxxxxxxxx

363. 38863 57318 Steep slopes with heath that is quite difficult to classify in NVC terms. It has been classed as H12c due to combination of *Calluna vulgaris, Vaccinium myrtillus* and grasses. Species present: *Calluna vulgaris*, *Juncus squarrosus*, *Luzula multiflora*, *Nardus stricta*, *Carex echinata*, *Potentilla erecta*, *Vaccinium vitis-idaea*, *Vaccinium myrtillus*, *Anthoxanthum odoratum*, *Empetrum nigrum*, *Festuca vivipara*, *Galium saxatile*, *Sphagnum papillosum*, *Sphagnum capillifolium*, *Rhytidiadelphus loreus*.

364. 38634 57106 Turbine 118 is situated close to some quite isolated M1 pools and could be re-situated to avoid these. Overall the blanket bog here is intact with localised hags and falls within M17 and M19 NVC types. K165-K168[TR]

365. 38500 56616 Turbine 129 located on a small area of A3 eroding bog with remaining deep peat blocks up to 20m across. This is M17a and M19 and bare peat (M3) and substrate. Overall area is active blanket bog approx. 70% cover. K169-K172 [TR]

366. 38780 56442 This location marks the edge of a large very wet area, lying mainly to the north, which supports much M17a waterlogged blanket bog with wet hollows and pools (M1). Typical species *Sphagnum papillosum*, *Sphagnum capillifolium*, *Sphagnum cuspidatum* and *Sphagnum denticulatum* are all prominent in continuous carpets over much of the surface. [TR]

367. 38014 54505 Blanket bog is predominantly of the M19 type here with prominent tussocks of *Eriophorum vaginatum* visually dominating along with *Calluna vulgaris*. The area also has a network of M6 acid flushes running into the south-east part of Maa Water (*Sphagnum palustre* particularly high cover in these). [TR]

368. 37743 54480 Here the track runs through an area of eroded bog which also has a large amount of re-vegetating and active blanket bog in the hag bottoms and is therefore considered of some value. There is much very wet ground supporting M17a and M1 with extensive *Sphagnum*. Care should be taken to avoid the wetter parts here and to route track through the least vegetated parts. K173 [TR]

369. 38013 54131 Turbine 155 located on intact blanket bog. Good condition M17b with *Calluna vulgaris*, *Eriophorum vaginatum*, *Trichophorum cespitosum*, *Narthecium ossifragum*, *Eriophorum angustifolium*, *Racomitrium lanuginosum*, *Cladonia portentosa* and patchy *Sphagnum capillifolium*. There is also M17a with increased amounts of *Sphagnum capillifolium* and also *Sphagnum papillosum* with less *Racomitrium lanuginosum* K174-K177 [TR]

370. 37198 53991 Fenceline between different grazing levels. Heavy on the west side with eroding peat hags to 1m high covering approx.20% of the area. To the east bare peat is virtually absent. K178-K182 [TR]

371. 37314 54201 Turbine 160 located on intact, uniform, good condition blanket bog. This is mainly M17a to the north and west and M17a/M17b/M19 to the south and east. K183-K186 [TR]

372. Turbine 156 on intact blanket bog, mainly M17b with depressions with M17a and wet pools/hollows (M1) K187-K190 [TR]

373. 38095 54766 Turbine 154 - Intact blanket bog with extensive *Sphagnum capillifolium* and *Sphagnum papillosum* (M17a) – also *Calluna vulgaris*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Eriophorum vaginatum*, *Narthecium ossifragum*, *Drosera rotundifolia*, *Cladonia portentosa*. There is also M17b and M19, more so on the slopes above to the east. Areas of shallower peat with rock outcrops 20m to the NE might be more suitable. K191-K194 [TR]

374. 38205 55738 Turbine 153 on area of intact blanket bog within hummocky mounds which support shallower peat with H10b dry heath. K195-K199 [TR]

375. 38656 55671 Turbine 146 on intact blanket which is variable between M17a, M17b and M19 NVC types. There is some patchy U6 d acid grassland and M15b and H10c on shallower peat over nearby rock outcrops. K200-K203 [TR]

NVC Target Notes

Nesting

1. 42324 54889 M10 flush within blanket bog. *Carex panicea*, *Carex viridula ssp. oedocarpa*, *Calluna vulgaris*, *Thalictrum alpinum*, *Pinguicula vulgaris*, *Potentilla erecta*, *Plantago maritima*, *Eriophorum angustifolium*, *Erica tetralix*, *Prunella vulgaris*, *Ctenidium molluscum*, *Campylium stellatum*, *Scorpidium scorpioides*, *Selaginella selaginoides*, *Carex dioica*, *Nardus stricta*. Many such flushes in the area so try and avoid damage here. [TR]

2. 42337 55572 Line of track runs through intact blanket bog which has a less intact and less active bog to the east of here (photograph N84). [TR]

3. 42384 55791 Eroded blanket bog to west, intact to the east. Route track through the more eroded bog approx.20m to the west. (photograph N85 looking north)

4. 42458 55791 Turbine 138 location approx. 70% blanket bog 30% bare or shallow peat or substrate with M3 and U6 grassland. Photograph N86-N89 [TR]

5. 44225 56000 Turbine location has M17 and M19 blanket bog with frequent M10 flushes on bare stony ground and shallow peat (*Scorpidium scorpioides*, *Scorpidium revolvens*, *Campylium stellatum*, *Carex viridula ssp. oedocarpa*, *Carex panicea*, *Thalictrum alpinum*, *Calluna vulgaris*). On shallow peat there is some M15b wet heath. Photograph N90-N92. [TR]

6. 44528 56906 Summit heath similar to H10b consisting of dominant *Calluna vulgaris* with abundant *Racomitrium lanuginosum* and *Juncus squarrosus*, *Cladonia portentosa*, *Hypnum jutlandicum*, *Empetrum nigrum*. Photograph N93-N95. [TR]

7. 44513 55631 Turbine 143 Mainly M17b with high cover of *Racomitrium lanuginosum*, *Cladonia portentosa* and *Eriophorum vaginatum* with *Eriophorum angustifolium*, *Calluna vulgaris*, *Sphagnum capillifolium* and *Hypnum jutlandicum*. Erosion is quite sparse and small-scale. There is an occasional M1 hollow and M10 flush on where peat has eroded to substrate. Photograph N96-N99. [TR]

8. 44651 55822 Wetter area in depression with a good amount of M17a blanket bog and M30 soakways and wet hollows. The blanket bog has extensive *Sphagnum papillosum* and *Sphagnum capillifolium* and is therefore active.

Aulacomnium palustre, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Carex panicea* and *Viola palustris* also occur. The soakways, classed as M30, consist of *Potamogeton polygonifolius*, *Sphagnum denticulatum*, *Carex rostrata* and *Menyanthes trifoliata*. The track goes right across this good condition bog. Photograph N100-N101. [TR]

9. 44819 55976 Track crosses a channel, the steep banks of which support wet and dry dwarf shrub heath (H10a, H21a, M15) with a dominant *Calluna vulgaris* and constant *Hylocomium splendens*, *Rhytidiadelphus loreus*. There is sparse *Eriophorum angustifolium* and *Eriophorum vaginatum* and there are also areas with extensive *Sphagnum capillifolium* (H21a). Patchy acid grassland (U4). Photograph N102. [TR]

10. 44870 55981 Track here crosses a nice wet soakway (M30, M17a, M1) with abundant *Potamogeton polygonifolius*, *Juncus bulbosus*, *Eriophorum angustifolium*, *Carex nigra*, *Sphagnum denticulatum* and *Sphagnum papillosum*. Photograph N103-N104. [TR]

11. 45048 55790 Turbine 140 is right on top of remains of some old dwelling or walls (check archaeology?) Most of the area here is intact M17 or M19 blanket bog with grassier areas of U4 and basic flushing (M10a with *Carex panicea*, *Carex viridula ssp. oedocarpa* and the moss *Scorpidium revolvens*. N105-N108 [TR]

12. 44750 56138 Turbine 131 is very close to a band of wetter blanket bog with acid and basic flushing (M30, M17a, M10a). Species noted: *Scorpidium scorpioides*, *Pinguicula vulgaris*, *Juncus bulbosus*, *Potamogeton polygonifolius*). This might be avoidable. N109-N112[TR]

13. 44812 56644 Turbine 148 located on good intact blanket bog with nice wet M1 pools/hollows. This could be shifted further to the west onto lower slopes which are mainly drier and more robust M19 blanket bog. The whole track to the north of here also runs through similar more waterlogged ground with more sensitive blanket bog types (M1, M30, M17a) and the more robust M19 approx. 40m to the west. Track and turbine could be moved to minimise damage. Photograph N113-N116. [TR]

14. 44937 57039 Track here goes through the wetter ground and more sensitive communities with drier blanket bog (M19) to the west approx.50-100m, species noted: *Potamogeton polygonifolius*, abundant *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Carex rostrata* and *Menyanthes trifoliata*. Consider moving track to avoid. Photograph N117. [TR]

15. 44988 57143 Turbine 115 located on the edge of more intact blanket bog with wet areas (M17a, M19). The M19 is indicated by *Calluna vulgaris*, *Eriophorum vaginatum* and *Eriophorum angustifolium* with much *Hylocomium splendens* along with *Rhytidiadelphus loreus* and, in wetter parts *Sphagnum capillifolium* and *Sphagnum papillosum*. *Sphagnum* is more extensive here than usual in M19 and somewhat transitional to M17a. Photograph N118-N121. [TR]

16. 43560 55461 Turbine 150 located on eroding blanket bog with hags and much bare peat with little re-vegetation or any active build-up. The remaining bog is mainly M17b dominated by *Calluna vulgaris* and *Racomitrium lanuginosum* with *Cladonia portentosa*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Cladonia uncialis* and *Hypnum jutlandicum* with sparse *Trichophorum cespitosum*. Bare peat occupies about 30% of the ground over areas up to about 5m across. Photograph N122-N125. [TR]

17. 43677 55880 M10 flush here has *Carex viridula ssp. oedocarpa*, *Carex panicea*, *Thalictrum alpinum*, *Narthecium ossifragum*, *Trichophorum cespitosum*, *Plantago maritima*, *Pinguicula vulgaris*, *Ctenidium molluscum*, *Scorpidium revolvens*, *Racomitrium lanuginosum*, *Calluna vulgaris*, *Campylium stellatum*, *Scorpidium scorpioides*, *Erica tetralix*, *Potentilla erecta*, *Selaginella selaginoides*, *Eriophorum angustifolium*, *Potamogeton polygonifolius*, *Calliergonella cuspidata*, *Sphagnum denticulatum*. [TR]

18. 43722 55952 Turbine 139 M17b and M17a blanket bog with some M6 flushes,M3 bare peat and also a little basic flushing on stony substrate and very thin peat (M10) Photograph N126-N129. [TR]

19. 43303 56029 Turbine 137 is blanket bog with hags and 10% of area bare peat. The blanket bog is mainly dry M17b consisting of *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Hypnum jutlandicum*, *Sphagnum capillifolium* and *Racomitrium lanuginosum*. There are also areas much like M19 with more luxuriant *Hylocomium splendens*, *Rhytidiadelphus loreus* and *Pleurozium schreberi* hypnoid mosses and no *Racomitrium lanuginosum*. On thin peats in hag bottoms re-vegetation has taken place and there is U6 *Juncus squarrosus* grassland and M15b wet heath. Photograph N130-N133. [TR]

20. 43333 56343 A *Juncus squarrosus* “dam” on the track line is holding back peat from eroding (Photograph N134). [TR]

21. 43128 56603 The track runs along a boundary between an intact area of blanket bog (A4) and a much more eroded area (A3 M17/M3). Track should be moved here to over 30m west in order to minimise damage to better blanket bog. [TR]

22. 43202 56785 Turbine 123 located within an area of intact blanket bog (M17a, M17b, M19, M1,M3) when it could be moved to a more appropriate area of eroded blanket bog upslope to the west and also use less track length. Photographs N135-N138. [TR]

23. 43075 56831 This is the alternative location for turbine 123 saving an area of intact blanket bog. Photographs N139, N140. [TR]

24. 43059 56573 A pool here showing effect *Juncus squarrosus* build-up (U6a) has in holding back water and erosion. Track should avoid damage to such areas as this in micro-placement on lay-down. Photographs N141-N142. [TR]

25. 43649 56723 Turbine 127 on the edge of an area of very eroded (A1) former blanket bog with widespread bare peat. There is also stony substrate and a U4 type grassland (*Festuca ovina* or *Festuca vivipara*) and patches of *Juncus squarrosus* dominated grassland (U6). Turbine - photograph N143-N146. U4 grassland N147-N148 [TR]

26. 44052 57078 Turbine 112 and the track leading to it are badly located within an area of intact and active blanket bog surrounded by more eroded areas of bog. There are hags here but the bottoms waterlogged and there is much vegetation and active build-up of mire vegetation. Bare peat is also being colonised more vigorously by *Eriophorum angustifolium*. Photograph N149-N152. [TR]

27. 43955 57093 Very wet area with pool containing *Potamogeton polygonifolius* right by line of track. Try and avoid this area. Photograph N153-N154. [TR]

28. 46542 55709 Borrow pit area is largely acid grassland with some more heathy patches and also areas of rich flushing. The grassland conforms to U4a and U4b consisting of *Nardus stricta*, *Festuca rubra*, *Anthoxanthum odoratum*, *Juncus squarrosus*, sparse *Holcus lanatus*, *Potentilla erecta*, *Galium saxatile*, *Luzula campestris*, *Cardamine pratensis*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Dicranum scoparium*, *Mnium hornum*, *Frullania sp.* and *Polytrichum commune*. The flushed areas are rich with much vegetation just coming out-these areas should be re-checked for rarities later in the season. Noted species: *Trifolium repens*, *Caltha palustris*, *Eriophorum angustifolium*, *Montia fontana*, *Myosotis scorpioides*, *Cardamine pratensis*, *Calliergonella cuspidata*, *Eriophorum angustifolium*. Small patches of dry heath occur over rock with thin peat consisting of heavily grazed *Calluna vulgaris* with *Hylocomium splendens*, *Dicranum scoparium* and *Nardus stricta*. There is also U6a type grassland dominated by *Juncus squarrosus* with *Sphagnum capillifolium*. Photograph N155-N158. [TR]

29. 46480 55890 Numerous M10a flushes within heath here have *Schoenus nigricans*, *Carex viridula ssp. oedocarpa*, *Pinguicula vulgaris*, *Eriophorum angustifolium*, *Potamogeton polygonifolius*, *Scorpidium scorpioides*, *Campylium stellatum*, *Blindia acuta*, *Scorpidium revolvens* and *Eleocharis sp.* [TR]

30. 46285 56081 Typical uniform dry heath dominated by *Calluna vulgaris* but with neither *Vaccinium myrtillus* nor *Erica cinerea* and therefore difficult to assign an NVC community. Within the *Calluna vulgaris* is sparse but constant or frequent *Juncus squarrosus*, *Galium saxatile*, *Anthoxanthum odoratum*, *Agrostis capillaris* with a layer of mosses composed mainly *Hylocomium splendens*, *Rhytidiadelphus squarrosus*, *Dicranum scoparium*, *Polytrichum alpestre, Cladonia portentosa, Hypnum jutlandicum* and *Mnium hornum*. Very occasionally there is also some *Empetrum nigrum*. In places where *Racomitrium lanuginosum* becomes dominant in the bryophyte layer the heath resembles H10b. *Sphagnum capillifolium* is also patchy and the heath then resembles a wet heath, M15b. [TR]

31. 46366 56211 M1 pools in M15b heath right beside line of track. [TR]

32. 46009 56653 Turbine 130 is right on the edge of an area of intact and active blanket bog (M17a, M17b) with high covers of *Sphagnum* species. Move turbine so as not to affect this area. Photograph N159-N162. [TR]

33. 45887 56726 Heavily grazed U4 acid grassland, short turf with patchy *Calluna vulgaris* (H10c). There is also occasional acid and basic flushing (M6, M10). Grassland consists of *Nardus stricta*, *Luzula campestris*, *Plantago lanceolata*, *Juncus squarrosus*, *Prunella vulgaris*, *Carex panicea*, *Dicranum scoparium*, *Hylocomium splendens*, *Narthecium ossifragum* and *Potentilla erecta*. Also present in the sward here is *Thalictrum alpinum* which indicates some degree of base enrichment and a transition towards CG10. There are also flushed and spring areas (M32, M10a) with abundant *Philonotis fontana*, *Bryum pseudotriquetrum*, *Scorpidium revolvens*, *Calliergonella cuspidata* and *Scorpidium scorpioides*. [TR]

34. 46455 56374 Area within fence here is more active with M1 hollows of abundant *Sphagnum cuspidatum* and *Eriophorum angustifolium*. There is also much less bare peat so this has been upgraded from A2 to A3. [TR]

35. 46570 56487 The majority of the area is one of previous and some current erosion but generally the hag bottoms are well vegetated with U6, M1 and M15d and there is active build-up within the matrix. Some areas have more bare peat. Photograph N163-N165. [TR]

36. 45235 56755 Turbine 124 Located on more intact blanket bog with less intact, more eroded bog to the NE. Track does a 90 degree turn here whereas it could go straight, over more eroded bog and also be less long. There is extensive *Sphagnum capillifolium* and *Sphagnum papillosum* here (M17a photographs N170 & N171) with *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Calluna vulgaris*, *Trichophorum cespitosum*, patchy *Cladonia portentosa* and *Racomitrium lanuginosum*. *Sphagnum compactum* also occurs. Within 100m of turbine there are hags, some of which have waterlogged bottoms and are revegetating with M1 (*Sphagnum cuspidatum*, *Sphagnum denticulatum*) but there are also areas of bare peat. Broadly though this is A5 blanket bog. Photograph N166-N169 [TR]

37. 45084 56933 A wet area of low-lying ground over which the track line goes in places. There is patchy *Calliergonella cuspidata* and areas of wet peat supporting *Potamogeton polygonifolius*, *Carex panicea*, *Scorpidium scorpioides*. This is not easy to classify in NVC terms but is between M30 and M10. There are also patches of *Sphagnum papillosum* (M17a) with areas of standing water and bare peat. [TR]

38. 45263 56898 Blanket bog east of track here is less waterlogged with more bare peat and is the drier M17b type rather than M17a. [TR]

39. 45778 57012 Turbine 120 Eroded and eroding blanket bog (A2) with only fragments of M17b remaining up to 40cm across. There is also heath on shallow peat consisting of *Calluna vulgaris*, *Racomitrium lanuginosum*, *Empetrum nigrum*, *Hylocomium splendens* and *Hypnum jutlandicum* along with bare peat, stony substrate and U$ and U6 type acid grasslands. Photograph N172-N175. [TR]

40. 45597 57384 Turbine 108 This is on the boundary between very intact and active blanket bog (A5) to the west and much more eroded bog to the east with much more bare peat. Photograph N176-N179. [TR]

41. 46067 57272 Very badly eroding area with a large amount of bare peat and no re-vegetation. Photograph N180. [TR]

42. 46275 57114 Turbine 116 on the edge of intact M19 blanket bog and more eroding M17b/M3 blanket bog. Photograph N181-N184. [TR]

43. 42141 56220 Borrow pit area – most of these slopes have quite similar vegetation, varying between blanket bog and heath with a peat depth of 30-100cm but mainly over 50cm deep and classed mainly as blanket bog. In NVC most like M19 with much *Calluna vulgaris* and *Eriophorum vaginatum* with *Eriophorum angustifolium* and *Erica tetralix* visually dominant. The moss layer has abundant *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Hypnum jutlandicum*, *Cladonia portentosa* and *Diplophyllum albicans*. There is patchy bare peat which is trampled by sheep but the area is generally intact (A5) and some good cover of *Sphagnum capillifolium*. Occasionally the vegetation is more like M17b with abundant *Racomitrium lanuginosum* along with *Trichophorum cespitosum*, *Sphagnum capillifolium* and less of the M19 hypnoid mosses. Photograph N185-N186[TR]

44. 42692 55651 Turbine 145 located right on edge of intact blanket bog to the east. Should therefore be shifted west onto more fragmented and currently eroding blanket bog with much dry, bare peat supporting very little re-vegetation or active build-up. The intact blanket bog to east consists of M19 (*Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Hypnum jutlandicum*, *Sphagnum capillifolium*) with some areas of M17b (*Racomitrium lanuginosum*, *Cladonia portentosa*, *Calluna vulgaris*, *Eriophorum vaginatum*, less hypnoid mosses and more *Sphagnum capillifolium*). Where the *Sphagnum capillifolium* and *Sphagnum papillosum* is more extensive it could be classed as M17a. Photograph N187-N190. [TR]

45. 42824 55616 Track runs along the boundary between an area of wetter and more intact blanket bog to the west and more fragmented and eroded bog to the east. Therefore shift track to the east in order to minimise damage. Also to the north of here a bend in the track should also be shifted north to avoid this wetter valley mire. [TR]

46. 42874 55250 Turbine 152 Frequent erosion channels up to 1m wide but not very deep. Bare peat is heavily trampled and not re-vegetating (A4). Much M17b

consisting of *Racomitrium lanuginosum*, *Calluna vulgaris*, *Cladonia portentosa*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Huperzia selago*. Bare peat has some sparse *Eriophorum angustifolium* but it is grazed heavily and trampled. Photograph N191-N194. [TR]

47. 46301 58000 Turbine 94 On previously and currently eroding blanket bog but the precise area of the turbine is waterlogged with large patches of active blanket bog vegetation consisting of hollows/pools with much M1 *Sphagnum denticulatum* and *Sphagnum cuspidatum* (Photographs N199-N200), although these are quite heavily trampled by sheep. It has therefore been upgraded to A4. Re-locate turbine to avoid damage to wet areas. Photograph N195-N199. [TR]

48. 46130 57518 Turbine 106 Largely intact blanket bog with some hags and current erosion but there is much intact M17b composed of *Racomitrium lanuginosum*, *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Empetrum nigrum*, *Trichophorum cespitosum*, *Cladonia portentosa*, *Hypnum jutlandicum*. Bare peat is frequent within this up to 1m wide and there is also patchy U6 *Juncus squarrosus* acid grassland. Photograph N201-N204. [TR]

49. 45823 57866 Turbine 97 Large area of eroded blanket bog with some fragments of deep peat still remaining, covering approx. 20% of ground (A2). There is much M3 bare peat plus shallow peat acid grassland and heath (U6/M15d) and there is also bare stony substrate. Turbine is currently located at the edge of one of the bigger more intact blacks of blanket bog approx. 50m across and could be shifted so as to avoid damage. Photograph N205-N208. [TR]

50. 45295 57702 Turbine 100 located on very intact blanket bog with extensive carpets of *Sphagnum capillifolium* and patchier *Sphagnum papillosum*, indicating active build-up of peat. *Eriophorum angustifolium* is prominent visually and there are also patches approaching M19 where *Hylocomium splendens* and *Rhytidiadelphus loreus* take over from *Sphagnum* and there is also an occasional acid flush (M6c) and wet hollow with *Sphagnum denticulatum* and *Sphagnum cuspidatum* (M1) Photograph N209-N212. [TR]

51. 46093 58411 Turbine 96 located on very intact blanket bog with extensive *Sphagnum capillifolium* and *Sphagnum papillosum* indicating active build-up of peat. *Calluna vulgaris*, *Eriophorum vaginatum* and *Eriophorum angustifolium* are visually abundant and it does not seem so heavily grazed here. Flushed ground is acid (M6) and there is also patchy M19 marked out by hypnoid mosses replacing *Sphagnum* in the moss layer. There is very little M3 bare peat at all here. Photograph N213-N216. [TR]

52. 45582 58174 Area of flushing (M6/M17a) on slopes has much *Sphagnum cuspidatum*, *Sphagnum papillosum* and *Sphagnum denticulatum* with *Eriophorum angustifolium* and *Carex nigra* growing through the carpet. Take care to avoid this area in micro-siting the track. Photograph N217. [TR]

53. 45557 58317 Turbine 93 on edge of eroding blanket bog (A4) but which remains largely intact with bare peat forming patches around 50cm wide. This is mainly quite dry blanket bog with much *Racomitrium lanuginosum* and *Calluna vulgaris*, *Eriophorum angustifolium*, *Eriophorum vaginatum*, *Erica tetralix*, *Trichophorum cespitosum*, *Hypnum jutlandicum, Cladonia portentosa, Cladonia uncialis* and *Sphagnum capillifolium*. Bare peat has some sparse *Eriophorum angustifolium* but it is heavily trampled. Photograph N218-N221. [TR]

54. 45651 58581 The track, south of this point, runs through an area with many acid flushes and soligenous ground (M6 and M30) supporting, in the wettest parts, *Menyanthes trifoliata* and *Potamogeton polygonifolius*. It may be less damaging to these if the track so these wetter areas are avoided. Photograph N222-N223. [TR]

55. 45602 58656 Track runs over very intact, wet and good quality M17a blanket bog with extensive *Sphagnum capillifolium* and *Sphagnum papillosum* carpets. Also there are wet hollows with *Sphagnum cuspidatum* (M1) and acid flushed ground (M6). [TR]

56. 45438 58786 Track here goes over intact blanket bog with much *Sphagnum papillosum* and *Sphagnum capillifolium*. This is active blanket bog as good as it gets in this area. Track could be re-routed though less valuable sheep grazing nearby to the west (U4) to avoid damage. [TR]

57. 45255 58836 Turbine 109 Located on intact blanket bog (A5). Much of it is M19 with abundant *Calluna vulgaris* and *Eriophorum vaginatum* with a lush carpet of *Hylocomium splendens*, *Rhytidiadelphus loreus* and some *Pleurozium schreberi*. There is sparse *Eriophorum angustifolium* and patchy *Sphagnum papillosum* and *Sphagnum capillifolium* also. Where *Sphagnum capillifolium* increases and hypnoid mosses decrease it becomes more like M17a. Turbine could potentially be re-located lower down in U4 acid grassland. Photograph N224-N227. [TR]

58. 45048 58223 Turbine 87 on in tact blanket bog (M17a and M17b) with extensive *Sphagnum papillosum* and *Sphagnum capillifolium* where the ground is more waterlogged and *Racomitrium lanuginosum* predominating with *Cladonia portentosa* on drier peat surfaces. *Calluna vulgaris* and *Eriophorum vaginatum* are the main vascular dominants with sparser *Eriophorum angustifolium* and *Trichophorum cespitosum*. Photograph N228-N231. [TR]

59. 44943 57855 Along track line there is base flushing (M10a)indicated by *Carex panicea*, *Carex viridula ssp. oedocarpa*, *Juncus bulbosus*, *Potamogeton polygonifolius*, *Campylium stellatum*, *Pinguicula vulgaris*, *Thalictrum alpinum* and *Scorpidium scorpioides*. [TR]

60. 44913 57382 Track here runs through lower, wetter ground with drier, more firm peat on slope above around 80-100m away to the west. On this wetter ground there is extensive patches of M17a consisting of *Sphagnum papillosum*, *Sphagnum capillifolium*, *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Calluna vulgaris*. Hollows can be wetter with standing water, *Sphagnum*

cuspidatum and *Sphagnum denticulatum* (M1) but these are generally quite heavily trampled by sheep. In the wettest parts of soakways there is generally some *Potamogeton polygonifolius* and *Sphagnum denticulatum* (M30) and there is also patchy drier peat surfaces with M17b or M19 type vegetation. Track in this area could be re-located higher up the slope to the west in order to avoid this wettest ground. Similarly to the south of here for much of its length. [TR]

61. 44571 58178 Turbine 86, and the track leading to it from the east, is located on very intact blanket bog in good condition. The NVC type is somewhere between M17a and M17b – there is usually extensive *Sphagnum capillifolium* with *Pleurozia purpurea* in the moss layer and the vascular dominants *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Trichophorum cespitosum*. There is often some *Sphagnum papillosum* (M17a) and on drier peat surfaces *Racomitrium lanuginosum* an *Cladonia portentosa* take over in the moss layer (M17b). *Calluna vulgaris* is predominant throughout with some m19 on steeper banks indicated by a high cover of *Hylocomium splendens* and decreased *Racomitrium lanuginosum* and *Sphagnum capillifolium*. Photograph N232-N235. [TR]

62. 44292 58558 Turbine 57 located on the edge of intact and active blanket bog (M17 and M19) with areas of extensive *Sphagnum* (A5). Track could be shifted to the east where there is more eroded and fragmented blanket bog, minimising damage. Photograph N236-N239. [TR]

63. 44789 58653 Turbine 103 located on quite intact (A4-A5) blanket bog than that further west (A2). This could be shifted to the west approx.50m or more onto a big eroded area. Photograph N240-N243. [TR]

64. 44211 58703 Muckle Hill, to the west of this point, is a very large area of massively eroded former blanket bog with very little remaining deep peat or active build-up. There is therefore much bare ground and shallow peat acid grassland (U6) or heath (M15d) and is an area very much more suited to development in order to minimise damage. Track layout currently runs right around the edge of this area and would enlarge the area of damaged blanket bog greatly. Re-think this whole area. [TR]

65. 44015 58918 Turbine 34 Located on edge of eroded blanket bog fragments with dry peat surface vegetation (M17b) and areas of shallow peat acid grassland and heath (U6, M15d) and bare peat (M3) and substrate. Not far to the south is an area of much more widely eroded former bog and moving turbine to here would avoid damage to the remaining peat blocks in the current location. Photograph N244-N247. [TR]

66. 44105 58926 Track here runs very close to wet areas with much M1 active bog pool/hollow vegetation (*Sphagnum denticulatum* and *Sphagnum cuspidatum*) within A4 eroding blanket bog. Shift track onto more massively eroded area of Muckle Hill. [TR]

67. 44427 58931Track runs over intact and active blanket bog with extensive continuous *Sphagnum papillosum* and *Sphagnum capillifolium* carpets which is also largely untrampled. Could be moved to more eroded area to the east of here. Photograph N248-N249. [TR]

68. 44496 59059 Turbine 43 Located on edge of intact blanket bog on low-lying wet ground with extensive *Sphagnum* carpet. Could be shifted onto eroded blanket bog 50-100m east. Photograph N250-N253. [TR]

69. 44796 59519 Turbine 40 on the edge of an area to the west with very intact blanket bog with extensive *Sphagnum* and waterlogged hollows supporting *Sphagnum denticulatum* and *Sphagnum cuspidatum* (M1). Shift onto more eroded (A3) area to the south of here. Photograph N254-N257. [TR]

70. 44951 59111 Turbine 37 located on variably eroded blanket bog (A3) with some large remaining fragments and also large patches of bare ground and shallow peat acid grassland and heath (U6, M15d). Micro-site so as to avoid damage to remaining peat blocks. Photograph N258-N261. [TR]

71. 43503 57279 Turbine 117 located on the edge of eroding blanket bog with hags over 2m high but not extensive. The blanket bog is more intact to the north. Photograph N262-N265. [TR]

72. 44041 57760 Track runs across mainly intact blanket bog with frequent but not extensive bare peat surfaces. Most of the NVC blanket bog types occur in a mosaic with M17b (*Racomitrium lanuginosum*, *Calluna vulgaris*, *Cladonia portentosa* low *Sphagnum capillifolium*) on drier surfaces and M17a (much *Sphagnum capillifolium*, *Sphagnum papillosum*) on more waterlogged ground and M19 (higher *Eriophorum vaginatum*, extensive *Hylocomium splendens* and much less *Sphagnum*). Photograph N266-N267 [TR]

73. 43794 57732 Turbine 105 located on the edge of intact blanket bog with increased waterlogging lower down – much active wet *Sphagnum capillifolium*, *Sphagnum papillosum*, *Sphagnum cuspidatum*, *Sphagnum denticulatum* in hollows. The track to here from the north also runs through this vegetation. Photograph N268-N271. [TR]

74. 43923 58311 Turbine 79 located on intact blanket bog (A5) with extensive areas supporting abundant *Sphagnum capillifolium* and *Sphagnum papillosum* (M17a). Vascular dominants are *Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Erica tetralix*, *Trichophorum cespitosum* and *Juncus squarrosus*. There is also some M1n bog with much increased *Eriophorum vaginatum* less *Sphagnum* and increased *Hylocomium splendens* and *Rhytidiadelphus loreus*. There is an area of more eroded (A1) blanket bog to the north approx.120m. Photographs N272-N275. [TR]

75. 44314 56653 Turbine 125 located on boundary between eroded (A3) blanket bog to the east and more intact peat to the west (A4). Mainly M17b (*Calluna vulgaris*, *Eriophorum vaginatum*, *Eriophorum angustifolium*, *Racomitrium*

lanuginosum, *Cladonia portentosa, Erica cinerea*). Move turbine 50-100m to the east. Photographs N276-N279 [TR]

76. 44193 55748 The blanket bog to the south of the quarry is more degraded and broken up on lower slopes than that to the north so maybe better to locate borrow pit to south. [TR]

77. 44523 57108 Turbine 114 located on very eroded area with only small remaining fragments of blanket bog which are continuing to erode. Most of area is bare peat and substrate with shallow peat vegetation similar to acid grassland and heathland. U6 has *Juncus squarrosus*, *Rhytidiadelphus loreus*, *Dicranum scoparium* and *Hypnum jutlandicum*. M15d/H10b has *Calluna vulgaris*, *Juncus squarrosus*, *Racomitrium lanuginosum*, *Hypnum jutlandicum*, *Cladonia uncialis* and *Rhytidiadelphus loreus*. Photograph N280-N283. [TR]

78. 44207 57577 Turbine 104 located on edge of an area of high erosion (A2) with only fragments of the drier M17b blanket bog type left. Mainly un-vegetated bare peat with patchy acid grassland or heathland on shallow peat (U6, M15d, H10b). Turbine could be finely positioned so as to minimise damage. Photograph N284-N287. [TR]

79. 44656 57573 Turbine 102 located just beyond edge of highly eroded area. Move this turbine south and up slope to avoid damaging more intact blanket bog. Photograph N288-N291. [TR]

80. 44140 55486 Natural hag system with *Racomitrium lanuginosum* hummocks and frequent pools (M1) that are intact with abundant *Sphagnum cuspidatum, Sphagnum denticulatum, Menyanthes trifoliata, Juncus bulbosus* (photo N5). All the ground within these fences is in good condition and could be easily avoided by moving the track to the north of the fence-line. [ND]

81. 44279 55576 *Potamogeton polygonifolius* flush (M29) through a strip of M6b vegetation with *Carex nigra, Equisetum palustre* and *Eriophorum angustifolium* running through active blanket bog in good condition. Locally abundant *Sphagnum denticulatum* (photo N6). [ND]

82. 44330 55738 Blanket bog in poorer condition with little structure and more *Trichophorum cespitosum, Molinia caerulea* and pleurocarpous mosses on mounds with *Cladonia* spp. [ND]

83. 44260 55926 M10a flush on stony substrate with abundant *Scorpidium scorpioides, Narthecium ossifragum, Carex viridula ssp. oedocarpa, Carex panicea, Pinguicula vulgaris, Campylium stellatum, Scapania undulata, Scorpidium revolvens, Blindia acuta* (photo N7). Also present around the margins are: *Thalictrum alpinum, Potamogeton polygonifolius* and *Blindia acuta*. There are frequent similar flushes around this slope that will be crossed by the proposed track. [ND]

84. 44345 56152 Around the edge of the plateau there are areas where the peat has slumped downhill due to erosion. The shallow peat and stony ground exposed supports a mosaic of *Nardus stricta* grassland (U5), *Juncus squarrosus* grassland (U6) and dry (H10) and wet heath (M15). [ND]

85. 44404 56224 *Potamogeton polygonifolius* flush (M29) with *Juncus bulbosus, Sphagnum denticulatum* and *Ranunculus flammula.* [ND]

86. 44513 56614 Hill of Flamister. The summit plateau is heavily eroded with large expanses of bare peat. Hags are not revegetating and sheep tracks are abundant, trampling is probably responsible for erosion of the walls of pools so that they drain out. Evident drying of the peat surface and peat loss. [ND]

87. 41639 60045 Site of Turbine 68 on a hilltop plateau. Some erosion of the deep peat but this is not extensive (photo N8 east, photo N9 south). Also see quadrat 44 (M17c). [ND]

88. 41957 59811 A large, hagged area on this hilltop (photo N10). [ND]

89. 42001 59775 Site of Turbine 73. There is an extensive hagged area across the summit of this hill, some large bare areas although the hag tops support blanket bog that is still in reasonable condition with *Sphagnum capillifolium.* A3 degrading to A2. (photos N11 & N12). [ND]

90. 42142 59426 A system of bog pools on a plateau below Hoo Kame (photo N13). Some M1 pools dominated by *Sphagnum cuspidatum* with some *Sphagnum denticulatum* and *Eriophorum angustifolium* at the margins. The only area of intact bog and pools within this extensive peat system which is generally very degraded so important to retain this feature. Moving the track at least 20m to the east and marking a buffer around these pools with tape to avoid damage. [ND]

91. 42278 59374 Site of turbine 75. A large hag system down slope from the location of this turbine with severe erosion. *Juncus squarrosus* grassland (U6) in valley bottoms. (photo 14 NE, photo 15 SE). [ND]

92. 42101 58905 Site of turbine 80 (photo N16 W, N17 E)All the peat has slumped away from the summit to leave bare peat hag walls surrounding the stony summit with occasional mounds of *Juncus squarrosus* and some *Calluna vulgaris, Racomitrium lanuginosum, Festuca ovina, Pleurozium schreberi, Hypnum jutlandicum, Cladonia portentosa, Rhytidiadelphus loreus, Empetrum nigrum* (U6d). Some *Vaccinium vitis-idaea* in good blanket bog just west of the summit. [ND]

93. 42088 60428 Site of turbine 64 (photo N18 E, N19 NW) just above a large area of bare peat and hagging. Above the turbine location is smooth blanket bog in relatively good condition. [ND]

94. 42399 60158 Site of turbine 67 (photo N20 E, photo N21 S). A large area of extreme hagging and bare peat. Very little *Eriophorum angustifolium* revegetation on peat and the hags are badly wind-eroded. [ND]

95. 42643 60723 Site of turbine 63 (photo N22 SW). Vast bare area across the top of mossy hill. [ND]

96. 41885 60375 Bog pools just outside the survey area but likely to be affected by works above (photo N23) so look again at layout here. M1 with *Sphagnum denticulatum, Eriophorum angustifolium, Sphagnum cuspidatum.* [ND]

97. 42073 60308 Two bog-pools still holding water, though with few species. The pools are dominated by *Eriophorum angustifolium* with *Sphagnum denticulatum* at the margins. In this area, where the peat is still damp, revegetation of bare peat areas is good, though where dry it is much less in evidence. This is a good example of natural peatland restoration and suggests that actions to retain water, such as stacking peat turves in hags to create natural dams could encourage bog species to re-establish. [ND]

98. 42072 60610 Some evident regeneration of *Eriophorum angustifolium* in damp peaty areas (photo N1), good example of conditions needed for natural regeneration. [ND]

99. 42153 60828 Very sluggish, almost stagnant burn channel through these deep, peat hags (photo N2). Some clumps of *Juncus effusus* and *Juncus bulbosus* alongside the channel, and algae abundant in wetter areas suggesting local nutrient loading. *Polytrichum commune* is locally abundant on peat mounds. [ND]

100. 42077 61002 A large bog-pool with a small amount of *Sphagnum denticulatum* on the south shore and sparse *Eriophorum angustifolium.* Relatively stable pool with signs of some regeneration. [ND]

101. 42335 60928 Site of turbine 59. A lightly hagged slope (photo N3). [ND]

102. 42804 61202 Site of turbine 56. Severely hagged above and on the slope (photo N4), predominantly M17b and bare peat. Below the turbine site is a broad valley mire of some interest and it is recommended that the turbine be moved 100m or so west, back onto the hilltop. [ND]

103. 42891 61281 A broad valley mire, possibly an old, infilled lochan, with a burn meandering along the east side (photos N25, N26). Areas of M17a with abundant *Sphagnum papillosum* but most of the valley base is *Eriophorum angustifolium* and *Sphagnum denticulatum* suggesting relatively recent revegetation. The peat here is very deep and sheep grazing is locally heavy. If possible, move the track 50m to the north to avoid this feature, both for ecological and logistical reasons. [ND]

104. 43039 61177 A group of bog-pools in relatively good condition right on the track-line (photo N27). Avoid if possible. [ND]

105. 43009 61031 Mounds of deep peat on the plateau about 10m diameter, supporting M19b type vegetation on the top. [ND]

106. 43128 60868 Site of turbine 61. (photo N28 NW) Relatively smooth peat mound on the summit plateau. Some small bog-pools present near the turbine, partly dried out and within unstable hags. Assessed from close by to avoid golden plover nest. [ND]

107. 43165 60938 A small depression with M17a vegetation in good condition and a Carex echinata soak running through (M6aii). Avoid this if possible. [ND]

108. 43234 61307 Site of turbine 53. This turbine is located on a slope of intact blanket bog (M17b) with few hags except on low mounds around the turbine site (photo N29 N). [ND]

109. 43945 62202 Site of turbine 48. (photo N30 S, smooth peat and photo N31 NE, revegetating runnel). A broad slope of largely smooth blanket bog (M17b) with frequent runnels but mainly revegetating (U6a) or pools (M1) where water retained. Some bare peat areas but these are small and damp so mostly revegetating with *Eriophorum angustifolium* (M3). Could move a bit further east to keep away from valley mire. [ND]

110. 43878 62117 A broad, shallow slope leading to a valley mire that is predominantly wet blanket bog (M17a) in good condition, with frequent *Sphagnum papillosum* and minimal bare peat (photo N32). [ND]

111. 43721 61682 Site of turbine 51. A hagged area but the rate of revegetation is good and hence is classed as activity A4. There are frequent mounds of *Racomitrium lanuginosum, Eriophorum vaginatum* and *Juncus squarrosus* (photo N33) and M1 in runnels. *Sphagnum capillifolium* is also relatively abundant on hag tops (photo N34). This turbine is currently sited just above a good area of M17a valley mire blanket bog that is crossed by the track between turbines 48 and 51. It which would be less affected if the track could be moved south, uphill by about 50m. [ND]

112. 43838 61375 Hagging on the hillside with frequent areas of peat slumping evident and the peat between hags stripped away to expose rock and mineral soil beneath. Some areas revegetated with *Juncus squarrosus* (U6) and wet heath (M15) and *Sphagna* present and appears to be a good example of natural recovery of a severely eroded area (photo N35). [ND]

113. 43825 61340 A large pool (M1) within hags but surrounding blanket bog locally in good condition. [ND]

114. 43971 61171 A large pool above turbine 58 and close to the track-line. Avoid by micro-siting. [ND]

115. 43838 61122 Site of turbine 58 (photo N36 S) Lightly hagged M17b. Not approached closely due to nesting birds. [ND]

116. 44031 61413 A large pool close to the track within an area of peat that is quite badly hagged and slumped. The pool supports M1 type vegetation with *Sphagnum denticulatum* and *Eriophorum angustifolium* at the margins and *Juncus bulbosus* in shallow water. Avoid. [ND]

117. 44111 61466 A large, shallow pool on the summit plateau with a pair of redshank. Adjacent peat is largely bare (photo N37). [ND]

118. 44067 61487 Site of turbine 54 (photo N38 W, photo N39 S) Turbine sited within an area where the peat has slumped away from the plateau. [ND]

119. 44091 61596 A large pool supporting abundant *Juncus bulbosus, Sphagnum denticulatum* and *Sphagnum cuspidatum* in shallow water, not just at the margins (photo N40). [ND]

120. 41382 60631 Heavily grazed blanket bog adjacent to the road which forms a mosaic with M15d (*Juncus squarrosus*/*Calluna vulgaris*) and U6d with some eroding bare peat. Sheep numbers in these areas were high at the time of survey. [KP]

121. 41522 60518 Frequent peat cuttings across this area. [KP]

122. 41783 60718 Steeper slope, over small area, supports generally drier vegetation with an overall 'grassy' appearance although predominantly over peat greater than 0.5m deep. Grazing pressures are particularly high with sheep preferentially grazing these slopes. In parts the vegetation is dominated by a mix of *Hypnum* sp., *Agrostis capillaris* and *Deschampsia flexuosa*, although predominantly of more typical U6d or grazed M19. [KP]

123. 41850 60769 Approximate turbine location number 62. Area of more-or-less intact blanket bog (M17b) with some minimal erosion. Sheep prints through these erosion channels are frequent and re-vegetation of bare peat is mainly by frequent *Eriophorum angustifolium*, although in parts over wider area there are scattered *Sphagnum* pools (M1). Photographs N41, N42 & N43. [KP]

124. 41873 61038 Peat locally eroded through to mineral soil/bedrock. *Juncus squarrosus* is colonising some areas and *Eriophorum angustifolium* is localised through peat where erosion processes have slowed sufficiently. Erosion is at its greatest around hags/peat blocks. [KP]

125. 41920 61110 Area of shallow peat which has become almost completely re-vegetated by mono-dominant *Juncus squarrosus*, interspersed by remaining peat blocks and stands of M15d (*Calluna vulgaris*/*Juncus squarrosus*). Photograph N44. [KP]

126. 41921 61267 Approximate turbine location number 55 (photographs N45, N46 & N47). Deep (1-2m) hagging through peat with associated erosion which is at a greater rate than re-vegetation. Locally *Juncus squarrosus* had formed dams within erosion gullies, behind which *Sphagnum cuspidatum* is able to grow in the wetter, more stable conditions (photograph N48). [KP]

127. 41717 60215 Small fragment of M17a with constant *Sphagna* (*Sphagnum palustre*, *Sphagnum capillifolium*, *Sphagnum papillosum*, *Sphagnum cuspidatum*) and an even sward of *Eriophorum vaginatum*, *Eriophorum angustifolium* and *Calluna vulgaris*. Also present at low cover are *Empetrum nigrum*, *Rhytidiadelphus loreus* and *Cladonia portentosa*. Immediately adjacent to this wetter blanket bog are fragments of *Rhytidiadelphus loreus* dominated deep peat with scattered *Eriophorum vaginatum*, *Calluna vulgaris* and *Juncus squarrosus* (photograph N49). [KP]

128. 41495 60320 Disused quarry which supports a mixture of *Juncus squarrosus* grassland (U6d), *Juncus effusus* (M23b) and U4 grassland (*Rhytidiadelphus squarrosus*, *Anthoxanthum odoratum*, *Agrostis capillaris*, *Holcus mollis*, *Rumex acetosa*, *Cirsium palustre*, *Deschampsia flexuosa* and *Cardamine pratensis*). Soakway at 41468 60331 is vegetated by *Potamogeton polygonifolius*, *Equisetum palustre*, *Juncus articulatus*, *Glyceria fluitans*, *Philonotis fontana*, *Cardamine pratensis*, *Juncus bulbosus* and *Cirsium palustre*. [KP]

129. 42624 61887 Stony flush (M10) with *Carex viridula* ssp. *oedocarpa*, *Juncus squarrosus*, *Narthecium ossifragum*, *Scorpidium scorpioides*, *Juncus bulbosus* and *Trichophorum cespitosum* which becomes closer to M30 soakway (*Potamogeton polygonifolius*, *Sphagnum denticulatum*, *Eriophorum angustifolium*, *Juncus squarrosus*, *Carex viridula* ssp. *oedocarpa*) down slope (photograph N50). [KP]

130. 42691 61869 Approximate location of turbine number 49 (photographs N51, N52 & N53) over area of M17b/M1/M3 which extends to the east of here. Immediately to the West is an area of shallower peat which supports wet heath (M15d). in parts a high cover of *Racomitrium lanuginosum* is present and the vegetation appears transitional towards H14. To avoid areas of deeper peat and frequent hagging micrositing of turbine may be preferable over areas of shallow peat. [KP]

131. 42260 61674 Approximate turbine location number 52 (photographs N54, N55 & N56). Majority of this area is of blanket bog (M17b) with patchy erosion (M3) and *Sphagnum* dominated pools/hollows (M1). In this area there is also more frequent vegetation of shallow peats (M15d/U6) where the peat appears to have slipped or become eroded away in the past and subsequently become re-vegetated. Micrositing of turbine where this more stable ground exists would be preferable. [KP]

132. 41978 61507 Short-grazed, species-rich calcareous grassland (CG10a) around rocky outcrop (*Thalictrum alpinum*, *Prunella vulgaris*, *Plantago lanceolata*, *Plantago maritima*, *Thymus polytrichus*, *Carex panicea*, *Achillea millefolium*,

Bellis perennis, *Achillea millefolium*, *Luzula campestris*, *Trifolium repens*, *Agrostis capillaris*, *Ranunculus ficaria*, *Selaginella selaginoides*, *Festuca ovina*, *Bryum alpinum*). Photographs N57 & N58. Area should be re-visited in July to search for potential Shetland rarities, particularly through crevices/ledges which are inaccessible to grazers, and to gather a full species list. [KP]

133. 41916 61405 Base-rich flush (M10) is mainly bare gravel with scattered *Carex panicea*, *Carex viridula* ssp. *oedocarpa*, *Thalictrum alpinum*, *Plantago maritima* and *Prunella vulgaris*. Grazing pressures are high. [KP]

134. 42614 62294 M1 bog pools dominated by aquatic *Sphagnum cuspidatum* with marginal *Eriophorum angustifolium* and *Sphagnum denticulatum*. Surrounding blanket bog is predominantly of the wetter M17a sub-community with abundant *Sphagnum papillosum* (photograph N59). Consider re-routing track to avoid this habitat. [KP]

135. 42675 62321 Location of turbine number 47 is within a mosaic of active blanket bog NVC types (M17a/b/M19) with little or no erosion (photographs N60 & N61). Pools are heavily vegetated and there is an undulating surface structure to the bog. An area of acid grassland to the North-north-west would be more suitable for turbine micrositing. [KP]

136. 43613 62248 Narrow ridge of drier vegetation and shallow peat which supports a mosaic of wet heath (M15d) and *Juncus squarrosus* dominated acid grassland (U6d). Photograph N62. [KP]

137. 43537 62259 Location of turbine number 66 (photographs N63, N64, N65 & N66). Dry grassy ridge/knoll within otherwise extensive intact and active blanket bog. *Juncus squarrosus* is frequent with *Galium saxatile*, *Hylocomium splendens*, *Polytrichum juniperinum*, *Luzula multiflora*, *Mnium hornum* and *Hypnum jutlandicum* (U6d). Where the frequency/cover of *Juncus squarrosus* becomes reduced or absent vegetation is closer to NVC documentation of U4. [KP]

138. 43379 62114 Any hagging here is generally small-scale with erosion gullies completely re-vegetated by *Eriophorum angustifolium*, *Sphagnum papillosum*, *Sphagnum cuspidatum*, *Sphagnum denticulatum*, *Sphagnum palustre*, *Calluna vulgaris* and *Erica tetralix* (photograph N67). Blanket bog is mainly intact M17b dominated by *Calluna vulgaris*, *Eriophorum angustifolium*, *Trichophorum cespitosum*, *Erica tetralix* and *Eriophorum vaginatum* over *Racomitrium lanuginosum* and *Cladonia portentosa*. Also present are *Huperzia selago*, *Potentilla erecta*, *Pleurozia purpurea*, *Cladonia uncialis*, *Narthecium ossifragum* and *Carex panicea* at low cover. [KP]

139. 43131 61835 Location of turbine number 50 (photographs N68, N69, N70 & N71). Small area of *Juncus squarrosus* dominated (U6) grassland, with associates including *Calluna vulgaris*, *Empetrum nigrum*, *Erica cinerea*, *Polytrichum commune*, *Sphagnum palustre*, *Hypnum jutlandicum*, *Pleurozium schreberi*, *Rhytidiadelphus loreus* and *Cladonia portentosa*, over shallow peat

(0.1 - 0.4m) within wider area of M17b. Blanket bog varies in terms of intactness and activeness with some parts intact and others bare/eroding (particularly nearer the fence to the north). As a whole re-vegetation rate greater than erosion with former erosion gullies becoming re-vegetated by *Juncus squarrosus* with some *Sphagnum* spp. Areas eroded in the past and subsequently stabilised tend to have become colonised by *Calluna vulgaris* (M15d). [KP]

140. 42826 62254 Hollows vegetated by U6d (*Juncus squarrosus*, *Rhytidiadelphus squarrosus*, *Potentilla erecta*, *Anthoxanthum odoratum*, *Carex nigra*) and M15d (*Calluna vulgaris*, *Juncus squarrosus*, *Sphagnum papillosum*, *Mnium hornum*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, *Eriophorum angustifolium*). Within this hollow are patches of building *Sphagnum papillosum* although still occurring over less than 0.5m peat (photographs N72 & N73). Similar small mounds of building *Sphagnum* are frequent over this area and in general the vegetation appears to be in a state of recovery. [KP]

141. 43039 62344 Soakway/flush (M6c/b/M30) with M17a along margins (photographs N74 & N75). Species present include *Juncus effusus*, *Potamogeton polygonifolius*, *Ranunculus flammula*, *Cardamine pratensis*, *Montia fontana*, *Juncus bulbosus*, *Philonotis fontana*, *Carex nigra*, *Sphagnum denticulatum*, *Calliergon cuspidatum*, *Caltha palustris* and *Pseudobryum cinclidioides.* [KP]

142. 43086 62273 Spring head/flush vegetated by *Juncus bulbosus*, *Caltha palustris*, *Ranunculus flammula*, *Cardamine pratensis*, *Carex nigra*, *Philonotis fontana* and *Pseudobryum cinclidioides* (photograph N76). [KP]

143. 43141 62290 Location of turbine number 70 (photographs N77, N78 & N79). Wide area of M19 blanket bog dominated by *Calluna vulgaris* and *Eriophorum vaginatum* over a mix of, predominantly pleurocarpous, bryophytes (*Hylocomium splendens*, *Rhytidiadelphus loreus*, *Sphagnum capillifolium*, *Sphagnum papillosum*). Also present, at low cover, are *Eriophorum angustifolium* and *Empetrum nigrum* ssp. *nigrum*. The high cover of *Hylocomium splendens* gives the vegetation a distinctive yellow colour and in parts becomes the dominant species in localised absence of *Calluna vulgaris* and *Eriophorum vaginatum* (photograph N79). Peat depth greater than 0.5m throughout. [KP]

144. 43431 62312 Flush with frequent *Potamogeton polygonifolius*, *Trichophorum cespitosum*, *Eriophorum angustifolium* and *Juncus bulbosus* adjacent to small mound of peat (photographs N80 & N81). This mound, with peat almost 0.5m deep, is mainly vegetated by *Bryum pseudotriquetrum*, *Ranunculus flammula*, *Cardamine pratensis*, *Agrostis capillaris*, *Cerastium fontanum* and *Sagina procumbens* none of which are known peat forming species. [KP]

145. 43825 62333 Acid flush/hollow (M6/M1) dominated by *Sphagnum denticulatum*, *Sphagnum cuspidatum* and *Eriophorum angustifolium* with *Juncus squarrosus*, *Agrostis capillaris* and *Carex nigra* (photograph N82). [KP]

APPENDIX 2: QUADRAT DATA

M1

Quadrat No.	1	2	3	4	5
Quadrant	Kergord	Kergord	Kergord	Kergord	Kergord
Date	30/05/08	05/06/08	12/07/08	11/07/08	13/07/08
Eastings	37901	39492	38868	39200	42272
Northings	53825	56743	58557	57895	65371
Surveyor	T. Rafferty	T. Rafferty	K. Proctor	K. Proctor	T. Rafferty
Slope (degrees)			0	0	
Aspect (degrees)			N.A.	N.A.	
Height (heath/herb/moss)	10/25/4	0/20/1	0/12/3	0/15/1	0/1/1
% cover (heath/herb/moss)	10/30/50	0/2/40	0/10/80	0/35/20	0/5/30

Species:

Sphagnum denticulatum	6	6	3	5	5	V	(3-6)
Sphagnum cuspidatum	7	5	9		4	IV	(4-9)
Eriophorum angustifolium	4	3	4	5		IV	(3-5)
Potamogeton polygonifolius				3	4	II	(3-4)
Juncus bulbosus			2	3		II	(2-3)
Carex echinata				2	3	II	(2-3)
Eriophorum vaginatum	6					I	(6)
Calluna vulgaris	5					I	(5)
Menyanthes trifoliata				4		I	(4)
Sphagnum papillosum	3					I	(3)
Erica tetralix	3					I	(3)
Juncus squarrosus			3			I	(3)
Sphagnum palustre			3			I	(3)
Polytrichum commune			3			I	(3)
Juncus effusus					3	I	(3)
Water	6	9	4		9	IV	(4-9)

M3

Quadrat No.	6	7	8	9	10
Quadrant	Kergord	Kergord	Kergord	Kergord	Kergord
Date	26/05/08	28/05/08	11/07/08	13/07/08	13/07/08
Eastings	41047	40920	39160	42326	41632
Northings	57392	59075	57789	65370	65143

Surveyor	K. Proctor	K. Proctor	K. Proctor	T. Rafferty	T. Rafferty		
Slope (degrees)	1	0	0				
Aspect (degrees)	200	N.A.	N.A.				
Height (heath/herb/moss)	0/15/0.5	0/5/0	0/12/0	0/20/2	0/20/0		
% cover (heath/herb/moss)	0/55/1	0/25/0	0/10/0	0/25/5	0/20/0		
Species:							
Eriophorum angustifolium	8	9	4	6	5	V	(4-9)
Sphagnum cuspidatum	8			3		II	(3-8)
Juncus squarrosus					3	I	(3)
Sphagnum papillosum					3	I	(3)
Bare peat	8	5	10	9	9	V	(5-10)
Litter			3			I	(3)

M6

Sub-community	**M6b**	**M6b**	**M6c**	**M6c**	**M6c**		
Quadrat No.	11	12	13	14	15		
Quadrant	Nesting	Kergord	Collafirth	Nesting	Kergord		
Date	20/05/08	11/07/08	12/05/08	10/05/08	12/07/08		
Eastings	45531	38863	42138	43960	38181		
Northings	58198	57796	65041	61914	54773		
Surveyor	T. Rafferty	K. Proctor	N. Dayton	N. Dayton	T. Rafferty		
Slope (degrees)		0	1	5			
Aspect (degrees)		N.A.	80	270			
Height (heath/herb/moss)	0/40/5	0/15/5	0/50/10	0/50/10	0/50/20		
% cover (heath/herb/moss)	0/25/90	0/35/85	0/60/70	0/40/80	0/30/95		
Species:							
Juncus effusus	4		4	7	6	IV	(4-7)
Sphagnum denticulatum	10	9	8	2		IV	(2-10)
Juncus bulbosus	3	3	4			III	(3-4)
Polytrichum commune			4	4	3	III	(3-4)
Carex nigra	3	2	5			III	(2-5)
Sphagnum palustre				6	10	II	(6-10)

Eriophorum angustifolium		4	4			II	(4)
Agrostis capillaris				4	3	II	(3-4)
Potentilla erecta		3		3		II	(3)
Galium saxatile				3	3	II	(3)
Carex panicea	3	2				II	(2-3)
Carex echinata		4	1			II	(1-4)
Rhytidiadelphus squarrosus				7		I	(7)
Nardus stricta		5				I	(5)
Anthoxanthum odoratum					3	I	(3)
Rumex acetosa					3	I	(3)
Agrostis canina					3	I	(3)
Sphagnum capillifolium			2			I	(2)
Viola riviniana		2				I	(2)
Ranunculus flammula		2				I	(2)
Plagiothecium undulatum				2		I	(2)
Bare peat			4			I	(4)

M10a

Quadrat No.	16	17	18	19	20		
Quadrant	Collafirth	Collafirth	Kergord	Kergord	Kergord		
Date	14/05/08	14/05/08	05/06/08	11/07/08	11/07/08		
Eastings	41770	41831	40657	39077	38455		
Northings	66105	66218	60823	57429	56261		
Surveyor	N. Dayton	K. Proctor	K. Proctor	K. Proctor	T. Rafferty		
Slope (degrees)	4	5	10	20			
Aspect (degrees)	345	200	350	340			
Height (heath/herb/moss)	0/5/1	0/10/1	0/8/1	0/5/1	0/8/2		
% cover (heath/herb/moss)	0/50/20	0/40/10	0/25/35	0/35/5	0/20/20		
Species:							
Carex viridula ssp. *oedocarpa*	4	3	4	5	3	V	(3-5)
Scorpidium scorpioides	5	4	5		4	IV	(4-5)
Pinguicula vulgaris	3		3	1	2	IV	(1-3)
Thalictrum alpinum			2	5	3	III	(2-5)
Carex panicea	4		3			II	(3-4)
Juncus bulbosus	4		3			II	(3-4)

Euphrasia sp.				3	3	II	(3)
Bryum pseudotriquetrum			4		2	II	(2-4)
Equisetum palustre	2		3			II	(2-3)
Carex nigra		2	3			II	(2-3)
Prunella vulgaris			2		3	II	(2-3)
Selaginella selaginoides				2	3	II	(2-3)
Ctenidium molluscum				1	3	II	(1-3)
Juncus articulatus				1	3	II	(1-3)
Schoenus nigricans		7				I	(7)
Sphagnum denticulatum	4					I	(4)
Calliergon cuspidatum	4					I	(4)
Nardus stricta				4		I	(4)
Campylopus atrovirens				4		I	(4)
Narthecium ossifragum	3					I	(3)
Potamogeton polygonifolius	3					I	(3)
Dicranella palustris	3					I	(3)
Trichophorum cespitosum		3				I	(3)
Campylium stellatum		3				I	(3)
Drepanocladus revolvens			3			I	(3)
Drepanocladus sp.			3			I	(3)
Fissidens sp.			3			I	(3)
Festuca vivipara				3		I	(3)
Festuca ovina				3		I	(3)
Blindia acuta					3	I	(3)
Plantago maritima					3	I	(3)
Galium saxatile				2		I	(2)
Agrostis capillaris				2		I	(2)
Viola riviniana				2		I	(2)
Carex pulicaris					2	I	(2)
Carex dioica	1					I	(1)
Bare ground		8	7	8	8	IV	(7-8)

M15a

Quadrat No.	21
Quadrant	Delting
Date	30/05/08
Eastings	38976
Northings	67954
Surveyor	K. Proctor

Slope (degrees)	10
Aspect (degrees)	220
Height (heath/herb/moss)	12/15/4
% cover (heath/herb/moss)	30/60/50

Species:

Calluna vulgaris	6	II	(6)
Thalictrum alpinum	5	II	(5)
Breutelia chrysocoma	5	II	(5)
Trichophorum cespitosum	4	II	(4)
Nardus stricta	4	II	(4)
Racomitrium lanuginosum	4	II	(4)
Deschampsia flexuosa	4	II	(4)
Hylocomium splendens	4	II	(4)
Pleurozium schreberi	4	II	(4)
Ctenidium molluscum	4	II	(4)
Carex panicea	4	II	(4)
Erica tetralix	3	II	(3)
Potentilla erecta	3	II	(3)
Prunella vulgaris	3	II	(3)
Hypnum jutlandicum	3	II	(3)
Polygala serpyllifolia	3	II	(3)
Selaginella selaginoides	3	II	(3)
Fissidens adianthoides	3	II	(3)
Viola riviniana	3	II	(3)
Taraxacum officinale	3	II	(3)
Pinguicula vulgaris	2	II	(2)
Huperzia selago	2	II	(2)

M15b

Quadrat No.	22	23
Quadrant	Nesting	Kergord
Date	13/05/08	01/06/08
Eastings	46339	36837
Northings	56270	54683
Surveyor	T. Rafferty	T. Rafferty
Slope (degrees)		
Aspect (degrees)		
Height (heath/herb/moss)	15/10/3	25/35/4
% cover (heath/herb/moss)	80/10/60	80/20/60

Species:

Calluna vulgaris	9	8	III	(8-

							9)
Sphagnum capillifolium	7	7				III	(7)
Juncus squarrosus	5	4				III	(4-5)
Rhytidiadelphus loreus	3	5				III	(3-5)
Eriophorum angustifolium	3	4				III	(3-4)
Dicranum scoparium	4					II	(4)
Hypnum jutlandicum	4					II	(4)
Cladonia portentosa	3					II	(3)
Trichophorum cespitosum		3				II	(3)
Eriophorum vaginatum		3				II	(3)

M15c

Quadrat No.	24	25	26	27	28		
Quadrant	Delting	Delting	Kergord	Kergord	Kergord		
Date	20/05/08	20/05/08	03/06/08	05/06/08	11/07/08		
Eastings	36919	37501	38163	38954	38670		
Northings	66510	66706	58368	60917	58148		
Surveyor	K. Proctor	K. Proctor	K. Proctor	K. Proctor	K. Proctor		
Slope (degrees)	3	3	15	2	10		
Aspect (degrees)	180	000	310	330	260		
Height (heath/herb/moss)	10/10/5	8/10/5	15/08/03	5/10/2	10/10/2		
% cover (heath/herb/moss)	65/15/65	25/10/90	60/40/40	35/25/70	30/10/20		
Species:							
Racomitrium lanuginosum	8	9	6	8	5	V	(5-9)
Calluna vulgaris	8	5	7	6	6	V	(5-8)
Erica cinerea	4	4	5	4	4	V	(4-5)
Hypnum jutlandicum	3	3	3	4	3	V	(3-4)
Trichophorum cespitosum	5		4	4	4	IV	(4-5)
Eriophorum angustifolium		4	3	4	3	IV	(3-4)
Juncus squarrosus			5	3	3	III	(3-5)
Rhytidiadelphus loreus	3		4	3		III	(3-4)
Nardus stricta			4	3	4	III	(3-4)
Potentilla erecta	3		3	3		III	(3)
Carex panicea	3		2			III	(2-

				3			3)
Cladonia uncialis	3	3		2		III	(2-3)
Cladonia portentosa	3	3				II	(3)
Narthecium ossifragum			3	3		II	(3)
Festuca ovina	2	3				II	(2-3)
Hylocomium splendens	4					I	(4)
Empetrum nigrum spp. *nigrum*			3			I	(3)
Deschampsia flexuosa			3			I	(3)
Pleurozium schreberi			3			I	(3)
Listera cordata	2					I	(2)
Dicranum majus	2					I	(2)
Plagiothecium undulatum			2			I	(2)
Carex binervis					2	I	(2)
Sphagnum capillifolium					2	I	(2)
Polygala serpyllifolia	1					I	(1)
Bare ground		4		3	7	III	(3-7)

M15d

Quadrat No.	29	30	31	32	33
Quadrant	Delting	Nesting	Delting	Nesting	Nesting
Date	13/05/08	10/05/08	20/05/08	12/05/08	12/0508
Eastings	44176	43848	37824	43649	43914
Northings	73074	61370	67191	56723	57356
Surveyor	K. Proctor	N. Dayton	K. Proctor	T. Rafferty	T. Rafferty
Slope (degrees)	2	3	5		
Aspect (degrees)	020	315	250		
Height (heath/herb/moss)	14/14/10	18/15/6	12/12/8	20/25/5	20/30/5
% cover (heath/herb/moss)	60/30/90	80/10/50	65/20/10	60/30/40	50/30/30

Species:

Calluna vulgaris	7	9	8	8	7	V	(7-9)
Juncus squarrosus	6	5	5	6	5	V	(5-6)
Hylocomium splendens	6	6	4	5	5	V	(4-6)
Rhytidiadelphus loreus	5	3	3	5	4	V	(3-5)
Hypnum jutlandicum	3	4	3	4	4	V	(3-4)
Nardus stricta	3		3	3	3	IV	(3)

Empetrum nigrum	3	3	3		3	IV	(3)
Sphagnum capillifolium	6	7				II	(6-7)
Racomitrium lanuginosum		3			3	II	(3)
Scapania gracilis	2			3		II	(2-3)
Sphagnum palustre	4					I	(4)
Pleurozium schreberi	4					I	(4)
Potentilla erecta	3					I	(3)
Lophocolea bidentata	3					I	(3)
Rhytidiadelphus squarrosus			3			I	(3)
Polytrichum juniperinum	2					I	(2)
Mnium hornum	2					I	(2)
Barbilophozia sp.	2					I	(2)
Erica cinerea			2			I	(2)
Carex bigelowii			2			I	(2)
Deschampsia flexuosa			2			I	(2)
Bare			4			I	(4)

M17a

Quadrat No.	34	35	36	37	38
Quadrant	Nesting	Collafirth	Nesting	Delting	Nesting
Date	12/05/08	12/05/08	09/05/08	27/05/08	14/05/08
Eastings	42924	42067	42073	39377	45176
Northings	66113	64679	60308	68785	56933
Surveyor	K. Proctor	N. Dayton	N. Dayton	K. Proctor	T. Rafferty
Slope (degrees)	0	1	0	0	
Aspect (degrees)	N.A.	90	N.A.	N.A.	
Height (heath/herb/moss)	10/20/5	20/20/3	12/15/15	15/25/10	25/40/8
% cover(heath/herb/moss)	30/70/95	30/60/80	30/40/90	30/35/95	20/30/90

Species:

Sphagnum papillosum	8	7	8	9	9	V	(7-9)
Calluna vulgaris	6	6	6	6	6	V	(6)
Sphagnum capillifolium	5	5	4	4	5	V	(4-5)
Eriophorum angustifolium	8	5	6	5	3	V	(3-8)
Eriophorum vaginatum	3	5	4	4	5	V	(3-5)
Cladonia portentosa		4	1		3	III	(1-4)
Racomitrium lanuginosum		3			4	II	(3-4)
Empetrum nigrum		3		3		II	(3)

Rhytidiadelphus loreus	3	3				II	(3)
Trichophorum cespitosum				3	3	II	(3)
Erica tetralix	3		2			II	(2-3)
Cladonia arbuscula		5				I	(5)
Hypnum jutlandicum		5				I	(5)
Pleurozia purpurea		4				I	(4)
Sphagnum cuspidatum					4	I	(4)
Sphagnum palustre	4					I	(4)
Hylocomium splendens			3			I	(3)
Narthecium ossifragum					3	I	(3)
Sphagnum tenellum		3				I	(3)
Cladonia uncialis		2				I	(2)
Juncus squarrosus				2		I	(2)
Pinguicula vulgaris				2		I	(2)
Dactylorhiza maculata	1					I	(1)

M17b

Quadrat No.	39	40	41	42	43
Quadrant	Nesting	Delting	Nesting	Nesting	Nesting
Date	11/05/08	19/05/08	19/05/08	26/05/08	27/05/08
Eastings	43231	40653	46301	44314	42424
Northings	62251	70223	58000	56635	56252
Surveyor	K. Proctor	N. Dayton	T. Rafferty	T. Rafferty	T. Rafferty
Slope (degrees)	3	2			
Aspect (degrees)	350	200			
Height (heath/herb/moss)	10/15/4	10/15/10	15/25/5	15/25/8	20/30/3
% cover(heath/herb/moss)	65/50/80	60/30/40	70/20/60	80/5/50	20/10/80

Species:

Racomitrium lanuginosum	8	5	6	6	9	V	(5-9)
Calluna vulgaris	7	8	8	8	5	V	(5-8)
Eriophorum angustifolium	6	3	4	3	3	V	(3-6)
Eriophorum vaginatum	5	4	3	3	5	V	(3-5)
Cladonia portentosa	4	6	4	3		IV	(3-6)
Hypnum jutlandicum		2	4	6		III	(2-6)
Huperzia selago	3	1			3	III	(1-3)
Erica cinerea				4	4	II	(4)
Rhytidiadelphus loreus			3	6		II	(3-6)
Trichophorum cespitosum	5		3			II	(3-

							5)
Cladonia uncialis	3	3				II	(3)
Sphagnum capillifolium			5			I	(5)
Pleurozium schreberi		4				I	(4)
Erica tetralix	4					I	(4)
Empetrum nigrum spp. nigrum		3				I	(3)
Carex nigra			3			I	(3)
Carex panicea	2					I	(2)
Cladonia arbuscula		2				I	(2)

M17c

Quadrat No.	44	45	46	47	48		
Quadrant	Nesting	Delting	Nesting	Kergord	Kergord		
Date	08/05/08	15/05/08	26/05/08	02/06/08	03/06/08		
Eastings	41639	40530	44162	37187	40001		
Northings	60045	71616	55935	55567	55011		
Surveyor	N. Dayton	K. Proctor	T. Rafferty	T. Rafferty	T. Rafferty		
Slope (degrees)	0	1					
Aspect (degrees)	085	080					
Height (heath/herb/moss)	6/6/4	15/10/5	10/30/5	10/10/3	6/30/4		
% cover(heath/herb/moss)	70/30/70	30/40/80	5/40/70	20/60/50	1/30/80		
Species:							
Calluna vulgaris	8	6	5	6	3	V	(3-8)
Sphagnum papillosum		6	8	5	9	IV	(5-9)
Sphagnum capillifolium	6	6	4	6		IV	(4-6)
Eriophorum vaginatum		3	5	4	3	IV	(3-5)
Juncus squarrosus	6	6		7		III	(6-7)
Eriophorum angustifolium		4	3	3		III	(3-4)
Anthoxanthum odoratum			5		4	II	(4-5)
Potentilla erecta			3		3	II	(3)
Empetrum nigrum spp. *nigrum*	2	2				II	(2)
Festuca rubra					4	I	(4)
Racomitrium lanuginosum	4					I	(4)
Rhytidiadelphus loreus	4					I	(4)
Sphagnum palustre		4				I	(4)
Cardamine pratensis					3	I	(3)
Carex panicea					3	I	(3)
Equisetum fluviatile					3	I	(3)

Erica tetralix		3				I	(3)
Festuca vivipara					3	I	(3)
Luzula multiflora					3	I	(3)
Mnium hornum		3				I	(3)
Narthecium ossifragum			3			I	(3)
Pinguicula vulgaris					3	I	(3)
Polygala serpyllifolia			3			I	(3)
Sphagnum cuspidatum		3				I	(3)
Succisa pratensis					3	I	(3)
Trichophorum cespitosum				3		I	(3)
Vaccinium myrtillus	3					I	(3)
Campylopus introflexus	2					I	(2)
Carex dioica					2	I	(2)
Cladonia portentosa	2					I	(2)
Nardus stricta					2	I	(2)
Plantago lanceolata					2	I	(2)

M19

Quadrat No.	49	50	51	52	53
Quadrant	Delting	Nesting	Delting	Nesting	Nesting
Date	13/05/08	7/05/08	15/05/08	13/05/08	19/05/08
Eastings	43100	44307	40872	45855	45427
Northings	72484	55826	72002	56639	57959
Surveyor	K. Proctor	N. Dayton	K. Proctor	T. Rafferty	T. Rafferty
Slope (degrees)	5	0	5		
Aspect (degrees)	270	200	020		
Height (heath/herb/moss)	20/22/3	25/30/15	20/25/5	25/30/8	20/30/8
% cover(heath/herb/moss)	75/20/60	40/40/90	50/35/70	90/<5/70	70/20/80

Species:

Calluna vulgaris	8	7	7	9	8	V	(7-9)
Hylocomium splendens	4	8	7	8	7	V	(4-8)
Rhytidiadelphus loreus	5	4	5	4	7	V	(4-7)
Eriophorum vaginatum	5	6	6	3	5	V	(3-6)
Eriophorum angustifolium	3	4	4	3	3	V	(3-4)
Empetrum nigrum	3	2	3		3	IV	(2-3)
Sphagnum capillifolium	5	3		4		III	(3-5)
Pleurozium schreberi		4	4			II	(4)
Sphagnum palustre	4					I	(4)
Hypnum jutlandicum		3				I	(3)

Erica tetralix		3	I	(3)
Mnium hornum	2		I	(2)
Luzula multiflora		2	I	(2)
Juncus squarrosus	2		I	(2)
Cladonia portentosa	2		I	(2)

M23b

Quadrat No.	54
Quadrant	Collafirth
Date	12/05/08
Eastings	43023
Northings	64866
Surveyor	N. Dayton

Slope (degrees)	0
Aspect (degrees)	220
Height (heath/herb/moss)	0/40/3
% cover(heath/herb/moss)	0/100/20

Species:

Juncus effusus	8	II	(8)
Agrostis canina	4	II	(4)
Ranunculus ficaria	3	II	(3)
Potentilla erecta	3	II	(3)
Anthoxanthum odoratum	3	II	(3)
Polytrichum commune	3	II	(3)
Rumex acetosa	3	II	(3)
Plagiomnium rostratum	2	II	(2)
Holcus lanatus	2	II	(2)
Cirsium palustre	2	II	(2)
Viola palustris	2	II	(2)
Galium saxatile	2	II	(2)

M32

Quadrat No.	55	56
Quadrant	Collafirth	Delting
Date	14/05/08	18/05/2008
Eastings	41933	39131
Northings	66069	70431
Surveyor	N. Dayton	N. Dayton

Slope (degrees)	2	2
Aspect (degrees)	010	270
Height (heath/herb/moss)	0/5/3	0/11/3
% cover(heath/herb/moss)	0/10/90	0/20/100

Species:

Philonotis fontana	7	8	III	(7-8)
Agrostis capillaris	3	4	III	(3-4)
Cardamine pratensis	5	2	III	(2-5)
Cardamine flexuosa	2	2	III	(2)
Potentilla erecta	1	3	III	(1-3)
Calliergon cuspidatum	7		II	(7)
Ranunculus flammula	4		II	(4)
Plagiomnium rostratum	4		II	(4)
Sphagnum papillosum		4	II	(4)
Rhytidiadelphus squarrosus		4	II	(4)
Rhytidiadelphus loreus		4	II	(4)
Pseudobryum cinclidioides		4	II	(4)
Potamogeton polygonifolius	3		II	(3)
Sphagnum denticulatum	3		II	(3)
Polytrichum formosum		3	II	(3)
Carex nigra		3	II	(3)
Anthoxanthum odoratum		3	II	(3)
Viola palustris		3	II	(3)
Caltha palustris	2		II	(2)
Mnium hornum (? stellare)		2	II	(2)

H10a

Quadrat No.	57	58
Quadrant	Delting	Nesting
Date	20/05/08	13/05/08
Eastings	37939	46506
Northings	66920	55857
Surveyor	K. Proctor	T. Rafferty
Slope (degrees)	15	
Aspect (degrees)	200	
Height (heath/herb/moss)	20/25/10	5/15/4
% cover (heath/herb/moss)	80/3/50	90/1/5

Species:

Calluna vulgaris	9	9	III	(9)
Hylocomium splendens	6	7	III	(6-7)
Dicranum scoparium		4	II	(4)

Pleurozium schreberi	4					II	(4)
Rhytidiadelphus loreus	4					II	(4)
Potentilla erecta	3					II	(3)
Rhytidiadelphus squarrosus	3					II	(3)
Juncus squarrosus		3				II	(3)
Eriophorum vaginatum		3				II	(3)
Eriophorum angustifolium	2					II	(2)
Carex panicea	2					II	(2)
Deschampsia flexuosa	2					II	(2)
Cerastium fontanum	1					II	(1)

H10b

Quadrat No.	59	60	61	62	63		
Quadrant	Delting	Delting	Nesting	Kergord	Kergord		
Date	19/05/08	30/05/08	14/05/08	05/06/08	12/07/08		
Eastings	40529	38963	45781	38928	38168		
Northings	69675	67290	56993	61176	55339		
Surveyor	N. Dayton	K. Proctor	T. Rafferty	K. Proctor	T. Rafferty		
Slope (degrees)	0	10		5			
Aspect (degrees)	N.A.	330		250			
Height (heath/herb/moss)	5/12/5	10/12/5	25/0/20	8/10/2	10/20/4		
% cover (heath/herb/moss)	50/10/50	40/8/80	80/0/50	25/20/15	90/1/40		
Species:							
Calluna vulgaris	7	7	9	5	9	V	(5-9)
Racomitrium lanuginosum	8	8	6	5	5	V	(5-8)
Hypnum jutlandicum	5	3	5	3	3	V	(3-5)
Hylocomium splendens	4	4	3		3	IV	(3-4)
Deschampsia flexuosa	4	3		3	3	IV	(3-4)
Empetrum nigrum spp. nigrum	3	2	3		3	IV	(2-3)
Nardus stricta	4	3		5		III	(3-5)
Erica cinerea		2		5	4	III	(2-5)
Agrostis capillaris		3		2		III	(2-3)
Cladonia uncialis		3		2		III	(2-3)
Festuca vivipara	1			3		III	(1-3)
Carex bigelowii	1			2		III	(1-2)

Carex panicea			4		II	(4)
Potentilla erecta		3	3		II	(3)
Vaccinium myrtillus	3	3			II	(3)
Cladonia portentosa		3			II	(3)
Rhytidiadelphus loreus		3			II	(3)
Juncus squarrosus	3				II	(3)
Vaccinium vitis-idaea	1				II	(1)
Huperzia selago	1				II	(1)
Carex binervis				3	I	(3)
Bare ground			8		I	(8)

H12a/H12c

Quadrat No.	64	65		
Quadrant	Kergord	Kergord		
Date	01/06/08	11/07/08		
Eastings	36804	38392		
Northings	54433	57093		
Surveyor	T. Rafferty	T. Rafferty		
Slope (degrees)				
Aspect (degrees)				
Height (heath/herb/moss)	30/40/4	20/30/4		
% cover (heath/herb/moss)	95/5/50	70/25/40		
Species:				
Calluna vulgaris	10	8	III	(8-10)
Hylocomium splendens	7	5	III	(5-7)
Rhytidiadelphus loreus	4	4	III	(4)
Vaccinium myrtillus	3	3	III	(3)
Carex nigra	2	4	III	(2-4)
Juncus squarrosus		5	II	(5)
Thuidium tamariscinum	3		II	(3)
Nardus stricta		3	II	(3)
Anthoxanthum odoratum		3	II	(3)
Potentilla erecta		3	II	(3)
Luzula multiflora		3	II	(3)
Polytrichum commune		3	II	(3)
Hypnum jutlandicum		3	II	(3)
Eriophorum angustifolium	2		II	(2)

H14

Quadrat No.	66

Quadrant	Kergord
Date	12/07/08
Eastings	39058
Northings	58288
Surveyor	K. Proctor
Slope (degrees)	3
Aspect (degrees)	225
Height (heath/herb/moss)	7/8/3
% cover (heath/herb/moss)	30/25/50

Species:

Calluna vulgaris	6	II	(6)
Racomitrium lanuginosum	6	II	(6)
Juncus squarrosus	5	II	(5)
Sphagnum capillifolium	5	II	(5)
Nardus stricta	3	II	(3)
Vaccinium myrtillus	3	II	(3)
Eriophorum angustifolium	3	II	(3)
Empetrum nigrum	3	II	(3)
Cladonia portentosa	3	II	(3)
Hypnum jutlandicum	3	II	(3)
Listera cordata	2	II	(2)
Cladonia uncialis	2	II	(2)

U6a

Quadrat No.	67	68	69
Quadrant	Delting	Kergord	Kergord
Date	19/05/08	12/07/08	12/07/08
Eastings	40554	39123	39053
Northings	70489	60301	60423
Surveyor	N. Dayton	K. Proctor	K. Proctor
Slope (degrees)	3	10	5
Aspect (degrees)	330	080	020
Height (heath/herb/moss)	0/12/5	10/15/4	10/20/5
% cover (heath/herb/moss)	0/80/50	2/50/60	5/35/75

Species:

Juncus squarrosus	8	7	6	IV	(6-8)
Sphagnum papillosum	4	7	8	IV	(4-8)
Nardus stricta	4	3	3	IV	(3-4)

Sphagnum capillifolium	7		4			III	(4-7)
Eriophorum angustifolium		4	4			III	(4)
Sphagnum palustre		4	4			III	(4)
Calluna vulgaris		3	4			III	(3-4)
Festuca vivipara	3	2				III	(2-3)
Luzula multiflora	1	1				III	(1)
Potentilla erecta	4					II	(4)
Polytrichum commune	4					II	(4)
Rhytidiadelphus squarrosus	4					II	(4)
Agrostis canina	4					II	(4)
Polytrichum juniperinum		4				II	(4)
Mnium hornum	3					II	(3)
Deschampsia flexuosa		3				II	(3)
Agrostis capillaris		3				II	(3)
Rhytidiadelphus loreus		3				II	(3)
Viola riviniana			3			II	(3)
Carex echinata			3			II	(3)

U6d

Quadrat No.	70	71	72	73	74
Quadrant	Delting	Delting	Kergord	Kergord	Kergord
Date	13/05/08	19/05/08	05/06/08	12/07/08	13/07/08
Eastings	43065	39666	39029	38675	41095
Northings	72382	70195	56549	58353	63709
Surveyor	K. Proctor	N. Dayton	T. Rafferty	K. Proctor	T. Rafferty
Slope (degrees)	2	0		0	
Aspect (degrees)	030	N.A.		N.A.	
Height (heath/herb/moss)	0/10/2	0/3/1	25/20/3	5/20/3	15/30/4
% cover (heath/herb/moss)	0/90/30	0/100/20	10/95/5	<1/90/25	1/70/60

Species:

Juncus squarrosus	9	6	10	9	5	V	(5-10)
Hylocomium splendens	4	5		3	6	IV	(3-6)
Rhytidiadelphus loreus	3		4	5	6	IV	(3-6)
Nardus stricta	3	5		4	4	IV	(3-5)
Anthoxanthum odoratum	4	4			3	III	(3-4)
Potentilla erecta	3	3			3	III	(3)
Rhytidiadelphus	4	4		2		III	(2-

squarrosus							4)
Empetrum nigrum			3	2	3	III	(2-3)
Polytrichum commune	3	6				II	(3-6)
Festuca ovina	3	4				II	(3-4)
Agrostis capillaris		4		3		II	(3-4)
Galium saxatile	3	3				II	(3)
Mnium hornum	3			3		II	(3)
Deschampsia flexuosa				3	3	II	(3)
Calluna vulgaris			4	2		II	(2-4)
Rumex acetosa	4					I	(4)
Polytrichum juniperinum	4					I	(4)
Dicranum scoparium		4				I	(4)
Pleurozium schreberi				4		I	(4)
Trichophorum cespitosum					4	I	(4)
Aulacomnium palustre					4	I	(4)
Hylocomium splendens	3					I	(3)
Luzula multiflora		3				I	(3)
Eriophorum angustifolium				3		I	(3)
Agrostis canina					3	I	(3)
Nathecium ossifragum					3	I	(3)
Campanula rotundifolia		2				I	(2)
Plagiothecium undulatum				2		I	(2)
Carex spp.		1				I	(1)
Bare peat				4		I	(4)

Technical Appendix 8.3: Groundwater Dependent Terrestrial Ecosystems

8.1.1 Table 8.3.1 provides information on the area of each NVC community in the ecological study area that is groundwater dependent, with their locations shown on Figure 8.3: NVC Communities and Figure 8.4: GWDTE.

Table 8.3.1: NVC Communities and their Groundwater Dependency

NVC Community	Groundwater Dependency	Area (ha)
H10/U6d/U4a	Moderate	7.73
H10a/M6c/U4a	High	0.21
H10b/M17b/U6d	Moderate	0.91
H10c/M15d/U4a	Moderate	0.46
H10c/U6d/H10a/M19	Moderate	4.14
H12c/U6	Moderate	0.89
H12c/U6d	Moderate	1.27
H21a/H10/M15b/U6d/U4a	Moderate	0.50
M10	High	0.09
M15b	Moderate	0.62
M15b/H10/H21a/U4a	Moderate	0.95
M15b/H10a/M10a	Moderate/high	2.35
M15b/H10b	Moderate	1.68
M15b/M17	Moderate	0.35
M15b/M17a/U6	Moderate	0.73
M15b/M17b/U6a/M3	Moderate	2.56
M15b/M6c/U6a/H10a	Moderate/high	0.50
M15b/U4a/U6d/H10	Moderate	3.59
M15b/U6d/U4a	Moderate	0.83
M15c/H10b/M19/M17b	Moderate	2.91
M15c/M17b/M19	Moderate	2.32
M15d	Moderate	0.80
M15d/H10	Moderate	0.60
M15d/H10b	Moderate	0.24
M15d/H10b/U4a	Moderate	1.60
M15d/H10c/U6d	Moderate	2.49
M15d/M10a	Moderate	2.20
M15d/M15b/H10/M19	Moderate	3.76
M15d/M17b/M19/U6/M3	Moderate	2.04
M15d/M17b/M3/M19/U6d	Moderate	1.92
M15d/M17b/U6a	Moderate	2.12
M15d/M17b/U6d/M3	Moderate	1.87

Table 8.3.1: NVC Communities and their Groundwater Dependency		
M15d/M17c/M3	Moderate	3.25
M15d/M19	Moderate	0.34
M15d/M19/H10c/U6a	Moderate	1.43
M15d/M3/M19/M17c	Moderate	0.96
M15d/M3/M19/U6d	Moderate	1.17
M15d/U4a/M19/U6	Moderate	1.54
M15d/U6/M3/M17b	Moderate	6.38
M15d/U6a	Moderate	0.66
M15d/U6a/H10b	Moderate	2.45
M15d/U6a/M17b/M1	Moderate	2.87
M15d/U6a/M17c/M17a	Moderate	0.38
M15d/U6d	Moderate	2.68
M15d/U6d/M17b	Moderate	0.12
M17/M3/M15d/U6	Moderate	1.21
M17/M3/U6	Moderate	2.84
M17/M3/U6a/M15d	Moderate	0.91
M17/U6/M15d/M3	Moderate	4.34
M17a/M15d/M17c	Moderate	1.40
M17a/M17b/M1/M3/U6a	Moderate	0.36
M17a/M17b/M19/M1/M30	Moderate	5.56
M17a/M17b/M30	Moderate	1.91
M17a/M17b/U6d/M19/M15b	Moderate	1.84
M17a/M17c/M15d	Moderate	3.53
M17a/M30/M3	Moderate	0.73
M17a/M6	High	1.45
M17a/M6b	High	1.31
M17b/M15b	Moderate	0.98
M17b/M15b/M3	Moderate	4.01
M17b/M15c	Moderate	3.34
M17b/M15c/M17a	Moderate	2.03
M17b/M15c/M19	Moderate	1.25
M17b/M15d	Moderate	0.28
M17b/M15d/M17a/U6/H10b	Moderate	0.91
M17b/M15d/M3	Moderate	7.46
M17b/M15d/M3/U6	Moderate	0.31
M17b/M15d/M3/U6a	Moderate	4.86
M17b/M15d/M3/U6d	Moderate	0.49

Table 8.3.1: NVC Communities and their Groundwater Dependency		
M17b/M15d/U6/M3	Moderate	1.59
M17b/M15d/U6a	Moderate	2.65
M17b/M15d/U6a/M3	Moderate	2.98
M17b/M17a/M15c	Moderate	3.45
M17b/M17a/M15c/M3/M19	Moderate	1.74
M17b/M17a/M15d/M1	Moderate	3.42
M17b/M17a/M15d/M19/U6a	Moderate	2.52
M17b/M17a/M15d/U6	Moderate	1.51
M17b/M17a/M19/M15d	Moderate	3.31
M17b/M17a/M19/M3/U6/M15	Moderate	4.06
M17b/M17a/M3/M15d/U6	Moderate	1.68
M17b/M17a/M30/M3/M19	Moderate	12.11
M17b/M17a/U6	Moderate	4.91
M17b/M17aU6a/M19/M3	Moderate	1.50
M17b/M19/M3/U6d	Moderate	1.02
M17b/M19/U6a/M15d/M3	Moderate	6.29
M17b/M3/M15b	Moderate	0.54
M17b/M3/M15b/U6d	Moderate	0.78
M17b/M3/M15d/U6	Moderate	1.08
M17b/M3/M15d/U6a	Moderate	3.23
M17b/M3/M17c/U6d/M15d	Moderate	2.06
M17b/M3/M19/M15d	Moderate	0.37
M17b/M3/U6	Moderate	23.25
M17b/M3/U6/M15d	Moderate	5.11
M17b/M3/U6/U4	Moderate	5.88
M17b/M3/U6a	Moderate	41.56
M17b/M3/U6d	Moderate	11.53
M17b/M3/U6d/M15d	Moderate	6.39
M17b/U6/M19/M3	Moderate	1.09
M17b/U6a	Moderate	10.62
M17b/U6a/M15d	Moderate	1.36
M17b/U6a/M3	Moderate	0.21
M17b/U6a/M3	Moderate	2.04
M17b/U6a/M3/M15d/H10b	Moderate	4.13
M17b/U6d	Moderate	1.17
M17b/U6d/U4a/M3	Moderate	1.06
M17c/M15d/U4a	Moderate	0.18

Table 8.3.1: NVC Communities and their Groundwater Dependency		
M17c/M17a/U4a/M15d	Moderate	4.05
M17c/M17b/U6c/M3	Moderate	1.93
M19/H10a/U6d/U4a	Moderate	1.46
M19/M15b	Moderate	9.70
M19/M15b/U4/M6b/U6	Moderate/high	0.92
M19/M15b/U6d	Moderate	9.23
M19/M15c/M15d/M17c	Moderate	2.63
M19/M15c/M19/M17c	Moderate	0.55
M19/M15d	Moderate	20.06
M19/M15d/M15c	Moderate	1.62
M19/M15d/M17c/M3	Moderate	8.25
M19/M15d/M3	Moderate	3.84
M19/M15d/U6d	Moderate	2.70
M19/M17a/M15b/M3	Moderate	1.68
M19/M17a/M15c	Moderate	3.42
M19/M17a/M15d	Moderate	2.28
M19/M17a/M15d/U6/M3	Moderate	0.89
M19/M17a/U6d	Moderate	5.37
M19/M17b/M10a	High	1.46
M19/M17b/M15d/U6	Moderate	6.00
M19/M17b/M3/M15d	Moderate	3.73
M19/M17b/U6a	Moderate	2.11
M19/M3/M15d	Moderate	2.07
M19/M3/M15d	Moderate	1.85
M19/M3/M17b/U6d/M15d	Moderate	1.77
M19/M5d/U6d	High/moderate	3.13
M19/M6/U6d	High/moderate	0.41
M19/M6b	High	3.21
M19/M6b/M6c	High	0.20
M19/U4/M6	High	2.28
M19/U6	Moderate	15.15
M19/U6/U4	Moderate	1.31
M19/U6a	Moderate	1.27
M19/U6a/U6d	Moderate	4.32
M19/U6d	Moderate	25.20
M19/U6d/H10c	Moderate	8.56
M19/U6d/M15d	Moderate	1.78

Table 8.3.1: NVC Communities and their Groundwater Dependency		
M19/U6d/M17a	Moderate	2.46
M19/U6d/U4	Moderate	0.12
M3/M15d/M19/U6d	Moderate	3.78
M3/M15d/U6d	Moderate	0.12
M3/M17b/M15d/U6d/U4a	Moderate	2.74
M3/M17b/M17a/M15d/U6	Moderate	5.24
M3/M17b/M19/M15d	Moderate	0.36
M3/M17b/U6/M15d	Moderate	2.44
M3/M17b/U6a	Moderate	3.65
M3/M17b/U6d/M15d/H10b	Moderate	7.97
M3/M17cM15d	Moderate	0.24
M3/M19/U6d	Moderate	0.79
M3/M19/U6d/M15d	Moderate	1.22
M3/M19/U6d/M17c	Moderate	3.31
M3/U4a/U6	Moderate	7.33
M3/U6/M15d/M17b	Moderate	1.31
M3/U6/M17b/M15d	Moderate	1.79
M3/U6a	Moderate	0.57
M3/U6d	Moderate	0.54
M3/U6d/M1/U4a/M17b/H10b	Moderate	6.87
M3/U6d/M19/M15d	Moderate	5.14
M3/U6d/U4a/M15d/M17b	Moderate	2.15
M3/U6d/U5b/M15d/M17c	Moderate	1.22
M30/M17a/M1	Moderate	0.16
M30/M6b	Moderate/high	0.37
M6/H21a/U6a/U4a	High/moderate	0.54
M6/M30	High/moderate	0.09
M6/U4a/M19	High	0.22
M6/U6	High/moderate	0.03
M6b	High	0.06
M6b//U4a/U6d	High/moderate	0.22
M6b/M17a	High	1.26
M6b/M30	High/moderate	0.08
M6b/U6	High/moderate	0.30
M6c	High	0.87
M6c/M6b	High	0.09
M6c/U4a/M15d	High/moderate	0.22

Table 8.3.1: NVC Communities and their Groundwater Dependency		
M6c/U4a/U6/H10a	High/moderate	0.24
M6c/U6d	High/moderate	0.54
M6c/U6d/H12c	High/moderate	0.51
M6c/U6d/U5b/M15	High/moderate	0.21
U4/M19/U6d/M15d	Moderate	1.31
U4/U6d/M15d/M19	Moderate	0.08
U4a/H10/M6b/M10/M3	High/moderate	0.27
U4a/M15d/U6a/M6	Moderate/high	0.20
U4a/U6d/M6c	Moderate/high	1.25
U4b/M17c/M23b	High	11.81
U4b/M23b	High	1.62
U4b/MG10a	Moderate	5.25
U4b/U4a/M15d/H10c/M6	Moderate/high	3.90
U4b/U6d/M6c/H10c	Moderate/high	0.57
U5/M6c	High	0.19
U5b/U6d/M15d	Moderate	0.95
U6/H10	Moderate	0.21
U6/M15d	Moderate	0.37
U6/M3/M15d/H10b/M17b	Moderate	6.72
U6/M3/M15d/M19	Moderate	1.39
U6/M3/M17b/M15d	Moderate	2.74
U6/M6c	Moderate/high	0.23
U6/U4/M15d	Moderate	5.99
U6/U4b	Moderate	1.36
U6/U5	Moderate	0.47
U6a	Moderate	0.52
U6a/M15d/M6c	Moderate/high	0.64
U6a/M15d/U4a/M6c	Moderate/high	0.10
U6a/M17b/H10b	Moderate	3.63
U6a/M6b/M15d	Moderate/high	0.07
U6a/M6c	Moderate/high	0.42
U6a/U5b	Moderate	2.08
U6d	Moderate	1.92
U6d/CG10a/M15d	Moderate/high	1.88
U6d/H12c	Moderate	2.51
U6d/M15b	Moderate	0.21
U6d/M15d	Moderate	10.50

Table 8.3.1: NVC Communities and their Groundwater Dependency

U6d/M15d/M19/H12c	Moderate	3.80
U6d/M15d/U4a	Moderate	1.05
U6d/M19/M15d	Moderate	4.30
U6d/M19/M15d/M3/U4	Moderate	1.02
U6d/M19/M17b/M3/M15d	Moderate	1.57
U6d/M3/M15d/M17b	Moderate	1.00
U6d/M6c	Moderate/high	1.34
U6d/M6c/M15d	Moderate/high	0.55
U6d/U4a	Moderate	7.42
Total		**638.31**

APPENDIX 8.4: RARE PLANTS SURVEY

The information contained within Rare Plants Survey that supported the 2009 ES was seen as relevant and thus was included in the 2018 EIA.

Viking Energy

RARE PLANTS SURVEY: VIKING WINDFARM

October 2008

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Catchment Management

Sustainability

Status : Final

Job No : 12411j
Copy No : 0
Rev. No : 00

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Table of Contents

List of Tables

1. INTRODUCTION

A National Vegetation Classification survey of specified parts of the Viking Windfarm application site was undertaken by Highland Ecology during the late-Spring/early-Summer months of April to June in 2008. That survey focused on the classification and mapping of the vegetation communities located within a 100m buffer zone extending from the situation of the tracks and turbine locations (resulting in a 200m wide corridor of vegetation classification).

Although it was undertaken within the recommended timeframe, the relatively early timing of the National Vegetation Classification survey was expected to result in a potential bias towards early flowering species. It was therefore considered prudent to undertake a further survey towards the end of the summer in order to record a full species list from each of the communities or areas highlighted as potentially containing rare or threatened species in a national or regional (Shetland) context. This report contains the findings of that survey and discusses their significance.

2. METHODOLOGY

The current survey was undertaken between the 11th and 15th of August, 2008 and focused on the communities and locations listed below in Table 1 that were identified by Highland Ecology as potentially containing notable species. Each location was determined precisely using a hand-held GPS unit (Garmin e-Trex) and a visual assessment made of the extent of the target communities or features. From within the limits of each of these communities or features, a comprehensive list of all of the bryophyte and phanerogam (flowering plant) species was produced.

In the case of the M10 community in particular, small 'islands' of the surrounding (blanket bog) vegetation were occasionally present within the flushes. It was decided that the species present on these islands would be omitted from the list unless they were rooted strictly within the limits of the community or feature of interest or were notable for their rarity (although the latter circumstance did not arise in practice).

The phanerogam species found at each location are listed in the tables below with their scientific and vernacular names. Although they have been contrived as a requirement of the Wildlife and Countryside Act (1981), the vernacular names for the bryophytes are not given because they have not entered into standard usage amongst bryologists or conservationists. Otherwise, the nomenclature follows the standard floras for each group[1].

The abundance of each species is also reported in the tables below according to the semi-quantitative DAFOR scale (*i.e.* **D**ominant, **A**bundant, **F**requent, **O**ccasional and **R**are).

[1] Phanerogams: Stace, C.A. 1997 New Flora of the British Isles. Cambridge University Press.
Mosses: Smith, A.J.E. 2004 The Moss Flora of Britain and Ireland. Cambridge University Press.
Liverworts: Paton, J.A. 1999 The Liverwort Flora of the British Isles. Harley Books.

Table 1: Locations or National Vegetation Classification Communities identified during the National Vegetation Classification survey as requiring a re-visit to check for the presence notable plant species. Their label within this report, grid reference and a description are indicated.

Report Section and Label	Grid Ref. (HU)	Description
3.1 M10 and M30 flush communities	Various	M10 flushes in general. These appeared to fairly species poor but should be checked when encountered on walk-over. They are fairly frequent each occurrence is not listed separately but they are target noted. Some of the target-noted M30 flushes target noted are also worth a second look (especially those listed below).
3.2 Calcareous Grassland	41978 61507	Short-grazed, species-rich calcareous grassland (CG10a) around rocky outcrop. Area should be re-visited in August to search for potential Shetland rarities and to gather a full species list, particularly the crevices and ledges that are inaccessible to grazers.
3.3 Rock outcrops	39179 57674	Scattered rocky outcrops in close proximity to one another. *Poa alpina* may grow here and it is not previously recorded from Shetland. This should be surveyed as the sample collected could not be positively confirmed.
3.4 Borrow pit	38467 56263	There may be base enrichment here as there are M10a flushes in this area which appear to be richer than usual. *Vaccinium uliginosum* was also found here and not seen elsewhere on survey.
3.5 Flush A	41659 66215	Small, species-rich, grassy flush with putative *Trollius europaeus* just emerging so worth a check.
3.6 Flush B	42309 65953	*Potamogeton polygonifolius* flush (M30) through a large area of species-rich, flushed grassland.
3.7 Flush C	41912 66099	*Potamogeton polygonifolius* flush (M30) through blanket bog (M17a) in good condition. Flush supports a rich flora with herbs as yet too small to identify.
3.8 Flush D	41083 70932	Flushed grassland around a herb-rich spring-head
3.9 Flush E	41035 70864	Site of turbine 10 with frequent base-rich flush communities
3.10 Meadow of Fitchin	39 70	Watercourses/burns in the vicinity of the Meadow of Fitchin, some of which appeared quite rich at the time of survey.
3.11 Flush F	38524 67072	A small stand of flushed grassland on the hillside with M6c and M6b at the base of the slope and some U4 grassland, *Philonotis fontana* springs M32 and base-rich flushes M10 at the top.
3.12 Oxnabool Burn	40287 70347	Mossy bank on the burn of Oxnabool with *Fontinalis antipyretica* in the stream and *Ranunculus flammula, Callitriche stagnalis* and *Persicaria amphibia* (new hectad record for this species).

At each of the locations specific attention was paid to the possible occurrence of rare, threatened or protected species and those that are rare in a Shetland context. Those species that were considered as potentially present in the habitats and areas visited during the course of the survey are listed in Table 2 according to their local, national and international rarity.

The weather during the course of the survey was dry and bright but overcast with occasional showers and mist towards the end of the week. These were ideal conditions for the survey, in terms of visibility and comfortable operating conditions.

Table 2: List of rare or otherwise notable species locally, in the UK, or Europe that are present in Shetland[2].

Internationally Rare	
Arenaria norvegica	*Euphrasia marshallii*
Cochlearia officinalis subsp. *scotica*	*Hieracium* spp.
Dactylorhiza incarnata subspp.	*Rumex acetosa* subsp. *hibernicus*
Euphrasia heslop-harrisonii	*Taraxacum* spp.
Wildlife and Countryside Act 1981	
Arneria norvegica subsp. *norvegica*	*Hieraceum* spp.
Nationally rare. Red Data Book Species	
Arenaria norvegica subsp. *norvegica*	*Hammarbya paludosa*
Carex aquatilis	*Pilosella flagellaris* subsp. *bicapitata*
Cochlearia officinalis subsp. *scotica*	*Polygonum boreale*
Eleocharis acicularis	*Potamogeton friesii*
Euphrasia frigida	*Potamogeton filiformis*
Euphrasia heslop-harrisonii	*Potamogeton praelongum*
Euphrasia marshallii	*Salix lapponum*
Euphrasia ostenfeldii	*Subularia aquatica*
Euphrasia foulaensis	*Taraxacum* spp.
Gnaphalium sylvaticum	
Locally Rare	
Alchemilla alpina	*Molinia caerulea* subsp. *arundinacea*
Betula pubescens subsp. *tortuosa*	*Myriophyllum spicatum*
Campanula rotundifolia	*Nymphaea alba* subsp. *occidentlis*
Chamerion angustifolium	*Osmunda regalis*
Cornus suecica	*Phyllitis scolopendrium*
Corylus avellana	*Polygonum aviculare*
Dactylorhiza incarnata subspp.	*Polypodium x mantoniae*
Drosera anglica	*Populus tremula*
Empetrum hermaphroditum	*Poramogeton friesii*
Euphrasia frigida	*Potamogeton filiformis*
Euphrasia heslop-harrisonii	*Potamogeton rutilius*
Festuca rubra subsp. *arctica*	*Rumex actetosa* subsp. *hibernicus*
Festuca rubra subsp. *scotica*	*Salicornia europaea* agg.
Gymnadenia conopsea subsp. *borealis*	*Salix cinerea subsp. cinerea*
Hammarbya paludosa	*Salix lapponum*
Hieracium spp.	*Salix x multinervis*
Juncus trifidus	*Saussurea alpina*
Juncus triglumis	*Sedum anglicum*
Juniperus communis	*Sparganium* spp.
Loiseleuria procumbens	*Taraxacum* spp.
Luzula spicata	*Trifolium dubium*
Melampyrum pratense subsp. *pratense*	*Vaccinium oxycoccus*

[2] Scott, W., Harvey, P., Diddlington, R. and Fisher, M. 2002 Rare plants of Shetland. Shetland Amenity Trust, Lerwick

3. RESULTS AND DISCUSSION

In this section of the report, the results of the floristic survey (a list of the species and their abundance) for each of the locations or National Vegetation Classification communities specified in Table 1 are presented. Each table lists the phanerogam species initially with the bryophyte species listed below. References to Target Notes refer to those included in the highland Ecology report on the National Vegetation Classification of the site included as an appendix with the Environmental Statement. A series of photographs were also taken and these can be provided upon request.

3.1 M10 and M30 flush communities

The greatest concentration of M10 flushes was located in Nesting but this community type is generally widespread and frequent to occasional, but localized, throughout most of the application site, with exception to the Collafirth quadrant, where only two species-poor examples were located. As a result of this frequency, a subset of target-noted M10 communities was selected, in the field, to represent the range of floristic diversity in the vicinity of each locality. The M30 community is less frequent in its occurrence and is generally confined to the margins of soakways and rills which limit its extent in relation to the larger expanses of M10.

Further observations of the floristic of the M10 and M30 communities are included in Sections 3.4, 3.5, 3.6, 3.7, 3.9 and 3.11.

3.1.1 Nesting M10 and M30 communities.

The M10 communities at Nesting were generally rather peaty with little exposure of the potentially base-rich, mineral substrate. This resulted in a greater frequency and cover of typical bog species such as common bog-cotton and bog asphodel than within the limits of the community elsewhere within the application boundary, as well as a high degree of intergradation with the M30 community type as evidenced in the high cover frequently attributable to bog pondweed.

Table 3: List of M30 species recorded at Target Note 12, Nesting.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	O
Calluna vulgaris	Heather	R
Carex nigra	Black Sedge	A
Carex panicea	Carnation Grass	O
Eriophorum angustifolium	Common Bog-cotton	R
Juncus articulatus	Jointed Rush	R
Juncus bulbosus	Bulbous Rush	O
Nardus stricta	Mat Grass	R
Potamogeton polygonifolius	Bog Pondweed	A
Ranunculus flammula	Lesser Spearwort	O
Sphagnum denticulatum	A moss	O

The vegetation cover within these communities was generally rather closed, especially in the case of Target Note 83, in comparison to examples elsewhere within the application boundary. Sedges are especially prominent with a typical cover of around 30% and the levels of grazing result in the frequent removal of their flowering spikes and the associated poaching, in combination with the closeness of the sward, is assumed to responsible for the low diversity and abundance of moss and liverwort species.

Table 4: List of M10 species recorded at Target Note 17, Nesting.

Scientific Name	Vernacular Name	Abundance
Carex panicea	Carnation Grass	F
Carex viridula subsp. *oedocarpa*	Yellow Sedge	A
Eriophorum angustifolium	Common Bog-cotton	R
Juncus articulatus	Jointed Rush	O
Juncus bulbosus	Bulbous Rush	O
Juncus squarrosus	Heath Rush	R
Montia fontana	Blinks	O
Nardus stricta	Mat Grass	O
Narthecium ossifragum	Bog Asphodel	R
Pinguicula vulgaris	Common Butterwort	F
Potamogeton polygonifolius	Bog Pondweed	F
Ranunculus flammula	Lesser Spearwort	O
Aneura pinguis	A liverwort	O
Blindia acuta	A moss	O
Pellia sp.	A liverwort	O
Racomitrium lanuginosum	A moss	R
Sphagnum compactum	A moss	R
Sphagnum denticulatum	A moss	F

Table 5: List of M10 species recorded at Target Note 29, Nesting.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	R
Carex dioica	Dioecious Sedge	O
Carex echinata	Start Sedge	R
Carex nigra	Black Sedge	O
Carex panicea	Carnation Grass	O
Carex pulicaris	Flea Sedge	O
Carex viridula subsp. Oedocarpa	Yellow Sedge	A
Danthonia decumbens	Heath Grass	R
Eleocharis palustris	Common Spike-rush	O
Eriophorum angustifolium	Common Bog-cotton	O
Festuca vivipara	Viviparous fescue	R
Juncus articulatus	Jointed Rush	F
Juncus bulbosus	Bulbous Rush	F
Nardus stricta	Mat Grass	O
Narthecium ossifragum	Bog Asphodel	R

Pinguicula vulgaris	Common Butterwort	R
Potamogeton polygonifolius	Bog Pondweed	R
Prunella vulgaris	Self-heal	R
Schoenus nigricans	Black Bog-rush	A
Selaginella selaginoides	Selaginella	R
Blindia acuta	A moss	R
Bryum pseudotriquetrum	A moss	R
Campylium stellatum	A moss	R
Scorpidium scorpioides	A moss	F
Sphagnum denticulatum	A moss	R

The M10 flush indicated by Target Note 29 is situated with 300m of the coast and this has resulted in a somewhat distinctive vegetation composition, especially the abundance of black bog-rush. It is assumed that the maritime influence is also responsible for the relatively low abundance mosses and especially, the absence of liverworts.

Table 6: List of M10 species recorded at Target Note 83, Nesting.

Scientific Name	Vernacular Name	Abundance
Carex hostiana	Tawny Sedge	R
Carex viridula subsp*. oedocarpa*	Yellow Sedge	A
Crepis capillaris	Smooth Hawksbeard	R
Drosera rotundifolia	Round-leaved Sundew	R
Eleocharis palustris	Marsh Spike-rush	A
Equisetum palustre	Marsh Horsetail	R
Eriophorum angustifolium	Common Bog-cotton	O
Juncus articulatus	Jointed Rush	R
Juncus bulbosus	Bulbous Rush	R
Molinia caerulea	Purple Moor-grass	R
Narthecium ossifragum	Bog Asphodel	R
Pinguicula vulgaris	Common Butterwort	F
Plantago maritima	Sea Plantain	R
Ranunculus flammula	Lesser Spearwort	R
Schoenus nigricans	Black Bog-rush	R
Selaginella selaginoides	Selaginella	R
Succisa pratensis	Devil's-bit Scabious	R
Trichophorum caespitosum	Deergrass	R
Aneura pinguis	A liverwort	R
Blindia acuta	A moss	O
Campylium stellatum	A moss	R
Scorpidium scorpioides	A moss	A

3.1.2 Delting M10 communities

Table 7: List of M10 species recorded at Target Notes 268 and 274, Delting.

Scientific Name	Vernacular Name	Abundance
Carex hostiana	Tawny Sedge	R
Carex viridula subsp. oedocarpa	Yellow Sedge	A
Drosera rotundifolia	Round-leaved Sundew	O
Eriophorum angustifolium	Common Bog-cotton	F
Festuca ovina	Sheep's Fescue	O
Juncus articulatus	Jointed Rush	R
Juncus squarrosus	Heath Rush	O
Nardus stricta	Mat Grass	O
Narthecium ossifragum	Bog Asphodel	R
Pinguicula vulgaris	Common Butterwort	F
Selaginella selaginoides	Selaginella	R
Aneura pinguis	A liverwort	O
Blepharostoma trichophylla	A liverwort	R
Blindia acuta	A moss	F
Campylopus introflexus	A moss	R
Nardia compressa	A liverwort	O

The M10 flushes in the vicinity of Target Notes 268 and 274 are rather species-poor in relation to examples elsewhere within the application boundary. This is presumed to a reflection of their relatively small area, both individually and cumulatively, as well as the prominence of edge effects because each occurrence is a linear drainage feature, directed downslope, and all are less than 5m wide.

A *Taraxacum* species that was not in flower, and consequently indefinitely determinable, was also recorded from blanket bog habitat in this vicinity. On the basis of leaf shape and habitat, it is assumed that this species is *T. faeroense* – a widespread and common species that is distinctive in its blanket bog habitat, leaf form and colour.

3.1.3 Kergord M10 and M30 communities

The M10 flushes indicated by target Notes 334 and 336 have developed over siliceous rock, which is exposed in places, and this has resulted in the development of a rather indistinct flora due to the low level of base-enrichment. As well as the more distinctive elements listed in Table 7 that were rooted within the exact limits of the flush areas, there are frequent small islands of blanket bog vegetation and this, in combination with the peat hagging evident in their vicinity, may indicate the relatively recent exposure of the flushed rock surfaces.

As is evident in the number of species listed in Table 8, the flush at Target Note 339 is most species-rich of the M10 communities visited during the course of the survey. This richness is assumed to relate to the large size of the flush and the availability of a variety of niches as well as the consequent ability of the distinctive species to maintain viable populations. Although the flush is crossed by numerous sheep tracks, grazing within it appears to be limited by the openness of the vegetation. The exposure of the mineral substrate is prominent within the flush and the herb cover is less than 10%.

Table 8: List of M10 species recorded at Target Notes 334 and 336, Kergord.

Scientific Name	Vernacular Name	Abundance
Carex panicea	Carnation Grass	O
Carex viridula subsp. oedocarpa	Yellow Sedge	A
Juncus bulbosus	Bulbous Rush	F
Juncus squarrosus	Heath Rush	O
Nardus stricta	Mat Grass	F
Andreaea rupestris	A moss	O
Blindia acuta	A moss	O
Nardia scalaris	A liverwort	R
Racomitrium heterostichum	A moss	R
Racomitrium lanuginosum	A moss	O
Sphagnum denticulatum	A moss	F

The plants recorded from the M30 community indicated by Target Note 356, and listed in Table 9, are rooted in peat marginally, or within a floating mat of the moss *Sphagnum denticulatum* towards the centre of the flush. A degree of enrichment is evident in the lush appearance of the vegetation and the presence of species such as soft rush and creeping bent and the moss *Campylium stellatum*. This has been amplified further through preferential grazing by sheep and a high degree of poaching has thus taken place which has resulted in the occasional appearance of the ruderal, procumbent pearlwort. A small rill is confined to the centre of the flush and is evident in the associated abundance of bog pondweed.

Table 9: List of M30 species recorded at Target Note 356, Kergord.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	F
Carex panicea	Carnation Grass	R
Eriophorum angustifolium	Common Bog-cotton	R
Juncus articulatus	Jointed Rush	R
Juncus bulbosus	Bulbous Rush	A
Montia fontana	Blinks	R
Potamogeton polygonifolius	Bog Pondweed	A
Ranunculus flammula	Lesser Spearwort	F
Rumex acetosa	Sorrel	R
Trichophorum caespitosum	Deergrass	F
Polytrichum commune	A moss	O
Sphagnum denticulatum	A moss	A
Sphagnum capillifolium	A moss	R
Sphagnum palustre	A moss	O

Table 10: List of M10 species recorded at Target Note 339, Kergord.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	R
Cardamine pratensis	Cuckooflower	R
Carex dioica	Dioecious Sedge	R
Carex hostiana	Tawny Sedge	O
Carex panicea	Carnation Grass	O
Carex pulicaris	Flea Sedge	R
Carex viridula subsp. oedocarpa	Yellow Sedge	A
Eleocharis palustris	Marsh Spike-rush	F
Equisetum palustre	Marsh Horsetail	R
Eriophorum angustifolium	Common Bog-cotton	R
Euphrasia scotica	Eyebright	R
Juncus articulatus	Jointed Rush	O
Juncus bulbosus	Bulbous Rush	O
Juncus effusus	Soft Rush	R
Pinguicula vulgaris	Common Butterwort	O
Potamogeton polygonifolius	Bog Pondweed	R
Prunella vulgaris	Self-heal	O
Ranunculus flammula	Lesser Spearwort	R
Rumex acetosella	Sheep's Sorrel	R
Sagina procumbens	Procumbent Pearlwort	O
Selaginella selaginoides	Selaginella	R
Thalictrum alpinum	Alpine Meadow-rue	R
Aneura pinguis	A liverwort	R
Blindia acuta	A moss	F
Bryum pseudotriquetrum	A moss	F
Calliergonella cuspidata	A moss	O
Campylium stellatum	A moss	F
Campylopus atrovirens	A moss	O
Ctenidium molluscum	A moss	O
Dicranum fuscescens	A moss	R
Drepanocladus revolvens	A moss	O
Hypnum cupressiforme	A moss	O
Racomitrium lanuginosum	A moss	R
Scorpidium scorpioides	A moss	A

3.2 Calcareous grassland

This grassland area has developed over an outcrop of limestone within a landscape otherwise dominated by more acid geology. The result is a distinctive area of lush growth which is clearly visible from the road, over a kilometre away, that has been grazed intensively by sheep to produce a low, tightly-cropped sward. The flora is equally distinctive and very diverse, in a local context, with niches available in the sward and upon the outcrops of limestone, especially within or upon sheltered fissures or faces.

A total of seventy-five species was recorded from the limits of this limestone area whose wider influence is limited by the acidity of the surrounding drift and blanket peat. Accordingly, the flushes below the outcrop do not reflect its presence and are dominated by typical blanket bog species.

Despite the diversity and distinctiveness of the flora here only one, potential rare or otherwise notable taxon was encountered – a species of *Taraxacum*. The identity of this (micro-)species was indeterminable in the absence of flowering parts (that had presumably been grazed) and the poaching and nutrient enrichment that increases the number of potential *Taraxacum* species.

Table 11: List of species recorded from the calcareous grassland and rock outcrops.

Scientific Name	Vernacular Name	Abundance
Achillea millefolium	Yarrow	O
Agrostis capillaris	Soft Bent	F
Agrostis stolonifera	Creeping Bent	O
Aira praecox	Early Hair-grass	O
Alchemilla glabra	Lady's Mantle	R
Anthoxanthum odoratum	Sweet Vernal Grass	F
Armeria maritima	Thrift	R
Asplenium trichomanes	Maiden–hair Spleenwort	F
Bellis perennis	Daisy	O
Calluna vulgaris	Heather	O
Cardamine pratensis	Cuckooflower	O
Carex panicea	Carnation Grass	F
Carex pulicaris	Flea Sedge	F
Cerastium fontanum	Common Mouse-ear	R
Cirsium vulgare	Spear Thistle	O
Crepis capillaris	Smooth Hawksbeard	R
Danthonia decumbens	Heath Grass	R
Deschampsia flexuosa	Wavy Hair-grass	O
Euphrasia confusa	Eyebright	F
Festuca ovina	Sheep's Fescue	R
Galium saxatile	Heath Bedstraw	R
Holcus lanatus	Yorkshire Fog	O
Juncus squarrosus	Heath Rush	R
Linum catharticum	Purging Flax	O
Lotus corniculatus	Bird's-foot Trefoil	R
Plantago major	Rat's-tail Plantain	F
Plantago maritima	Sea Plantain	A
Poa annua	Annual Meadow-grass	R
Poa compressa	Compressed Meadow-grass	O
Poa pratensis	Smooth Meadow-grass	O
Potentilla erecta	Tormentil	R

Prunella vulgaris	Self Heal	F
Ranunculus acris	Meadow Buttercup	O
Sagina procumbens	Procumbent Pearlwort	R
Selaginella selaginoides	Selaginella	O
Sibbaldia procumbens	Sibbaldia	O
Taraxacum officinale agg.	Dandelion (not in flower)	R
Thalictrum alpinum	Alpine Meadow-rue	O
Thymus drucei	Wild Thyme	F
Trifolium repens	White Clover	O
Viola palustris	Marsh Violet	O
Viola canina	Heath Dog Violet	R
Andreaea rupestris	A moss	R
Barbula unguiculata	A moss	O
Amphidium mougeotii	A moss	F
Aneura pinguis	A liverwort	R
Anoectangium aestivum	A moss	R
Bryum argenteum	A moss	R
Bryum capillare	A moss	O
Bryum pallens	A moss	R
Bryum sp.	A moss	R
Campylium stellatum	A moss	O
Ceratodon purpureus	A moss	O
Ctenidium molluscum	A moss	F
Distichium capillaceum	A moss	O
Frullania tamarisci	A liverwort	R
Grimmia funalis	A moss	O
Homalothecium sericeum	A moss	R
Hypnum cupressiforme	A moss	F
Isothecium myosuroides	A moss	R
Mnium hornum	A moss	O
Pellia sp.	A liverwort	R
Plagiochila porelloides	A liverwort	R
Plagiomnium elatum	A moss	R
Plagiomnium undulatum	A moss	O
Plagiothecium denticulatum	A moss	R
Pogonatum aloides	A moss	R
Pogonatum urnigerinum	A moss	R
Pohlia wahlenbergii	A moss	R
Preissia quadrata	A liverwort	R
Racomitrium lanuginosum	A moss	O
Rhytidiadelphus squarrosus	A moss	O
Scleropodium purum	A moss	O
Thuidium tamariscinum	A moss	O
Tortella tortuosa	A moss	F

3.3 Rock outcrops

These rock outcrops are situated within an area of heavily-grazed U6 grassland that is enriched by the mineral material eroded from the outcrops. The inaccessible crevices and faces provide a refuge for the more grazing-sensitive species as well as a small number of those that are generally restricted to such outcrops, such as the filmy fern and the *Racomitrium* moss species.

The vegetation contains some elements of high altitude vegetation – most obviously in the abundance of least willow, and the occasional presence of northern blueberry, but the putative alpine meadow-grass, a relatively distinct species when in 'flower' was not located despite a specific search. Despite these high-altitude elements, the occasional appearance of the grazing sensitive, greater woodrush suggests the past presence of woodland.

Some elements of the M10 flush community were also present in a species-poor stand that dissects the north-western edge of the lowest outcrop that is in greatest proximity to the windfarm infrastructure. Yellow sedge and the moss *Scorpidium scorpioides* were the predominant and most distinctive species within the limits of this community.

Table 12: List of species located on the rock outcrops.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	O
Anthoxanthum odoratum	Sweet vernal Grass	F
Carex echinata	Star Sedge	O
Carex panicea	Carnation Grass	O
Carex viridula subsp. oedocarpa	Yellow Sedge	A
Deschampsia flexuosa	Wavy Hair-grass	O
Dryopteris dilatata	Broad Buckler Fern	R
Empetrum nigrum	Crowberry	R
Euphrasia scotica	Eyebright	O
Festuca ovina	Sheep's Fescue	R
Festuca vivipara	Viviparous fescue	R
Galium saxatile	Heath Bedstraw	O
Huperzia selago	Fir Clubmoss	F
Hymenophyllum wilsonii	Wilson's Filmy Fern	R
Juncus articulatus	Jointed Rush	R
Juncus bulbosus	Bulbous Rush	R
Juncus squarrosus	Heath Rush	R
Luzula multiflora	Heath Woodrush	R
Luzula sylvatica	Greater Woodrush	R
Nardus stricta	Mat Grass	O
Narthecium ossifragum	Bog Asphodel	R
Pinguicula vulgaris	Common Butterwort	F
Polypodium vulgare	Polypodium	O
Potentilla erecta	Tormentil	R
Salix herbacea	Least Willow	F
Selaginella selaginoides	Selaginella	R

Thalictrum alpinum	Alpine Meadow-rue	R
Trichophorum caespitosum	Deer Grass	R
Vaccinium myrtillus	Blaeberry	O
Vaccinium uliginosum	Northern Blaeberry	R
Viola canina	Heath Dog-violet	R
Amphidium mougeotii	A moss	R
Andreaea rupestris	A moss	R
Anoectangium aestivum	A moss	R
Aneura pinguis	A liverwort	R
Barbilophozia floerkei	A liverwort	O
Bryum pseudotriquetrum	A moss	R
Campylopus paradoxus	A moss	R
Ctenidium molluscum	A moss	R
Dicranum scoparium	A moss	F
Diplophyllum albicans	A liverwort	O
Hypnum cupressiforme	A moss	O
Isothecium myosuroides	A moss	O
Lophozia ventricosa	A liverwort	F
Marsupella emarginata	A liverwort	R
Mnium hornum	A moss	O
Mylia taylorii	A liverwort	O
Nardia scalaris	A liverwort	F
Palustriella commutata	A moss	R
Pellia sp.	A liverwort	R
Polytrichum commune	A moss	F
Polytrichum juniperinum	A moss	F
Racomitrium aciculare	A moss	R
Racomitrium heterostichum	A moss	F
Racomitrium lanuginosum	A moss	A
Rhytidiadelphus loreus	A moss	O
Scapania gracilis	A liverwort	R
Scapania dentata	A liverwort	R
Scorpidium scorpioides	A moss	R

3.4 Borrow pit area

This area is distinct in the presence of a flushed grassland within an area otherwise dominated by heather-dominated heath on the slopes leading to blanket bog on the more level ground below. A certain degree of base-enrichment is evident in the occurrence and frequency of the mosses *Campylium stellatum*, *Ctendidum molluscum* and *Tortella tortuosa*. Phanerogams indicative of base-rich conditions are restricted by the intensive and preferential grazing that occurs here although the diminutive alpine meadow-rue persists under the cover of encroaching heather shrubs. This grazing has also resulted in localised puddling and nutrient enrichment and in the localised presence of ruderal species such as common mouse-ear and procumbent pearlwort.

Scientific Name	**Vernacular Name**	**Abundance**
Agrostis capillaris	Soft Bent	A
Agrostis stolonifera	Creeping Bent	F
Anthoxanthum odoratum	Sweet Vernal Grass	F
Calluna vulgaris	Heather	F
Carex dioica	Dioecious Sedge	O
Carex echinata	Start Sedge	O
Carex panicea	Carnation Grass	F
Carex viridula subsp. *oedocarpa*	Yellow Sedge	F
Cerastium fontanum	Common Mouse-ear	O
Crepis capillaris	Smooth Hawksbeard	O
Danthonia decumbens	Heath Grass	R
Euphrasia confusa	Eyebright	F
Festuca ovina	Sheep's Fescue	F
Festuca rubra	RedFescue	A
Festuca vivipara	Viviparous Fescue	R
Juncus effusus	Soft Rush	R
Juncus squarrosus	Heath Rush	F
Luzula sylvatica	Greeater Woodrush	R
Luzula multiflorum	Heath Woodrush	O
Nardus stricta	Mat Grass	F
Plantago lanceolata	Ribwort Plantain	F
Plantago maritima	Sea Plantain	O
Potentilla erecta	Tormentil	O
Prunella vulgaris	Self Heal	F
Selaginella selaginoides	Selaginella	O
Sibbaldia procumbens	Procumbent Pearlwort	O
Taraxacum officinale agg.	Dandelion	R
Thalictrum alpinum	Alpine Meadow-rue	F
Viola palustris	Marsh Violet	O
Viola canina	Heath Dog Violet	R
Bryum pseudotriquetrum	A moss	O
Calliergonella cuspidata	A moss	O
Campylium stellatum	A moss	O
Ctenidium molluscum	A moss	F
Dicranum fuscescens	A moss	O
Dicranum scoparium	A moss	F
Hylocomium splendens	A moss	A
Hypnum cupressiforme	A moss	O
Isothecium myosuroides	A moss	O
Mnium hornum	A moss	F
Plagiothecium undulatum	A moss	R
Polytrichum juniperinum	A moss	O
Racomitrium heterostichum	A moss	F
Racomitrium lanuginosum	A moss	F
Scleropodium purum	A moss	O
Thuidium tamariscinum	A moss	O
Tortella tortuosa	A moss	O

3.5 Flush A

Table 13: Species recorded from Flush A.

Scientific Name	Vernacular Name	Abundance
Anthoxanthum odoratum	Sweet vernal Grass	R
Bellis perennis	Daisy	R
Carex dioica	Dioecious Sedge	F
Carex flacca	Glaucous Sedge	R
Carex hostiana	Tawny Sedge	O
Carex nigra	Black Sedge	F
Carex panicea	Carnation Grass	O
Carex viridula subsp. oedocarpa	Yellow Sedge	O
Cirsium palustre	Marsh Thistle	R
Epilobium palustre	Marsh Willowherb	R
Equisetum palustre	Marsh Horsetail	R
Eriophorum angustifolium	Common Bog-cotton	R
Euphrasia scotica	Eyebright	R
Festuca vivipara	Viviparous Fescue	R
Holcus lanatus	Yorkshire Fog	R
Juncus articulatus	Jointed Rush	A
Nardus stricta	Mat Grass	O
Narthecium ossifragum	Bog Asphodel	R
Pinguicula vulgaris	Common Butterwort	R
Plantago lanceolata	Ribwort Plantain	R
Plantago maritima	Sea Plantain	R
Potamogeton polygonifolius	Bog Pondweed	R
Potentilla erecta	Tormentil	R
Ranunculus flammula	Lesser Spearwort	R
Sagina procumbens	Procumbent Pearlwort	R
Schoenus nigricans	Black Bog-rush	O
Succisa pratensis	Devil's-bit Scabious	R
Thalictrum alpinum	Alpine Meadow-rue	O
Trichophorum caespitosum	Deergrass	R
Blindia acuta	A moss	F
Bryum pseudotriquetrum	A moss	O
Campylium stellatum	A moss	O
Campylopus atrovirens	A moss	R
Campylopus introflexus	A moss	R
Dicranum scoparium	A moss	R
Hylocomium splendens	A moss	R
Pellia sp.	A liverwort	O
Racomitrium aciculare	A moss	R
Scorpidium scorpioides	A moss	F

This species-rich flush is located within a complex of flushes that all approximate to M10 although elements of the M6 community become apparent within the stands where some peat development has occurred. The species list in Table 12 below was collated from the species-rich flush located at HU 41659 66245 and the flora of the remaining flushes is derived from this list but with greater representation of less-distinctive, moorland species.

The primary reason for visiting this flush was to determine the possible presence of globeflower (*Trollius europeas*) but this could not be located here or in the wider area. This does not preclude its presence because sheep graze these slopes and it may have fallen prey to their activity. Otherwise, the flora of this flush in particular is relatively rich and distinctive from that in the surrounding vegetation types. The surrounding flushes are less distinctive and intergrade with the vegetation of the surrounding grassland and heath vegetation.

3.6 Flush B

This flush flows through a limited area of relatively species-rich grassland, in the bottom of a peat hag, which has been grazed intensively to produce a short, tightly-cropped sward. The flush, which is referable to M30, is dominated by bog pondweed along the course of the water flow and by a marginal, floating raft of the bog moss *Sphagnum denticulatum*. The main diversity of flowering species, as listed in Table 13, within the flush whereas the adjacent grassland is dominated by creeping bent with occasional stands of Yorkshire fog. The stonewort, *Nitella flexilis*, is located in the water channel upstream of flush community.

Table 14: Species recorded from Flush B.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	A
Caltha palustris	Marsh Marigold	A
Cardamine pratensis	Cuckooflower	F
Carex nigra	Black Sedge	F
Epilobium palustre	Marsh Willowherb	R
Equisetum fluviatile	Marsh Horsetail	F
Holcus lanatus	Yorkshire Fog	F
Juncus articulatus	Articulated Rush	A
Juncus bulbosus	Bulbous Rush	A
Myosotis secunda	Creeping Forget-me-not	F
Ranunculus flammula	Lesser Spearwort	A
Stellaria uliginosa	Bog Stitchwort	A
Nitella flexilis var. flexilis	Stonewort	O
Sphagnum denticulatum	A bog moss	A

3.7 Flush C

This flush is situated with an area of blanket bog in good condition and was noted for its apparent diversity during the National Vegetation Classification survey when the constituent herbs were too small to identify. The current survey identified these herbs in a mature condition and they are listed below in Table 14.

The open water is dominated by the bog mosses *Sphagnum cuspidatum* and *S. denticulatum* with marginal stands of bottle sedge. Where the ground is more consolidated, a limited range and low cover of herbs is present within a relatively dominant and diverse lawn of mosses.

Grazing is relatively light in this area and this is presumed to be a combination of the wet, infirm ground conditions and the scarcity of palatable species.

Table 15: Species recorded from Flush C.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	O
Caltha palustris	Marsh Marigold	O
Cardamine palustris	Cuckooflower	O
Carex echinata	Star Sedge	O
Carex nigra	Black Sedge	F
Carex rostrata	Bottle Sedge	O
Galium palustre	Marsh Bedstraw	O
Juncus articulatus	Articulated Rush	F
Juncus bulbosus	Bulbous Rush	F
Nardus stricta	Mat Grass	O
Potentilla erecta	Tormentil	O
Ranunculus flammula	Lesser Spearwort	F
Trichophorum caespitosum	Deergrass	O
Triglochin palustris	Marsh Arrow-grass	O
Aulacomnium palustre	A moss	O
Mnium hornum	A moss	R
Philonotis fontana	A moss	F to A
Sphagnum cuspidatum	A moss	O
Sphagnum denticulatum	A moss	A
Warnstorfia exannulata	A moss	O

3.8 Flush D and associated grassland

The area of flushed grassland is situated around a springhead marked by a large mound of the moss *Philonotos fontana*. As is typical for the area, the enrichment of the grassland by the flush attracts intensive grazing and the production of a closed sward and the poaching and nutrient enrichment permits the persistence of the 'weed' species procumbent pearlwort. Otherwise, species of bent and fescue are predominant with significant stands of soft rush.

The open channel is marked by elements of the M30 flush community and some indication of base-enrichment is apparent in the presence of yellow sedge. This community is however dominated by bog pondweed as well as a relatively diverse assemblage of common moss and liverwort species.

Table 16: Species recorded from Flush D.

Scientific Name	Vernacular Name	Abundance
Anthoxanthum odoratum	Sweet vernal Grass	R
Callitriche stagnalis	Common Water-starwort	A
Cardamine pratensis	Cuckooflower	O
Carex viridula subsp. oedocarpa	Yellow Sedge	O
Galium palustre	Marsh Bedstraw	O
Juncus bulbosus	Bulbous Rush	F
Juncus effusus	Soft Rush	O
Potamogeton polygonifolius	Bog Pondweed	R
Ranunculus flammula	Lesser Spearwort	R
Rumex acetosa	Sorrel	R
Sagina procumbens	Procumbent Pearlwort	O
Viola palustris	Marsh Violet	R
Calliergonella cuspidata	A moss	R
Drepanocladus fluitans	A moss	O
Drepanocladus revolvens	A liverwort	R
Pellia sp.	A liverwort	O
Philonotis fontana	A moss	O
Polytrichum commune	A moss	O
Polytrichum juniperinum	A moss	O
Rhytidiadelphus squarrosus	A moss	R
Scapania dentata	A liverwort	R
Sphagnum capillifolium	A moss	R
Sphagnum denticulatum	A moss	A

Table 17: Species recorded from the grassland associated with Flush D.

Scientific Name	Vernacular Name	Abundance
Agrostis capillaris	Soft Bent	F
Agrostis stolonifera	Creeping Bent	O
Carex nigra	Black Sedge	R
Carex panicea	Carnation Grass	O
Deschampsia flexuosa	Wavy Hair-grass	O
Festuca ovina	Sheep's Fescue	O
Festuca rubra	Red Fescue	O
Festuca vivipara	Viviparous fescue	R
Galium palustre	Marsh Bedstraw	O
Juncus effusus	Soft Rush	A
Juncus squarrosus	Heath Rush	F
Poa humilis	Spreading Meadow-grass	R
Potentilla erecta	Tormentil	F
Viola palustris	Marsh Violet	O

Aulacomnium palustre	A moss	O
Dicranum scoparium	A moss	R
Hypnum jutlandicum	A moss	O
Mnium hornum	A moss	R
Polytrichum commune	A moss	O
Polytrichum juniperinum	A moss	O
Sphagnum papillosum	A moss	O
Rhytidiadelphus squarrosus	A moss	R
Hylocomium splendens	A moss	R
Sphagnum capillifolium	A moss	R

3.9 Flush E

This area around the situation of Turbine 10 shows evidence of base-enrichment and the vegetation composition is comparable to the flora described above for Flush D except for the very heavy grazing pressure here that has reduced the diversity and the abundance of the distinctive species significantly.

Table 18: Species recorded from Flush E.

Scientific Name	Vernacular Name	Abundance
Anthoxanthum odoratum	Sweet vernal Grass	R
Cardamine pratensis	Cuckooflower	R
Carex panacea	Carnation Grass	R
Carex viridula subsp. oedocarpa	Yellow Sedge	R
Galium palustre	Marsh Bedstraw	O
Ranunculus flammula	Lesser Spearwort	R
Rumex acetosa	Sorrel	R
Sagina procumbens	Procumbent Pearlwort	O
Viola palustris	Marsh Violet	R
Pellia sp.	A liverwort	R
Philonotis fontana	A moss	O
Polytrichum juniperinum	A moss	O
Rhytidiadelphus squarrosus	A moss	O
Sphagnum denticulatum	A moss	A

3.10 Meadow of Fitchen

Two discrete habitats, distinguished from the adjacent blanket bog habitat, were investigated in the vicinity of the Meadow of Fitchen: the banks of the burn (which are composed of eroded peat faces and minor outcrops of bedrock and boulders) and the adjacent, rush-dominated, alluvial margins. The former habitat is typified by a low diversity of phanerogams, partly due to the instability of the banks and the poor substrate afforded by the smooth exposures of rock. The bryophyte flora is only slightly more diverse and dominated by ruderal species able to rapidly and repeatedly recolonise fresh peat and mineral exposures as well as a limited number of more strictly riparian species (such as *Jungermannia atrovirens*, *Racomitrium aciculare* and *Scapania undulata*).

The rush-dominated, riparian areas at the Meadow of Fitchin are heavily grazed and poached and dominated by stands of the unpalatable soft rush. Between the stands of soft rush, the vegetation is limited to a narrow range of phanerogam associates with a relatively diverse assemblage of moss and liverwort species in areas that are grazed but not subject to severe trampling.

Table 19: Riparian species recorded from the Meadow of Fitchin.

Scientific Name	Vernacular Name	Abundance
Blechnum spicant	Hard Fern	R
Callitriche hamulata	Intermediate Water-starwort	R
Callitriche stagnalis	Common Water-starwort	O
Cardamine pratensis	Cuckooflower	R
Galium saxatile	Heath Bedstraw	R
Juncus articulatus	Jointed Rush	O
Juncus bulbosus	Bulbous Rush	F
Juncus effusus	Soft Rush	R
Potamogeton polygonifolius	Bog Pondweed	R
Ranunculus flammula	Lesser Spearwort	O
Sagina procumbens	Procumbent Pearlwort	O
Viola palustris	Marsh Violet	O
Batrachospermum gelatinosum	Frogspawn Algae	O
Blindia acuta	A moss	F
Dicranella heteromalla	A moss	F
Dicranella palustris	A moss	R
Diplophyllum albicans	A liverwort	O
Draparnaldia	An alga	R
Fontinalis antipyretica	A moss	F
Jungermannia atrovirens	A liverwort	R
Lophozia ventricosa	A liverwort	O
Mnium hornum	A moss	O
Pellia sp.	A liverwort	F
Pogonatum aloides	A moss	F
Polytrichum commune	A moss	O
Racomitrium aciculare	A moss	R
Racomitrium heterostichum	A moss	R
Scapania dentata	A liverwort	O

Table 20: Species recorded from rush-dominated riparian areas in the Meadow of Fitchin.

Scientific Name	Vernacular Name	Abundance
Agrostis capillaris	Soft Bent	A
Agrostis stolonifera	Creeping Bent	A
Cardamine pratensis	Cuckooflower	F
Carex nigra	Black Sedge	O
Epilobium palustre	Marsh Willowherb	O
Holcus lanatus	Yorkshire Fog	F
Juncus articulatus	Jointed Rush	O
Juncus effusus	Soft Rush	D
Ranunculus acris	Meadow Buttercup	O
Ranunculus flammula	Lesser Spearwort	O
Rumex acetosella	Sheep's Sorrel	F
Sagina procumbens	Procumbent Pearlwort	O
Calliergonella cuspidata	A moss	F
Drepanocladus fluitans	A moss	F
Drepanocladus revolvens	A moss	R
Pellia sp.	A liverwort	R
Polytrichum commune	A moss	O
Rhizomnium punctatum	A moss	R
Sphagnum denticulatum	A moss	O
Sphagnum mucronatum	A moss	O
Sphagnum palustre	A moss	O
Sphagnum papillosum	A moss	F

3.11 Flush F

Table 21: Species recorded from Flush F.

Scientific Name	Vernacular Name	Abundance
Callitriche stagnalis	Common Water-starwort	O
Cardamine pratensis	Cuckooflower	O
Carex panicea	Carnation Grass	F
Cerastium fontanum	Common Mouse-ear	R
Juncus bulbosus	Bulbous Rush	F
Montia fontana	Blinks	O
Ranunculus flammula	Lesser Spearwort	F
Sagina procumbens	Procumbent Pearlwort	R
Viola palustris	Marsh Violet	F
Aulacomnium palustre	A moss	R
Barbilophozia hatcheri	A liverwort	R
Calliergonella cuspidata	A moss	D
Philonotis fontana	A moss	O
Sphagnum compactum	A moss	R
Sphagnum palustre	A moss	R

The species list for this location was recorded from the flush itself and the flushed grassland area down-slope. The whole area is subject to intensive grazing which has resulted in the creation of a short, close-cropped sward within an area otherwise dominated by blanket bog and heath communities, with small areas of erosion where sheep have gathered.

Table 22: Species recorded from the grassland associated with Flush F.

Scientific Name	Vernacular Name	Abundance
Agrostis stolonifera	Creeping Bent	F
Agrostis capillaris	Soft Bent	A
Aira praecox	Early Hair-grass	F
Anthoxanthum odoratum	Sweet vernal Grass	F
Calluna vulgaris	Heather	A
Cardamine pratensis	Cuckooflower	O
Carex panicea	Carnation Grass	F
Cerastium fontanum	Common Mouse-ear	O
Empetrum nigrum	Crowberry	O
Euphrasia confusa	Eyebright	F
Euphrasia scotica	Eyebright	O
Festuca ovina	Sheep’s Fescue	A
Festuca rubra	Red Fescue	F
Festuca vivipara	Viviparous Fescue	O
Huperzia selago	Fir Clubmoss	R
Juncus bulbosus	Bulbous Rush	O
Juncus effusus	Soft Rush	A
Potentilla erecta	Tormentil	F
Prunella vulgaris	Self-heal	O
Ranunculus acris	Meadow Buttercup	O
Sibbaldia procumbens	Procumbent Pearlwort	F
Aulacomnium palustre	A moss	F
Calliergonella cuspidata	A moss	F
Climacium dendroides	A moss	R
Dicranum fuscescens	A moss	F
Dicranum scoparium	A moss	O
Fissidens adianthoides	A moss	O
Hylocomium splendens	A moss	F
Mnium hornum	A moss	F
Pellia sp.	A liverwort	O
Polytrichum commune	A moss	F
Polytrichum juniperinum	A moss	F
Sphagnum palustre	A bog moss	F

3.12 Oxnabool Burn

Two areas of habitat were investigated at this location on the Oxnabool Burn – the vegetation of a flushed slope above the burn and the species established in the riparian zone, on rocks subject to periodic or permanent submergence. *Persicaria amphibia* had been recorded from here but could not be located during the current survey and may have been grazed during the intervening period. However, the intensity of grazing in this area is relatively low.

Table 23 Flush vegetation on the bank above Oxnabool Burn.

Scientific Name	Vernacular Name	Abundance
Agrostis capillaris	Soft Bent	R
Agrostis stolonifera	Creeping Bent	O
Anthoxanthum odoratum	Sweet vernal Grass	O
Calluna vulgaris	Heather	A
Deschampsia flexuosa	Wavy Hair-grass	A
Empetrum nigrum	Crowberry	R
Eriophorum angustifolium	Common Bog-cotton	F
Festuca vivipara	Viviparous fescue	R
Juncus articulatus	Jointed Rush	R
Juncus effusus	Soft Rush	O
Juncus squarrosus	Heath Rush	O
Nardus stricta	Mat Grass	O
Potentilla erecta	Tormentil	F
Viola palustris	Marsh Violet	R
Dicranum scoparium	A moss	R
Polytrichum commune	A moss	O
Polytrichum juniperinum	A moss	O
Sphagnum palustre	A moss	A
Sphagnum papillosum	A moss	O

Table 24: Riparian and semi-/aquatic vegetation in the Oxnabool Burn.

Scientific Name	Vernacular Name	Abundance
Anthoxanthum odoratum	Sweet vernal Grass	R
Callitriche stagnalis	Common Water-starwort	F
Juncus articulatus	Jointed Rush	F
Juncus bulbosus	Bulbous Rush	F
Juncus squarrosus	Heath Rush	R
Luzula multiflora	Heath Woodrush	R
Ranunculus flammula	Lesser Spearwort	O
Sagina procumbens	Procumbent Pearlwort	A
Chiloscyphus polyanthus	A liverwort	D
Diplophyllum albicans	A liverwort	O
Drepanocladus fluitans	A moss	O
Fontinalis antipyretica	A moss	A
Jungermannia atrovirens	A liverwort	R
Pellia sp.	A liverwort	R
Rhabdoweisia crispa	A moss	R
Scapania dentata	A liverwort	F
Sphagnum denticulatum	A moss	R

4. DISCUSSION

A total of ninety-one flowering plants and eighty-five algae, moss and liverwort species was recorded during the current survey from the locations and communities highlighted during the National Vegetation Classification survey. None of these species are included amongst those in the list of rare or otherwise notable species in Shetland, in Table 2, with exception to one taxon: *Taraxacum*. Two (micro-)species attributable to this genus were located. Although both populations were indeterminate on account of the absence of flowering parts, one has been assumed to be a widespread and common taxon (*T. faeroense*), although the other is indeterminate.

No other notable species or taxa (in a local, national or international context) were encountered during the survey and the species in each location were generally found to be common and widespread.

A small proportion of weed species (especially *Cerastium fontanum* and *Sibbaldia procumbens*) was recorded from each habitat and this reflects the intensive grazing that takes place in the area. This and the related puddling of the ground create small patches amenable to the persistence of annual species and also results in the probable loss of diversity, especially amongst the tall herbs, sub-/shrubs and trees. This grazing is intensive to moderate over most of the site and it is known to be a major factor in the composition of the vegetation in Shetland.

The floristic composition of the calcareous grassland (Section 3.2) is the most diverse and distinctive, and it also contained the greatest proportion of locally uncommon species. Most of these 'local rarities' are specific to calcareous rocks and soil within an area otherwise dominated by acid bedrock and drift deposits. The less basic rock-outcrops (Section 3.3) are almost equally diverse but contain a large proportion of species derived from the adjacent, acid grassland, heath and bog habitats which resulted in the derivation of a much less-distinctive list of species.

The flush communities were generally distinctive in terms of their physiognomy as well as their floristics. The M30 communities are generally rather species-poor and dominated by bog pondweed (*Potamogeton polygonifolius*) and the bog moss *Sphagnum denticulatum* with occasional to frequent occurrences of a limited range of associates (see Table 3 and Table 9 for examples), many of which are derived from adjacent blanket bog and heath habitat.

In contrast, the M10 communities are very distinctive in terms of their physiognomy and their floristics. They are typically distinct for the exposure of open, gravely substrate, although at times, this may include a considerable proportion of peat which results in the increased presence of common blanket bog species. Where the substrate is more base-rich and mineral in composition, the vegetation is dominated by an open sward of sedges, typically with variable extents of the moss *Scorpidium scorpioides*.

As a consequence of the above findings and those of the earlier National Vegetation Classification survey, it may be assumed that there are no rare or otherwise notable species within the habitats and locations directly influenced by the windfarm and its infrastructure.

The most notable location, in terms of its species composition and limited extent, is the area of limestone outcrop (Section 3.2) which is outside of the footprint of the development and this is also the case for the more acidic rock outcrop vegetation (described in Section 3.3). In both of these cases, the potential for direct or indirect impacts to arise is further reduced by their upstanding and water-shedding nature. The current plans for the windfarm development therefore offer no threat to these areas and this can be confirmed during the construction phase by micro-siting according to the direction of the Ecological Clerk of Works.

Other areas of habitat, such as the M10 and M30 flushes although less distinctive and/or diverse in their floristic composition are still valuable habitats that can contain species that are uncommon locally (such as a range of sedges, black bog-rush or water forget-me-not). These flushes are widespread and especially frequent in the south of the application site, and should be avoided where possible by micro-siting according to the direction of the Ecological Clerk of Works.

5. CONCLUSIONS

No rare or otherwise notable plant species were recorded during the survey.

The most distinctive flora, in the vicinity of the limestone outcrop is outside the direct development footprint and naturally robust to any changes in drainage. This is also the case for the less distinctive flora of the rock outcrops.

The flush areas contain a number of species that are restricted in their distribution locally and these flushes, especially those attributable to the NVC community M10, should be avoided by micro-siting where possible.

APPENDIX A

List of all species recorded from the locations and NVC communities described above

Phanerogams

Achillea millefolium	Yarrow
Agrostis capillaris	Soft Bent
Agrostis stolonifera	Creeping Bent
Aira praecox	Early Hair-grass
Alchemilla glabra	Lady's Mantle
Anthoxanthum odoratum	Sweet Vernal Grass
Armeria maritima	Thrift
Asplenium trichomanes	Maiden–hair Spleenwort
Bellis perennis	Daisy
Blechnum spicant	Hard Fern
Callitriche hamulata	Intermediate Water-starwort
Callitriche stagnalis	Common Water-starwort
Calluna vulgaris	Heather
Caltha palustris	Marsh Marigold
Cardamine pratensis	Cuckooflower
Carex dioica	Dioecious Sedge
Carex echinata	Star Sedge
Carex flacca	Glaucous Sedge
Carex hostiana	Tawny Sedge
Carex nigra	Black Sedge
Carex panicea	Carnation Grass
Carex pulicaris	Flea Sedge
Carex rostrata	Bottle Sedge
Carex viridula subsp. oedocarpa	Yellow Sedge
Cerastium fontanum	Common Mouse-ear
Cirsium vulgare	Spear Thistle
Crepis capillaris	Smooth Hawksbeard
Danthonia decumbens	Heath Grass
Deschampsia flexuosa	Wavy Hair-grass
Drosera rotundifolia	Round-leaved Sundew
Dryopteris dilatata	Broad Buckler Fern
Eleocharis palustris	Common Spike-rush
Empetrum nigrum	Crowberry
Epilobium palustre	Marsh Willowherb
Equisetum palustre	Marsh Horsetail
Eriophorum angustifolium	Common Bog-cotton
Euphrasia confusa	Eyebright
Euphrasia scotica	Eyebright
Festuca ovina	Sheep's Fescue
Festuca rubra	Red Fescue
Festuca vivipara	Viviparous Fescue
Galium palustre	Marsh Bedstraw
Galium saxatile	Heath Bedstraw

Holcus lanatus	Yorkshire Fog
Huperzia selago	Fir Clubmoss
Hymenophyllum wilsonii	Wilson's Filmy Fern
Juncus articulatus	Jointed Rush
Juncus bulbosus	Bulbous Rush
Juncus effusus	Soft Rush
Juncus squarrosus	Heath Rush
Linum catharticum	Purging Flax
Lotus corniculatus	Bird's-foot Trefoil
Luzula multiflora	Heath Woodrush
Luzula sylvatica	Greeater Woodrush
Molinia caerulea	Purple Moor-grass
Montia fontana	Blinks
Myosotis secunda	Creeping Forget-me-not
Nardus stricta	Mat Grass
Narthecium ossifragum	Bog Asphodel
Pinguicula vulgaris	Common Butterwort
Plantago lanceolata	Ribwort Plantain
Plantago major	Rat's-tail Plantain
Plantago maritima	Sea Plantain
Poa annua	Annual Meadow-grass
Poa compressa	Compressed Meadow-grass
Poa humilis	Spreading Meadow-grass
Poa pratensis	Smooth Meadow-grass
Polypodium vulgare	Polypodium
Potamogeton polygonifolius	Bog Pondweed
Potentilla erecta	Tormentil
Prunella vulgaris	Self-heal
Ranunculus acris	Meadow Buttercup
Ranunculus flammula	Lesser Spearwort
Rumex acetosa	Sorrel
Rumex acetosella	Sheep's Sorrel
Sagina procumbens	Procumbent Pearlwort
Salix herbacea	Least Willow
Schoenus nigricans	Black Bog-rush
Selaginella selaginoides	Selaginella
Sibbaldia procumbens	Sibbaldia
Stellaria uliginosa	Bog Stitchwort
Succisa pratensis	Devil's-bit Scabious
Taraxacum officinale agg.	Dandelion (not in flower)
Thalictrum alpinum	Alpine Meadow-rue
Thymus drucei	Wild Thyme
Trichophorum caespitosum	Deer Grass
Trifolium repens	White Clover
Triglochin palustris	Marsh Arrow-grass
Vaccinium myrtillus	Blaeberry
Vaccinium uliginosum	Northern Blaeberry
Viola palustris	Marsh Violet

Mosses, liverworts and algae

Amphidium mougeotii	A moss
Andreaea rupestris	A moss
Aneura pinguis	A liverwort
Anoectangium aestivum	A moss
Aulacomnium palustre	A moss
Barbilophozia floerkei	A liverwort
Barbilophozia hatcheri	A liverwort
Barbula unguiculata	A moss
Batrachospermum gelatinosum	Frogspawn Algae
Blepharostoma trichophylla	A liverwort
Blindia acuta	A moss
Bryum argenteum	A moss
Bryum capillare	A moss
Bryum pallens	A moss
Bryum pseudotriquetrum	A moss
Bryum sp.	A moss
Calliergonella cuspidata	A moss
Campylium stellatum	A moss
Campylopus atrovirens	A moss
Campylopus introflexus	A moss
Campylopus paradoxus	A moss
Ceratodon purpureus	A moss
Climacium dendroides	A moss
Ctenidium molluscum	A moss
Dicranella heteromalla	A moss
Dicranella palustris	A moss
Dicranum fuscescens	A moss
Dicranum scoparium	A moss
Diplophyllum albicans	A liverwort
Distichium capillaceum	A moss
Draparnaldia	An alga
Drepanocladus fluitans	A moss
Drepanocladus revolvens	A liverwort
Fissidens adianthoides	A moss
Fontinalis antipyretica	A moss
Frullania tamarisci	A liverwort
Grimmia funalis	A moss
Homalothecium sericeum	A moss
Hylocomium splendens	A moss
Hypnum cupressiforme	A moss
Hypnum jutlandicum	A moss
Isothecium myosuroides	A moss
Jungermannia atrovirens	A liverwort
Lophozia ventricosa	A liverwort
Marsupella emarginata	A liverwort
Mnium hornum	A moss
Mylia taylorii	A liverwort
Nardia compressa	A liverwort
Nardia scalaris	A liverwort

Nitella flexilis var. flexilis	Stonewort
Palustriella commutata	A moss
Pellia sp.	A liverwort
Philonotis fontana	A moss
Plagiochila porelloides	A liverwort
Plagiomnium elatum	A moss
Plagiomnium undulatum	A moss
Plagiothecium denticulatum	A moss
Plagiothecium undulatum	A moss
Pogonatum aloides	A moss
Pogonatum urnigerinum	A moss
Pohlia wahlenbergii	A moss
Polytrichum commune	A moss
Polytrichum juniperinum	A moss
Preissia quadrata	A liverwort
Racomitrium aciculare	A moss
Racomitrium heterostichum	A moss
Racomitrium lanuginosum	A moss
Rhizomnium punctatum	A moss
Rhytidiadelphus loreus	A moss
Rhytidiadelphus squarrosus	A moss
Scapania dentata	A liverwort
Scapania gracilis	A liverwort
Scleropodium purum	A moss
Scorpidium scorpioides	A moss
Sphagnum capillifolium	A moss
Sphagnum compactum	A moss
Sphagnum cuspidatum	A moss
Sphagnum denticulatum	A moss
Sphagnum mucronatum	A moss
Sphagnum palustre	A moss
Sphagnum papillosum	A moss
Sphagnum papillosum	A moss
Thuidium tamariscinum	A moss
Tortella tortuosa	A moss
Warnstorfia exannulata	A moss

APPENDIX 8.7: FISH SURVEY

The information contained within Fish Survey that supported the 2009 ES was seen as relevant and thus was included in the 2018 EIA.

VIKING WIND FARM, SHETLAND:

BASELINE ASSESSMENT OF FISH POPULATIONS

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October 2008

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CONTENTS

APPENDICES

SUMMARY

Introduction and aims

The Viking Energy Partnership is developing a proposal for a 540MW, 150 turbine wind farm on Mainland, Shetland. During the construction of the proposed wind farm there will be physical disturbance to soils including removal that may alter the hydrological characteristics of the site. Soil exposure during construction may pose the risk of inputs of suspended solids to watercourses, causing siltation or sedimentation. Several of the streams will be directly affected by construction of track crossings. Impacts such as sedimentation or pollution may have consequences some distance downstream from the point source.

The aim of the work reported herein was to undertake a survey of freshwater fish in watercourses potentially affected by the proposed wind farm development. The fish survey describes the distribution and abundance of fish species at catchment level within streams that (i) will have turbines constructed within the catchment and/or (ii) will be crossed by new access tracks. Sites locations were chosen both to provide information on the distribution of fish in streams and to provide a baseline for monitoring.

Methods

Surveys were conducted on 11 catchments during late August and early September 2008. Data on absolute salmonid abundance were collected at a series of fully quantitative electric fishing sites (n=19), sampled by depletion methods. Excepting the Wester Filla Burn, at least one fully quantitative survey was carried out in each catchment, with more than one on the larger streams. As collecting fully quantitative data is time consuming an additional series of semi-quantitative sites (n=41) was surveyed in order to widen coverage and provide additional data on abundance. Correction factors for trout and salmon were calculated from fully quantitative data, allowing estimates of absolute fish abundance to be made at semi-quantitative survey sites. A small number of qualitative (presence versus absence) surveys were also conducted (n=6) in order to increase data on fish species distribution.

Non-salmonid species were counted at all survey sites, although it was not always practical to capture them. The SFCC Electric Fishing protocols suggest that where eels are not captured their number during the first electric fishing run through a site should be recorded. This procedure was followed for non-salmonid species at all sites.

All fish captured were held in covered bins prior to processing. Fish were anaesthetised using 2-phenoxy-ethanol to ease handling. Salmon and trout were identified and scored separately and counts of non-salmonids were recorded. Fork length of trout and salmon was measured to the nearest 1mm. Salmon and trout scales were collected to assist with age determination. Fish were allowed to recover fully in clean water before being released back into the survey reach.

Fish densities and error estimates at multiple run sites were calculated using the programme REMOVE (Clarke 1989). At single run sites minimum densities for fry and parr were estimated as number of fish caught divided by area. All densities are expressed as fish per 100 square metres (fish.100m^{-2}).

Main Findings

- Five species were identified in the 11 streams surveyed: European eel *Anguilla anguilla*, Atlantic salmon *Salmo salar*, brown and sea trout *Salmo trutta*, three-spined stickleback *Gasterosteus aculeatus* and flounder *Platichthys flesus* (Table I).

- Trout were present in all catchments surveyed. Trout fry density varied greatly between and within catchments (Table II), but parr density in most was fair or good by national standards (National Rivers Authority Fisheries Classification Scheme).

- A weak trout fry year class was apparent in some streams. This may be an artefact of site selection but equally may reflect year-to-year changes in recruitment. The spring and summer of 2008 were unusually dry, potentially affecting fry survival prior to survey.

- Trout abundance at several sites was affected by the presence of stocked fish. These were not always identifiable in the field.

- Salmon were present in only two catchments and densities were poor. One-year-old parr were identified in the Burrafirth catchment but fry were absent, suggesting sporadic spawning. Both fry and 1+ parr were present in the Laxo catchment, but numbers were low and distribution restricted.

Table I. *Species occurrence by catchment.*

Catchment	**Survey sites (n)**	**Eel**	**Trout**	**Salmon**	**3-spined stickleback**	**Flounder**
Laxobigging	8	X	X			
Skella Dale	4		X			
Wester Filla	2		X			
Laxo	13	X	X	X	X	
Grunnafirth	5	X	X			
Crookadale	3	X	X			
Quoys	7	X	X			X
Kirkhouse	3		X			
Sandwater	3	X	X		X	
Weisdale	3	X	X			
Burrafirth	15	X	X	X		X

Table II. *Mean density of trout and salmon by catchment (correction factors applied).*

Catchment	**DENSITY ESTIMATE (fish.100m^{-2})**			
	Trout		**Salmon**	
	0+	*1++*	*0+*	*1++*
Laxobigging	12.0	14.8	0.0	0.0
Skella Dale	4.4	12.8	0.0	0.0
Wester Filla	103.8	17.1	0.0	0.0
Laxo	38.5	14.1	0.5	0.5
Grunnafirth	6.4	12.0	0.0	0.0
Crookadale	20.8	9.0	0.0	0.0
Quoys	1.6	7.6	0.0	0.0
Kirkhouse	11.0	6.6	0.0	0.0
Sandwater	23.8	4.3	0.0	0.0
Weisdale	18.0	20.2	0.0	0.0
Burrafirth	21.8	9.4	0.0	0.9

1 INTRODUCTION

1.1 Aims

The aim of this work was to undertake a survey of freshwater fish in selected watercourses, in relation to a planning application for the proposed Viking Wind Farm, Mainland, Shetland. The survey identified fish species present at a series of electric fishing sites and provided quantified data on the abundance of trout *Salmo trutta* and Atlantic salmon *Salmo salar*.

1.2 Background

The Viking Energy Partnership (a partnership between Scottish & Southern Energy and Viking Energy Limited) is developing a proposal for a 540MW, 150 turbine wind farm on Mainland, Shetland. The planning application will be accompanied by an Environmental Statement (ES), part of which includes this report, detailing the findings of a survey of freshwater fish in catchments potentially affected by the wind farm development.

Surveys of the aquatic environment, including fish, are required to inform the environmental assessment of the proposed wind farm. The freshwater streams of Shetland are important spawning areas for sea trout and brown trout, the mainstay of local recreational fisheries. Salmon have also been recorded in several Shetland streams, including some that drain the core wind farm area. Concerns were raised during the consultation process about the potential for impacts on watercourses, mediated via changes in water quality, particularly siltation and increased levels of suspended solids.

1.3 Fish distribution in Shetland

In comparison with mainland Scotland, Shetland supports a very limited range of freshwater fish species. Davies *et al* (2004) list only eight species: European eel *Anguilla anguilla*, rainbow trout *Oncorhynchus mykiss* (an introduced species), Atlantic salmon, brown and sea trout, Arctic charr *Salvelinus alpinus*, three-spined stickleback *Gasterosteus aculeatus*, nine-spined stickleback *Pungitius pungitius* and flounder *Platichthys flesus*. Laughton Johnston (2002) suggests that lampreys (either *Lampetra spp*. or *Petromyzon marinus*) may also be present. However, there is no evidence for this. The national survey of lampreys during 2003-04 identified no records of lampreys from Shetland and none were found during a survey of seven streams (Watt & Ravenscroft 2005). Table 1 summarises the known distribution of each species in central mainland Shetland, based on Davies *et al* (2004) and records accessed via the National Biodiversity Network (NBN) Gateway.

Table 1. *Occurrence of freshwater fish in central mainland Shetland (based on D.A.F.F. data accessed via NBN Gateway)*

Species	Known or likely occurrence within study area
Eel	Widely distributed within study area.
Brown/sea trout	Widely distributed within the study area.
Atlantic salmon	Previously recorded in: Burn of Weisdale, Burn of Sandwater, Burn of Kirkhouse, Laxo Burn, Burn of Grunnafirth, Burn of Lunklett (Burrafirth).
Rainbow trout	Not known within the study area.
Arctic char	Not known within the study area. On Shetland, known only from Loch of Girlsta.
Three-spined stickleback	Recorded in all 10km grid squares covering study area (10km square resolution only).
Nine-spined stickleback	Not recorded in study area. Single record from 10km square HU50.
Flounder	Likely to be widely distributed in lower reaches of accessible streams.

1.4 Priority species for survey

Salmonids i.e. salmon and trout were considered the primary target for quantified survey. This was due to (i) their recreational and commercial value for sport fishing by local and visiting anglers (ii) the statutory status of Atlantic salmon. It was also considered important to collect quantified data on eels, due to current concerns over rapid declines in eel stocks.

Atlantic salmon are widespread in northern and southwestern Britain, but absent from large areas of south England due to poor water quality, barriers and habitat degradation (Davies *et al* 2004). Adult populations have declined throughout the salmon's north Atlantic range over the last ten to twenty years due to a reduction in marine survival (O' Maoileidigh 2002). In addition, the species is threatened throughout its range by pollution, over-exploitation, fish farming, habitat degradation, barriers to migration, predation and mis-management such as inappropriate stocking (Hendry & Cragg-Hine 2003). The Atlantic salmon is listed under Annex II of the Habitats and Species Directive. Salmon are also listed under the Bern Convention and the UK Biodiversity Action Plan.

The brown trout is distributed throughout the Atlantic, North, White and Baltic sea basins of Europe, from Spain to Russia. The species occurs both as freshwater resident forms (brown trout) and anadromous forms (sea trout). Although locally common, populations of brown trout and sea trout have declined in many areas due to pollution, disease and habitat degradation. Brown trout genetics are poorly understood but it is clear that numerous genetically distinct sub-populations exist. Unfortunately the phylogeographic structure of trout populations has been affected by stocking (Kottelat & Freyhof 2007) and many unique races may already have been lost (Antunes *et al* 1999). It has been proposed that brown trout be included on an updated UK BAP list (Biodiversity Reporting & Information Group 2007). The proposed list suggests that priority actions for trout are primarily research into taxonomy and ecology. Brown trout and sea trout are widespread in Shetland, although the sea trout stock component has declined significantly in recent decades.

Eel populations are currently in rapid decline throughout the Atlantic region, for unknown reasons. ICES consider that the European eel stock is outside safe biological limits. In September 2007 the European Union issued regulations (Council Regulation (EC) No 1100/2007) intended to underpin recovery of the stock of the European eel. The regulation requires member states to produce Eel Management Plans to reduce anthropogenic mortalities of eels. Target escapement of silver eel biomass is at least 40% of the escapement that would have been expected if no anthropogenic influences had impacted the stock. In addition, the eel is due to be listed on Appendix II of CITES from March 2009, limiting trade in eels from the EU to the rest of the world.

1.5 Salmon, trout and eel habitat requirements

The physical habitat requirements of juvenile salmonids have been subject to a considerable amount of detailed study; Crisp (1993), Hendry & Cragg-Hine (1996) and Summers *et al.* (1996) provide useful reviews. Habitat requirements are briefly summarised below and in Table 2, based on these reviews.

Female salmonids deposit their eggs in redds, which they excavate in gravel runs and the tails of pools. A good supply of oxygen is essential for eggs to develop and this is facilitated by a flow of water through the gravel bed. Clogging with fine sediment such as silt and fine sand reduces water flow resulting in egg mortality from lack of oxygen. Egg survival is also affected by redd 'washouts' during winter spates – the direct, physical, scouring out of eggs from the gravel. Substrate stability, the dynamics of water flow and the weather all determine the extent of siltation and washouts.

After hatching the young fry disperse from the redds and set up territories. Salmon fry prefer fast flows (>30 cm/s) and favour areas with surface turbulence (riffle habitat). They require a rough bed of pebble, cobble and gravel. Trout fry often use slower flowing areas than salmon fry. Good cover is essential for maintaining high trout densities.

Salmon that have survived their first winter (parr) prefer deeper water (15-40cm) and a coarser substrate than fry, consisting of pebbles, cobbles and boulders. Cover is important to attaining high densities of juvenile salmon as they are territorial. Territorial aggression is reduced when parr are visually isolated from one another e.g. by boulders. During the winter juvenile salmon may leave shallow, fast flowing areas to seek shelter in deeper water. This is probably a response to poorer swimming performance resulting from low temperatures. Trout parr generally occur is slower flows than salmon parr. Cover is again essential and trout are often to be found along the banks of stream and rivers beneath undercuts, among tree roots or in marginal vegetation.

Adult salmon and trout require deeper water than do juveniles. Pools and deep glides are important resting areas for upstream migrating fish. Cover remains important for adult salmon, particularly in smaller streams. In larger rivers cover is less important as deep water provides refuge.

Vegetation in the riparian zone may play an important role in the ecology of a river and hence the habitat it provides for fish. Vegetation provides shade, reducing extremes of temperature in summer. It also provides energy through leaf fall, insect drop and dissolved nutrients, fish cover via roots and overhanging boughs and stabilises the stream banks and channel from erosion. Rivers are dynamic by nature and a degree of erosion and change is entirely normal. Indeed, the downstream movement of gravel and pebble is important to maintaining spawning and nursery habitats for fish. However, unnaturally high or low levels of erosion or sediment transport can have serious consequences for fish and their habitat.

Table 2. *Summary of habitat preferences of salmon and trout*

Life stage	Parameter	Preferred habitat	
		Salmon	**Trout**
Spawning	*Substrate*	Stable, not compacted. Mean grain size up to 80 mm. Fines<20%.	Similar to salmon but mean grain size usually 10 – 40 mm.
	Flow	20 – 50 $cm.s^{-1}$ up to twice female body length in $cm.s^{-1}$.	Generally 20-50 $cm.s^{-1}$, up to twice female body length in $cm.s^{-1}$.
Fry	*Substrate*	Pebble, cobble and gravel.	Variable, but cover essential.
	Flow	Fast flowing, 50-70 $cm.s^{-1}$	0-20 $cm.s^{-1}$
	Depth	<20 cm.	10-40 cm.
Parr	*Substrate*	Cobble and boulder.	Variable, but cover essential.
	Flow	Fast, 50-70 $cm.s^{-1}$	Slow, 0-20 $cm.s^{-1}$
	Depth	10-40 cm.	20-60 cm.

European eels are catadromous i.e. resident in freshwater but migrating to sea to spawn. Young elvers enter rivers in late winter and spring, migrating into all kinds of fresh waters. They do not migrate directly to the headwaters of all streams, but gradually disperse to become distributed through all suitable waters. Their dispersal capabilities are astounding, and they have been known to scale dam walls or crawl through damp grass during their migrations. The freshwater niche of the European eel is very broad and consistent eel-habitat relations are difficult to identify. Anguillid eels appear to be generalists that are tolerant of and adaptable to a wide range of habitats under different conditions (Wiley *et al* 2004). Tesch (1977) suggests that so long as temperature and oxygen requirements are met, there are few stretches of water that are not suitable for eels. The main requirement for eels is cover, as they are averse to light and require suitable refuges during daylight hours. Eels of different size show different substrate preferences. Larger eels require large hollows, crevices or weed beds whereas small eels are sometimes abundant in cobble substrates, as they can burrow between the stones. Tree stumps, roots and other large structures provide ideal cover for eels. Eel diet is diverse, but the majority of diet consists of benthic invertebrates (Moriarty 1978; Kottelat & Freyhof 2007).

The three-spined stickleback is widespread in Scotland, including the Northern Isles. It exists as both a marine and a freshwater race. The marine race exhibits greater development of its external, bony plates and spines than the freshwater race (Maitland & Campbell 1992). The three-spined stickleback is considered to be one of the original post-ice age colonisers of Scottish streams, along with salmon, trout and eels. Three-spined sticklebacks may exist in a wide range of habitats, often favouring slow flowing reaches with abundant vegetation. They feed on insect larvae and zooplankton.

The flounder is generally regarded as a marine species, but is in fact quite common in the lower reaches of many rivers. It has been caught up to 50km inland in Loch Lomond (Maitland 2007). Young flounders often move into freshwater for a year or two before migrating back to sea. Flounders are commonly found over sandy substrates and feed on a wide variety of invertebrates. The diet of young flounders in freshwaters consists of worms, insects and molluscs.

2 METHODS

2.1 Rationale

During the construction of the wind farm there will be physical disturbance to soils including removal that may alter the hydrological characteristics of the site. As a result of soil exposure during construction, there is a potential risk of inputs of suspended solids to watercourses, causing siltation or sedimentation. In addition, particularly during construction, potential sources of pollution will be present on the site. Many of the stream that will be directly affected by construction e.g. by track crossings are tiny, possibly supporting few fish. However, impacts such as sedimentation or pollution may have consequences for fish some distance downstream from the point source. Therefore the survey was designed to describe the distribution and abundance of fish species at catchment level within streams that (i) will have turbines constructed within the catchment and/or (ii) will be crossed by new access tracks.

2.2 Site selection

2.2.1 Survey streams

Streams selected for survey are listed in Table 3 and shown on Figures 1 to 3.

***Table 3**. Catchments for survey and proposed number of survey sites.*

Catchment and major tributaries	Number of survey sites		
	Quantitative	*Semi-quantitative*	*Qualitative*
B. Laxobigging, North Burn, B. of Westerbutton, B. of Easterbutton	3	5	0
B. of Skelladale	1	3	0
Wester Filla	0	2	0
Laxo Burn, Gossawater, Easter Filla, Seggie	4	7	2
B. of Grunnafirth, B. of Forse	2	3	0
B. of Quoys	1	2	0
B. of Crookadale	1	4	2
B. of Kirkhouse	2	1	0
B. of Pettawater	1	2	0
B. of Weisdale	1	2	0
Burrafirth, South B. of Burrafirth, B. of Atlascord, Marrofield Water, B. of Lambawater, B. of Lunklet	3	10	2
TOTAL	**19**	**41**	**6**

2.2.2 Site selection within streams

Sites locations were chosen to (i) provide information on the distribution of fish in streams potentially impacted by the proposed development (ii) provide a baseline for monitoring potential downstream effects resulting from construction or operation of the wind farm. Sites were chosen to be representative of salmon and trout habitats in each catchment, based on the results of the visual inspections. Site locations for each quadrant are shown on Figures 1 to 3. A full list of survey sites is provided as Appendix 1. Site photographs are submitted electronically with this report along with detailed data on substrate, flow, depth and bank-side vegetation at each site. Copies are held by Waterside Ecology and can be provided on request.

2.3 Electric fishing

2.3.1 Survey types

The survey was intended to provide data on both fish abundance and fish distribution. Data on absolute salmonid abundance were collected at a series of fully quantitative

Figure 1. *Survey sites Delting and Collafirth. Closed circles are fully quantitative survey sites, open circles semi-quantitative.*

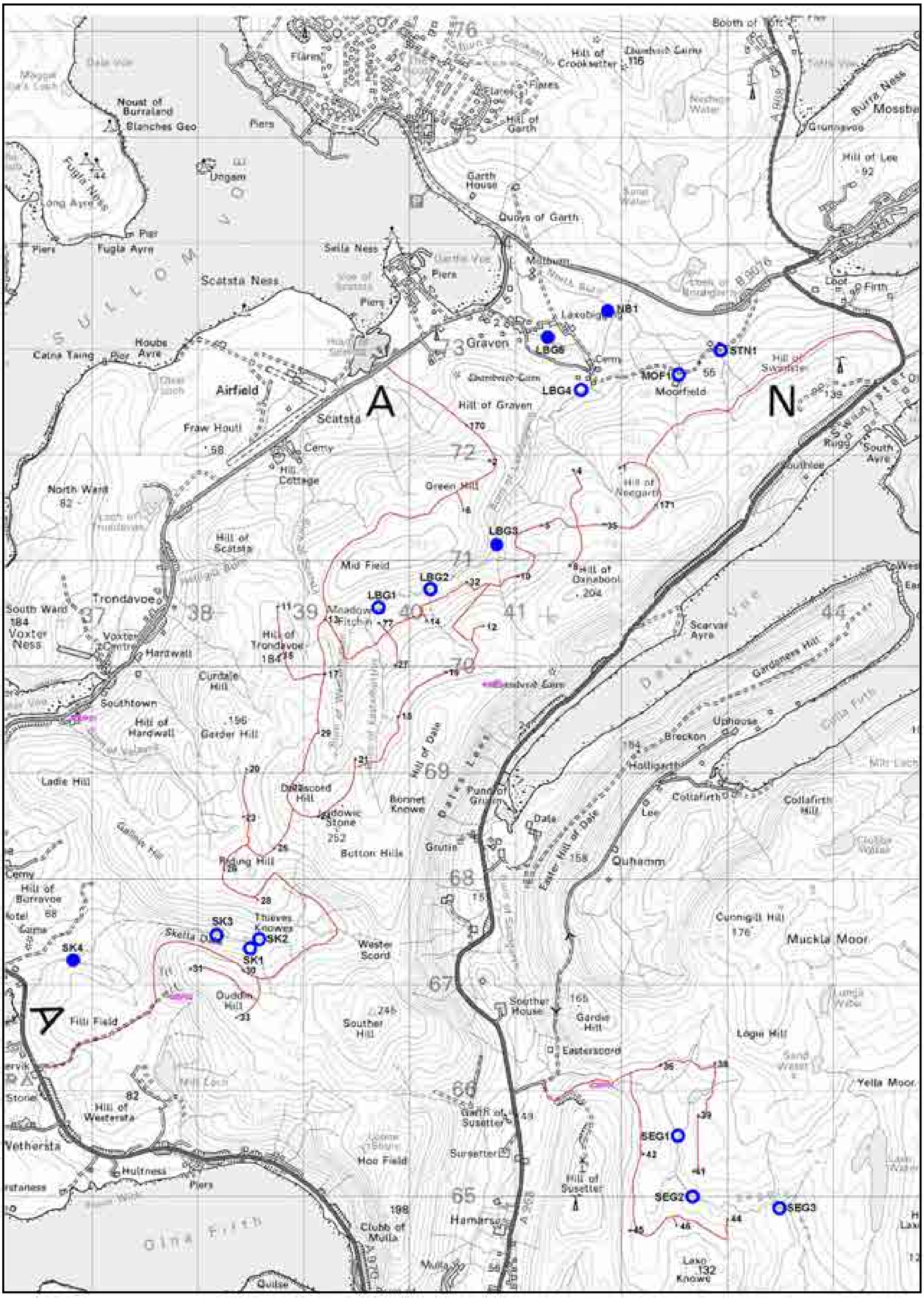


Figure 2. *Survey sites Nesting. Closed circles are fully quantitative sites, open circles semi-quantitative, open triangles qualitative.*

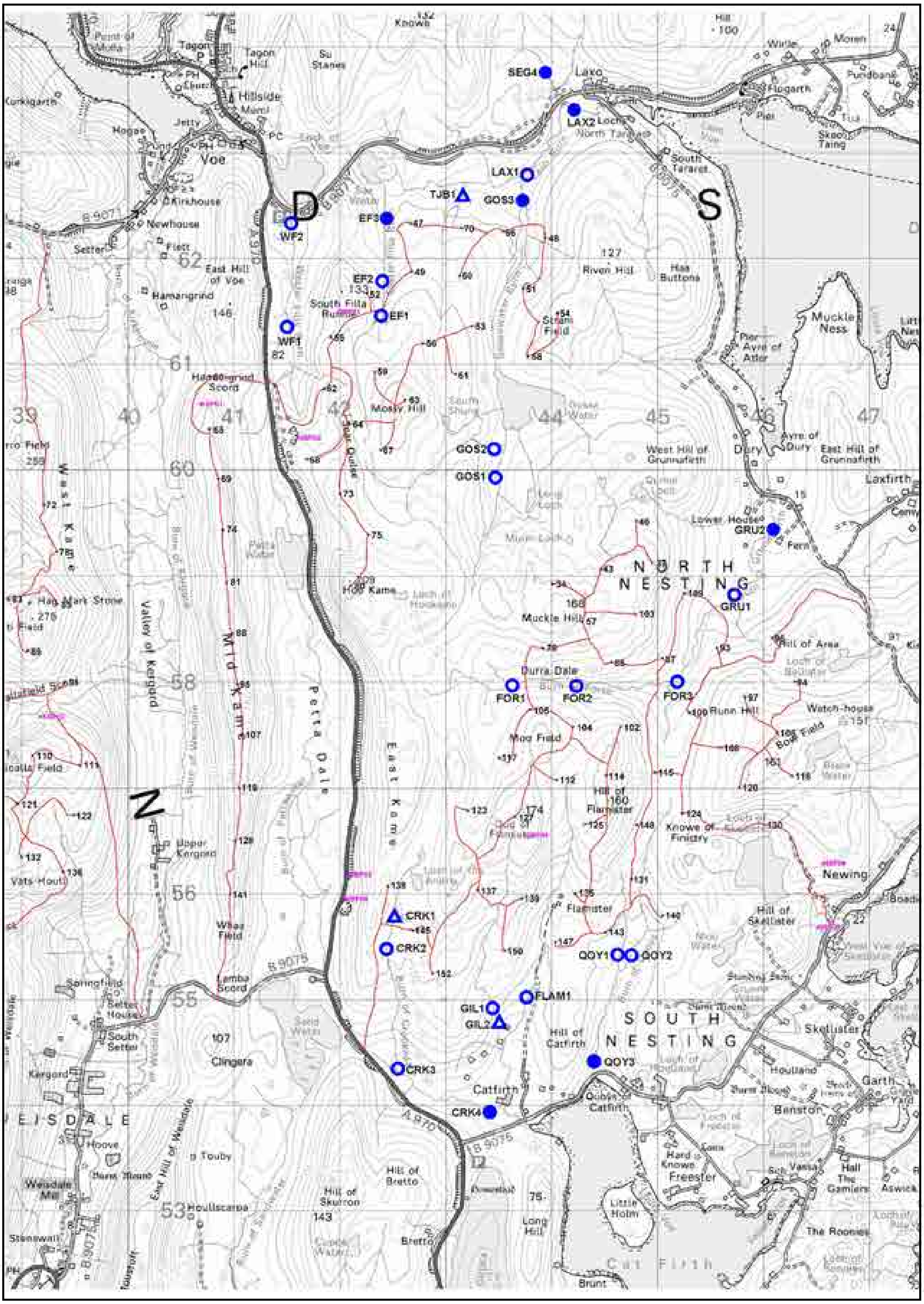
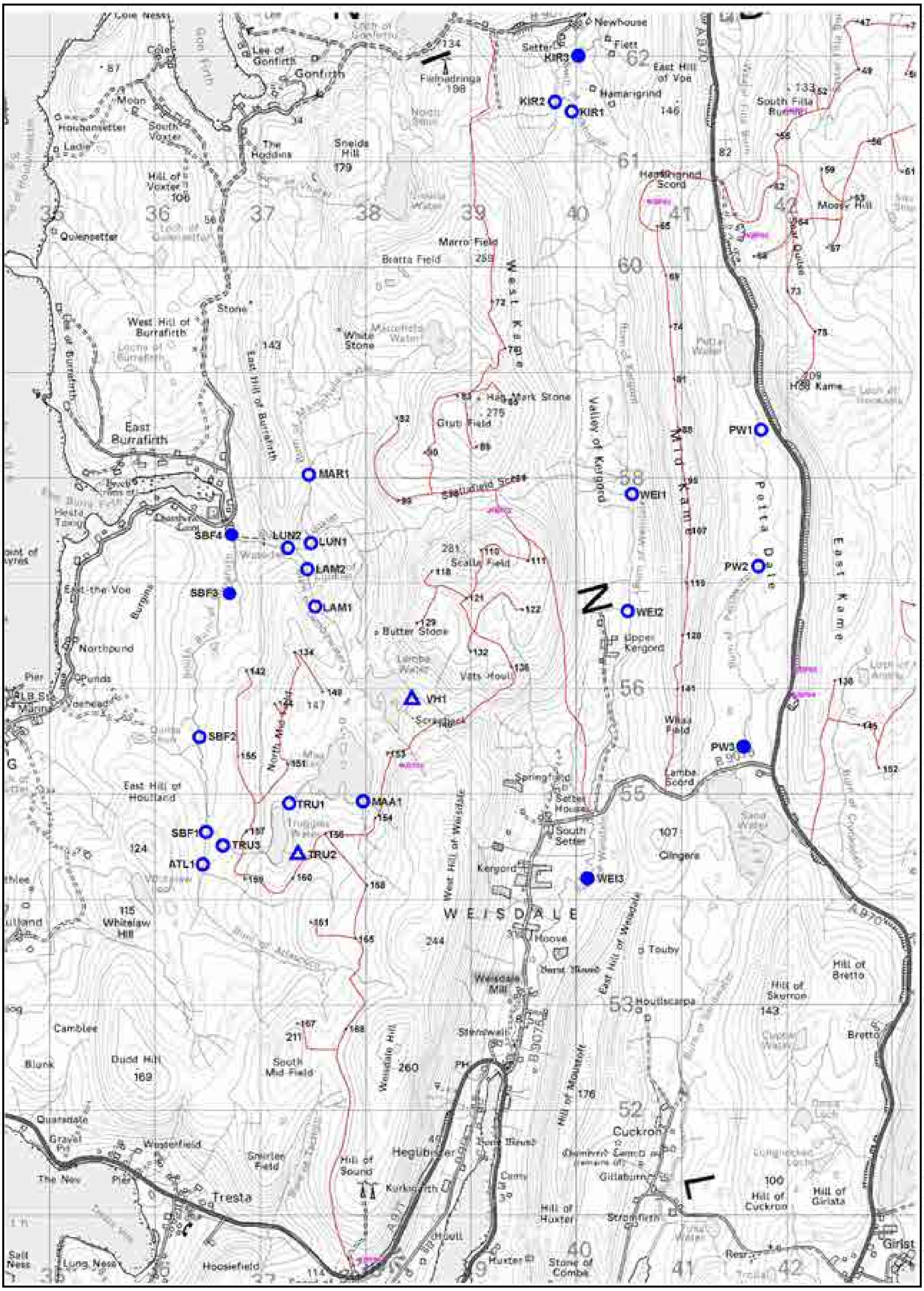


Figure 3. *Survey sites Kergord. Closed circles are fully quantitative sites, open circles semi-quantitative, open triangles qualitative.*



electric fishing sites (n=19). At least one fully quantitative survey was carried out in most survey streams, with several on the larger streams. As collecting fully quantitative data is time consuming an additional series of semi-quantitative sites (n=41) were surveyed in order to greatly widen coverage. Correction factors for trout and salmon were calculated from fully quantitative data to allow estimates of absolute fish abundance to made at semi-quantitative survey sites (see below). A small number of qualitative (presence versus absence) surveys were also conducted (n=6).

Non-salmonid species were counted at all survey sites, but it was not always practical to capture them. For instance, where large numbers of juvenile sticklebacks are present it would be difficult or impossible to capture all of them without significant disruption to salmonid survey. Similarly, where significant numbers of eels are present it may be difficult to efficiently capture both eels and salmonids during the same survey. This creates particularly problems at semi-quantitative sites where a consistent efficiency is required if minimum density data are to be used to infer absolute density (see section 2.3.3). The Scottish Fisheries Co-ordination Centre (SFCC) Electric Fishing protocols (SFCC 2007) suggest that where eels are not captured their number during the first electric fishing run through a site should be recorded. This procedure was followed for non-salmonid species at all sites.

2.3.2 *Fully quantitative surveys*

Fully quantitative surveys were carried out to SFCC protocols. Sections of stream were isolated using stop nets, to prevent fish from moving in or out of the site during surveys. The length of the survey section was at least five times wet width, much more in narrow streams, and included a variety of habitat types. Each section of stream was fished through at least three times using backpack electric fishing gear. The catch from each run through the site was held and processed separately. Multiple pass fishing allows absolute fish densities to be calculated, based on the decline in catch during successive runs (Zippin 1958).

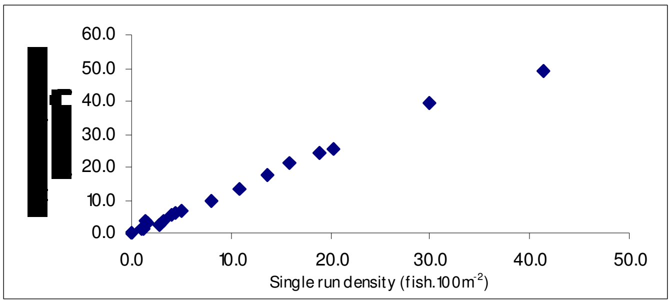
2.3.3 *Semi-quantitative surveys*

A series of semi-quantitative surveys was also conducted. No stop nets were used at these sites and a single electric fishing run was made through each. Generally, some fish will be missed during single pass electric fishing. The proportion missed depends on a variety of factors including conductivity, water depth, flow, habitat structure and the experience of the survey team. Correction factors for fish density from single run sites are provided in Figure 4. These are based on the relationship between the depletion (Zippin) estimates of absolute density from three-run, fully quantitative sites and the single run minimum density estimates (using only the first run) from those same sites. The data suggest that, as rule of thumb, about 80% of fish were caught in the first run through each site. No correction factor could be calculated for salmon fry as they were present at too few sites, so the correction factor for salmon parr was used.

2.3.4 *Fish processing*

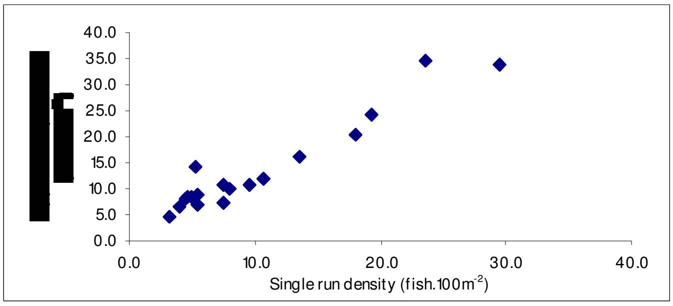
All fish captured were held in covered bins prior to processing. Fish were anaesthetised using 2-phenoxy-ethanol to ease handling. Salmon and trout were identified and scored separately and counts of non-salmonids were recorded. Salmonid fork length was measured to the nearest 1mm. Scales were collected to assist with age determination. Fish were allowed to recover fully in clean water before being released back into the survey reach.

***Figure 4**. Relationship between single-run minimum density and absolute density (Zippin density estimated based on multiple run depletion fishing) for trout fry, trout parr and salmon parr.*



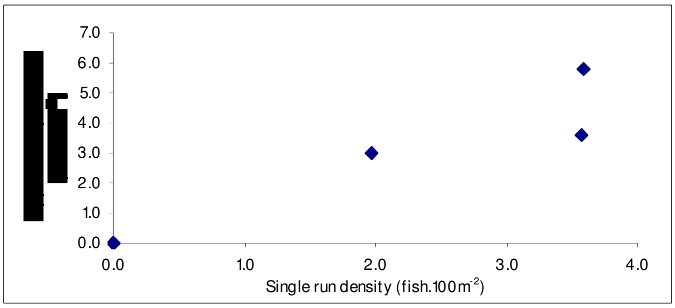
Trout fry

Absolute density = 1.27(minimum density)



Trout parr

Absolute density = 1.27(minimum density)



Salmon parr

Absolute density = 1.33(minimum density)

2.3.5 Nomenclature and data handling

Throughout this report, the term fry is used to describe young of the year. These fish are also referred to as 0+ (i.e. fish in their first year of life). Parr is used to describe fish of more than one year. The shorthand terms 1+ and 2+ refer to fish in their second and third year of life respectively.

Data were entered into MS Excel spreadsheets submitted with this report (*Viking fish data 2008.xls*). Fish densities and error estimates at multiple run sites were calculated using the programme REMOVE (Clarke 1989). At single run sites minimum densities for fry and parr were estimated as number of fish caught divided by area. Correction factors relating minimum density to actual density are described above. All densities are expressed as fish per 100 square metres (fish.100m^{-2}).

National Rivers Authority classifications (National Rivers Authority 1994) are used to describe salmonid densities in the text of this report. Thus, for example, if it stated that trout fry abundance in a stream was ‘excellent’, the density of trout will have been greater than 38 per 100 square metres (Table 4).

Table 4. *NRA National Fisheries Classification Scheme for Atlantic salmon and brown trout*

Classification	Density per 100m^2			
	Salmon fry	**Salmon parr**	**Trout fry**	**Trout parr**
A (excellent)	=>86	=>19.0	>38	>21
B (good)	45.0 – 85.9	10.0 – 18.9	17 - 37.9	12-20.9
C (fair)	23 – 44.9	5.0 – 9.9	8 – 16.9	5 – 11.9
D (fair/poor)	9.0 – 22.9	3.0 – 4.9	3 – 7.9	2 – 4.9
E (poor)	<9.0	<3.0	<3.0	<2
F (fishless)	absent	absent	absent	absent

2.3.6 Survey dates and conditions

Two teams of experienced and qualified surveyors carried out electric fishing surveys between 28th August and 9th September 2008. Surveys were suspended on 1st September due to high water levels. Water levels on all other days were low or only slightly elevated.

2.3.7 Stocking

Shetland Anglers Association regularly stocks trout fry into several of the survey streams. Data on stocking were provided in order to assist interpretation of electric fishing results. Members of the Association pointed out that most stocking is in the lower reaches of streams with good road access and that data at sites greater than 0.5km from road access are unlikely to be affected by stocked fry.

Table 5. *Trout stocking by Shetland Anglers Association.*

Stream	Year	Number of fish stocked
Dury Voe Burn	2007	1500
	2008	1000
East Burrafirth Burns	2007	1100
Burn of Laxo	2007	750
	2008	2000
Sae Water	2006	6000
	2007	2250
Laxobigging Burn	2004	2000
(Mostly below Dam)	2007	3500
	2008	6000
Petta Water and	2006	4000
outlet Burn	2007	1200
Sand Water Loch	2006	9000
	2007	4000
Burn of Skelladale	2003	2000
North Burn of Voe	2007	550

3 RESULTS

3.1 Delting

3.1.1 Burn of Laxobigging

Description and proposed wind farm developments

The Burn of Laxobigging flows northwards to reach the sea in Garths Voe, immediately south of the Sullom Voe oil terminal. It is a moderately sized stream, some 4m wide in its lowest reaches. Shetland Angler's Association considers that the stream is an important sea trout spawning stream (Shetland Angler's Association 2006).

A dam has been constructed at HU417727, about 2km up from the sea. This seems likely to prevent further upstream access for anadromous fish species. The dam was originally constructed to provide a water supply for a military base at Graven/Sullom Voe during WWII. It is thought that it no longer serves any purpose (David Pottinger, Shetland Anglers Association pers. comm.). Approximately 1km upstream from the dam there are two waterfalls at HU411720. The lower waterfall appears passable but the upper fall is a difficult obstacle and may be impassable at most or all flows.

Shetland Anglers Association stocked 3500 trout fry in the area below the dam during 2007 and a further 6000 during 2008.

Proposed turbine sites 1, 2, 5, 6, 8, 10, 12, 13, 14, 16, 18, 21, 24, 27, 29, 32, 35, 170 and 171 fall within the catchment. Stream crossing points (turbine access track) are proposed for the following locations:

- HU402706: Burn of Oxnabool, track between T14 & T32;
- HU396702: Burn of Easterbutton, track between T14 & T13;
- HU397691: Burn of Easterbutton, track between T18 & T21;
- HU394701: Burn of Westerbutton, track between T14 & T13;
- HU424717: Burn of Moorfield, track between T171 and T1;
- HU425723: Burn of Moorfield, track between T1 and A968 road;
- HU430724: Stenswall Burn, track between T1 and A968 road; and
- HU432726Stenswall Burn tributary, ca. – track crossing between T1 and A968 road.

Habitat and survey sites

Good quality juvenile salmonid habitat is present throughout the Burn of Laxobigging, Burn of Easterbutton and Burn of Westerbutton. Spawning areas suitable for both trout and salmon are present in the accessible reaches downstream from the dam. Above the dam, further areas of spawning substrate are scattered along the length of the stream. Patches of trout spawning habitat extend right up into the headwaters of the burns of Eaterbutton and Westerbutton. Young trout were seen in both these streams during a preliminary walkover survey.

North Burn is mainly rather slow flowing. Undercut banks and draped vegetation provide suitable rearing habitat for young trout. While the full length of the burn was not surveyed, those reaches that were examined lacked spawning habitat. North Burn is formed from the Stenswall and Moorfield Burns. These small streams have a few small patches of spawning habitat suited only to trout.

Other tributaries of the Burn of Laxobigging (Burn of Oxnabool, Runnar Burn and Burn of Berdale) are short and steep. Habitat suited to young trout is present only in small sections of the lower reaches of these streams. This and their small size suggest these minor tributaries do not contribute greatly to fish production.

Eight sites were chosen for survey, five in the Burn of Laxobigging and three in the North Burn sub-catchment (Figure 1, Table 6).

***Table 6**. Burn of Laxobigging catchment, survey sites.*

Site Code	Stream	NGR	Survey type	Description
LBG1	B. of Laxobigging	HU3975 7059	SQ	Riffle/runs & pools with gravel & cobble base.
LBG2	B. of Laxobigging	HU4025 7073	SQ	Mixed substrate and flow. Good habitat.
LBG3	B. of Laxobigging	HU4082 7118	FQ	Pools with bedrock - undercuts suited to trout. Riffle and run sections with cobble & pebble.
LBG4	B. of Laxobigging	HU4171 7271	SQ	Mixed habitat with pools and runs.
LBG5	B. of Laxobigging	HU4114 7311	FQ	Decent mixed juvenile habitat with areas suited to salmon and trout.
STN1	Stenswall Burn	HU4292 7296	SQ	Much bedrock. Generally poor fish habitat.
MOF1	B. of Moorfield	HU4257 7276	SQ	Steep, bouldery burn with mossy rocks and little pools suited to trout parr.
NB1	North Burn	HU4188 7337	FQ	Good bank cover. Decent juvenile trout habitat but stream lacks spawning habitat.

Survey types: FQ = fully quantitative; SQ = semi-quantitative.

Fish populations

Fish species present at electric fishing sites were trout and eels. No other species were encountered. Eels were present at seven of eight sites, including the uppermost site LBG1. Trout were present at all sites. Salmon were absent at all survey sites.

Mean density of trout fry and parr (corrected) were 12.0 fish.100m^{-2} and 14.8 fish.100m^{-2} respectively. Densities at site LBG4 were significantly affected by the presence of stocked trout fry. These were clearly identifiable by their large size (compared to wild fry), badly deformed fins and, in many cases, enlarged eyes. Discounting clearly stocked fry would give a density of 9 fry.100m^{-2} at this site and would reduce mean density to 9.7 fry.100m^{-2}. Without stocking, densities of wild fry may have been greater at site LBG4, since it was striking that the smaller wild fry were present only in very shallow edge areas, suggesting displacement by larger stocked fry.

***Table 7**. Trout abundance and number of other fish species, Laxobigging.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
LBG1	10.9	18.1	13.5	23.0	Eels (2)
LBG2	5.2	21.9	6.4	27.8	-
LBG3	1.3	9.5	*1.3*	*10.8*	Eels (3)
LBG4	22.4	9.8	27.8	12.5	Eels (11)
LBG5	13.6	19.2	*17.6*	*24.1*	Eels (23)
STN1	0.0	2.6	0.0	3.3	Eels (2)
MOF1	21.3	8.0	26.4	10.1	Eels (3)
NB1	2.7	5.5	*2.7*	*6.9*	Eels (5)
All sites mean	***9.7***	***11.8***	***12.0***	***14.8***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

3.1.2 Burn of Skelladale

Description and proposed wind farm developments

This is a small stream, approximately 3m wide in its lower reaches, flowing west into Busta Voe, south of the village of Brae. The stream has no major tributaries. It is considered a valuable sea trout spawning stream (Shetland Anglers Association 2006).

The lower 1km of the stream is fast flowing with boulder substrate and is rather unstable. Approximately 0.5km up for the tidal limit at HU365671 there is 2.5m high waterfall. There is deep pool below this and it seems probable that it is passable by larger sea trout and salmon. Around 0.5km above the waterfall there is a section of lower gradient where the stream meanders. Here, deposits of gravel and pebble provide spawning habitat suited to salmon and trout. There is around 0.5km of good quality juvenile salmonid habitat upstream from this area. Further upstream, the gradient increases and the streambed is mainly bedrock. A ≥5m high waterfall at HU376676 is clearly impassable to upstream migrating salmon or trout. Upstream from the waterfall there are long sections of habitat suitable for juvenile trout. Spawning substrates are present. The small stream joining from the south at HU385674 is steep with little spawning potential

Turbines 26, 28, 30 and 31 will be located in the catchment (Figure 1). Five road crossings over upper feeder streams are proposed as follows:

- HU390688: track between T28 & T30;
- HU392676: track between T28 & T30;
- HU393675: track between T28 & T30;
- HU389673: track between T28 & T30;
- HU386671: track crossing T28 & T30.

Four sites were chosen for survey (Table 8), three on the main stem of the Burn of Skelladale and one on the small, unnamed tributary joining from the south at HU385674.

Table 8. *Burn of Skelladale catchment, survey sites.*

Site Code	Stream	NGR	Survey type	Description
SK1	Unnamed tributary	HU3851 6726	SQ	Tiny stream, sometimes running underground. Some pools and shallow runs.
SK2	Burn of Skelladale	HU3856 6741	SQ	Glides, pool and pebbly runs.
SK3	Burn of Skelladale	HU3820 6747	SQ	Some long glide sections with undercut banks.
SK4	Burn of Skelladale	HU3679 6721	FQ	Very stable with boulder cover. Spawning habitat a short distance upstream.

Survey types: FQ = fully quantitative; SQ = semi-quantitative.

Fish populations

The only species captured during electric fishing was trout. Mean density of trout fry and parr (corrected) were 4.4 fish.100m^{-2} and 12.8 fish.100m^{-2} respectively.

Table 9. *Trout abundance and number of other fish species, Burn of Skelladale.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
SK1	0.0	1.9	0.0	2.5	-
SK2	11.1	11.1	13.8	14.1	-
SK3	3.0	11.0	3.7	14.0	-
SK4	0.0	18.1	0.0	*20.5*	-
All sites mean	***3.5***	***10.5***	***4.4***	***12.8***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

By national standards, trout fry density would be classified as fair to poor and parr density as good. The low ratio of fry to parr is striking and is quite consistent across sites, indicating a weak 2008 year class. This is unlikely to be an artefact of site selection since (i) suitable fry habitat was present at all sites (all sites were at least 40m long with a variety of depth and flow) and (ii) spawning habitat was present near all sites with the exception of site 1.

3.2 Collafirth

3.2.1 Seggie Burn

The Seggie Burn is part of the Laxo Burn system. Data for survey sites on the Seggie Burn are presented within section 3.3.2.

3.3 Nesting

3.3.1 Wester Filla Burn

This is a very small stream with an average width of about 1m. It flows north into Loch of Voe, which is fished for brown trout. Sea trout and salmon do not have access to Loch of Voe or the Wester Filla Burn. Proposed turbines T55 and 62 fall within the catchment of the Wester Filla Burn. Two road crossing are proposed; the first at HU413608 (track A970 road & T62) and the second at HU419609 (track between T55 and T62).

Stream habitats in the Wester Filla Burn consist of numerous little runs, glides and pools. The lower and middle reaches contain excellent spawning habitat for trout in the form of gravel and pebble substrates in pool-tails and glides. Undercut banks with draped heather provide cover for young trout. Two sites were surveyed semi-quantitatively (Table 10).

***Table 10**. Wester Filla Burn, survey sites.*

Site Code	Stream	NGR	Survey type	Description
WF1	Wester Filla Burn	HU4153 6113	SQ	Pools and gravel runs with some boulder & cobble.
WF2	Wester Filla Burn	HU4153 6236	SQ	Shallow gravel and pebbles. Good fry habitat. Spawning habitat present.

Survey types: FQ = fully quantitative; SQ = semi-quantitative.

<u>Fish populations</u>

The only fish species present at survey sites was trout (Table 11). Fry were abundant, consistent with the presence of plentiful, good quality spawning habitat. Mean density of trout fry and parr (corrected) were 103.8 fish.100m^{-2} and 17.1 fish.100m^{-2} respectively.

***Table 11**. Trout abundance and number of other fish species, Wester Filla Burn.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
WF1	55.5	9.4	68.8	12.0	-
WF2	111.9	17.5	138.7	22.2	-
All sites mean	***83.7***	***13.5***	***103.8***	***17.1***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

3.3.2 Laxo Burn

<u>Description and proposed wind farm developments</u>

The Laxo is one of the larger catchments in Shetland; the Laxo Burn itself averaging some 7m in width in its lower reaches. It enters the sea in Laxo Voe, the northwest extremity of the larger Drury Voe on the east side of Mainland. The catchment is complex with four main sub-catchments: the Seggie Burn, Mill Burn (including Burn of Sandwater and Laxo Water), Gossawater Burn (including Gossa Water, Corgill Burn and Burn of Dale) and Saewater Burn (including Sae Water and the Easter Filla Burn). The catchment is shown on Figure 2.

The Laxo catchment is potentially impacted by developments in the Collafirth and Nesting quadrants. All the Collafirth turbines (T36, 38, 39, 41, 42, 44, 45 and 46) fall within the drainage of the Seggie Burn. Nesting turbines 47 to 51, 53, 54, 56, 58, 59, 61, 63, 64, 66, 67, 70 and 75 fall within the southern part of the catchment, mainly in the drainages of the Gossawater Burn and the Easter Filla Burn. Road crossings are proposed at:

- HU421661: Seggie Burn, between T36 & T42
- HU426662: Seggie Burn, between T36 & T38
- HU428660: Seggie Burn between T38 & T39
- HU422604: Easter Filla Burn between T64 & T67/T63;
- HU424615: Easter Filla Burn between T52 & T49;
- HU430623: Thomas Jamieson's Burn between T47 & T70;
- HU437623: Gossawater Burn minor tributary, between T66 & T48;
- HU438623: Gossawater Burn, between T66 & T48;
- HU439622: Gossawater Burn minor tributary between T48 & T51 and
- HU439618: Gossawater Burn minor tributary between T48 & T51.

<u>Habitat and survey sites</u>

The Easter Filla Burn is the largest tributary of the Saewater Burn. It is a small stream, mainly <2m in width. Habitat consists of pools, riffles and runs with a moderate to steep gradient followed by a short, low gradient meandering reach just south of Sae Water. There are some good sections of spawning habitat in the lower reaches, suitable for trout or salmon. Further upstream in the steeper sections spawning habitat is present as small patches, suited only to trout.

Thomas Jamieson's Burn is a tiny (<1m wide) stream. It carries little water and no spawning areas were identified. Substrate is mainly peat.

The Gossawater Burn flows out of Gossa Water (HU436607) and joins the Saewater Burn to form the Laxo Burn. It is 2m to 3m wet width in its lower reaches. The gradient is moderate and good quality mixed juvenile salmonid habitat is present throughout. The best spawning areas are in the lower, meandering reaches, downstream from the track crossings between T66 and T48. However, small areas of spawning habitat are present all the way up to the loch. Spawning habitat in the Gossawater Burn is suitable for salmon and trout. The inflow streams at the south side of Gossa Water - Burn of Dale and Corgill Burn - contain excellent trout spawning habitat. Gossa Water is one of the most important sea trout fisheries on Shetland and these streams undoubtedly represent the main spawning areas.

Habitats in the Saewater Burn are highly variable. Around the confluence of Thomas Jamieson's Burn the stream is slow flowing and deep (>50cm) with growth of *Potamogeton* spp. Such habitat is best suited to trout parr and adult brown trout. Further downstream towards the Gossawater confluence it consists of alternating sections of run and glide, with substrates dominated by stable cobble, boulder and pebble. Some spawning habitat is present, suited mainly to salmon due the large grain size. Juvenile habitats are suited to both salmon and trout, with moderate flows and good cover both in-stream (cobble, boulder and macrophytes) and alongside the banks. Similar habitat continues all the way down to the estuary.

No obstacles were identified in the above streams that would impede access for migratory fish. The waterfall on the Laxo Burn immediately upstream from the tidal limit is clearly passable, but may delay access for fish during periods of low water.

The Seggie Burn is the largest tributary of the Laxo Burn, some 4m wet width in its lower reaches. It is around 5km in length. The lower 400m is steep and bouldery with large areas of bedrock. Above this the gradient eases and substrates consist of cobble, pebble and boulder providing good habitat for juvenile salmonids. Habitat suitable for salmon and trout extends upstream beyond Kingshouse (HU436649). A significant waterfall around 3m in height is present at HU43376492. The waterfall is not vertical and may be passable to larger trout or to salmon on high flows, but this is uncertain. Above the waterfall the stream is of low or moderate gradient and meanders between steep peat banks. Some good spawning areas are present, especially on the bends around HU430648. Smaller patches of spawning substrate extend into the upper reaches around HU425656, but these are of lesser quality and suited only to trout. The stream in these upper reaches consists of run and glide habitat with peat or gravel substrates providing little cover. However, the stream is only about 1m wide in these upper reaches, and good cover is present in the form of undercuts and draped vegetation along the banks. Such habitat is well suited to trout production.

Thirteen sites were selected for electric fishing in the Laxo Burn catchment (Table 12).

***Table 12**. Laxo Burn catchment, survey sites.*

Site Code	Stream	NGR	Survey type	Description
EF1	Easter Filla Burn	HU4240 6154	Q	Pools and runs. Cobble boulder and pebble substrate.
EF2	Easter Filla Burn	HU4242 6180	SQ	Runs, riffles and pools. Pebble and cobble. Meandering.
EF3	Easter Filla Burn	HU4242 6233	FQ	Runs, riffles and pools. Meandering. Good cover.
TJB1	Thomas Jamieson's Burn	HU4316 6251	Q	Mainly peat channel with few hard substrates. Tiny stream.
GOS1	Burn of the Dale	HU4349 5996	SQ	Lots of patches of spawning for trout. Sequence of pools and pebble/gravel runs.
GOS2	Corgill Burn	HU4353 6022	SQ	Cobble and pebble in runs and shallow glides. Good juvenile trout habitat with spawning.
GOS3	Gossawater Burn	HU4370 6254	FQ	Good mixed juvenile habitat, typical of lower stream.
SEG1	Seggie Burn	HU4253 6556	SQ	Narrow stream with little pools and runs. Undercut banks.
SEG2	Seggie Burn	HU4265 6500	SQ	Excellent bank cover but little cover in stream. Pools and runs.
SEG3	Seggie Burn	HU4354 6486	SQ	Good mixed juvenile habitat. Varied depth and flow with moderate cover and plentiful undercuts.
SEG4	Seggie Burn	HU4395 6377	FQ	Stable boulder and cobble with run/riffle/pool sequences. Good cover.
LAX1	Laxo Burn	HU4372 6277	SQ	Typical of reach - short sections of stony run interspersed with glides & pools.
LAX2	Laxo Burn	HU4416 6343	FQ	Stable, weed-covered boulder and cobble surrounded by gravel. Runs and glides.

Survey types: Q = qualitative; FQ = fully quantitative; SQ = semi-quantitative.

Fish populations

Fish species present in the catchment were trout, salmon, eels and three-spined stickleback (Table 13a and 13b). Trout were present at all sites. Salmon were present in the middle reaches of the Seggie Burn around Kingshouse (site SEG 3), in the lower reaches of the Gossawater Burn (site GOS3) and in the Laxo Burn at site LAX1, near the Gossawater confluence. Eels were present in most streams, but confined to sites in the lower and middle reaches. Three-spined sticklebacks were identified only from the bottom of the catchment, at site LAX2.

Table 13a. *Trout abundance and number of other fish species, Laxo Burn.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
EF1	present	present	present	present	-
EF2	41.9	6.2	51.9	7.9	-
EF3	18.9	3.3	*24.1*	*4.6*	Eels (1)
TJB1	present	absent	present	absent	-
GOS1	107.4	0.0	133.2	0.0	-
GOS2	120.8	12.1	149.8	15.3	-
GOS3	1.0	7.9	*1*	*9.9*	Eels (7)
SEG1	13.4	24.1	16.6	30.6	-
SEG2	12.2	28.4	15.1	36.1	-
SEG3	11.6	11.6	14.4	14.8	Eels (11)
SEG4	5.1	13.5	*6.7*	*16*	Eels (16)
LAX1	3.7	7.4	4.6	9.4	Eels (12)
LAX2	4.5	7.4	*5.9*	*10.8*	Eels (49), 3sp. stickleback (1)
All sites mean	***30.9***	***11.1***	***38.5***	***14.1***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Table 13b. *Salmon abundance and number of other fish species, Laxo Burn.*

Site Code	SALMON DENSITY (fish.100m^{-2})			
	Single run		Absolute	
	0+	*1++*	*0+*	*1++*
EF1	absent	absent	absent	absent
EF2	0.0	0.0	0.0	0.0
EF3	0.0	0.0	*0.0*	*0.0*
TJB1	absent	absent	absent	absent
GOS1	0.0	0.0	0.0	0.0
GOS2	0.0	0.0	0.0	0.0
GOS3	1.0	2.0	*1.0*	*3.0*
SEG1	0.0	0.0	0.0	0.0
SEG2	0.0	0.0	0.0	0.0
SEG3	0.0	1.7	0.0	2.3
SEG4	0.0	0.0	*0.0*	*0.0*
LAX1	3.7	0.0	4.9	0.0
LAX2	0.0	0.0	*0.0*	*0.0*
All sites mean	***0.4***	***0.3***	***0.5***	***0.5***

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Trout densities in the catchment were highly variable. Excellent densities of fry were present in the Easter Filla Burn (sites EF1 and EF2) and in the inflow streams to Gossa Water (sites GOS1 and GOS2). Trout fry numbers in the Seggie Burn were good, except at the lowest site, SEG4. Trout parr numbers in the Seggie Burn were good or excellent throughout. Trout fry numbers in the Laxo Burn itself were fair to poor, but parr numbers were fair, perhaps suggesting that trout parr drop down into the mainstem from the feeder streams where fry numbers were higher.

Average number of juvenile salmon was poor throughout the catchment and salmon were found at only three of thirteen sites. Salmon fry were present at low numbers in the lower reaches of the Gossawater Burn and in the Laxo Burn near the Gossawater confluence (site LAX1). Salmon parr were present in the lower reaches of the Gossawater Burn and in the Seggie Burn at Kingshouse (SEG3). No fry were found in the Seggie Burn, suggesting a missing year class.

3.3.3 Burn of Grunnafirth

Description and proposed wind farm developments

The Burn of Grunnafirth runs from west to east entering the sea in the southwest of Dury Voe. The stream is about 6km in length and some 4m wide in its lower reaches. The only large tributary is the Quinni Burn, which flows into the Burn of Grunnafirth about 400m up from the sea (Figure 2). The catchment is potentially impacted by developments in the Nesting quadrant. Turbines T40, 43, 57, 79, 86, 87, 93, 96, 100, 102, 103 104 and 105 are within the catchment. Four stream crossings are proposed at:

- HU450580: Burn of Forse between T87 & T115;
- HU438580: Burn of Forse between T105 & T79;
- HU455586: Burn of Grunnafirth between T109 & T93; and
- HU446591: unnamed inflow burn into Quinni Loch, between T43 & T40/37.

Stany Burn in the upper part of the catchment is small and mainly peat based, flowing between steep, incised peat banks. However, some patches of gravel at pool tails and on bends provide a little potential spawning habitat for trout. Further downstream the watercourse is called Burn of Forse. Good trout habitat is present in this stream with long reaches of cobble and pebble, mixed flows and good cover beneath overhanging banks. A 3.5m high waterfall at HU444580 is probably impassable, limiting upstream access for migratory salmonids. Proceeding downstream, the burn becomes more open in character and provides good quality juvenile and spawning habitat, suited both to trout and salmon. Similar habitat continues downstream to the sea, with only a few areas of bedrock and no significant obstacles to fish movement. The proposed stream crossing at HU455586 is in an area of good quality salmonid habitat, with spawning potential. Five sites were selected for survey (Table 14).

***Table 14**. Burn of Grunnafirth, survey sites.*

Site Code	Stream	NGR	Survey type	Description
FOR1	Burn of Forse	HU4362 5798	SQ	Deep, slow moving with hard gravel bed.
FOR2	Burn of Forse	HU4423 5799	SQ	Riffle, run & glide with mixed substrates.
FOR3	Burn of Forse	HU4519 5802	FQ	Stable cobble and pebble in runs and glides. Good salmonid habitat.
GRU1	Burn of Grunnafirth	HU4574 5885	SQ	Boulder & cobble in glides and runs. Good salmonid habitat.
GRU2	Burn of Grunnafirth	HU4606 5946	FQ	Mixed substrate in riffle, run and glide.

Fish populations

Two species, trout and eels, were present at survey sites (Table 15). Average densities of trout fry and parr were fair-poor and good respectively. Densities were highly variable. No trout were captured at the upper two sites on Burn of Forse (FOR1 and FOR2) but fry and parr densities at site FOR3, below the Twart Burn confluence, were good and excellent respectively. Trout fry numbers at the two sites in the lower catchment were poor and, both at sites GRU1 and GRU2 were lower than trout parr numbers. Overall, the data suggest a weak 2008 trout year class.

***Table 15**. Trout abundance and number of other fish species, Burn of Grunnafirth.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
FOR1	0.0	0.0	0.0	0.0	Eels (2)
FOR2	0.0	0.0	0.0	0.0	Eels (6)
FOR3	15.9	29.5	*21.5*	*34*	Eels (13)
GRU1	3.9	13.8	4.9	17.6	Eels (3)
GRU2	4.0	4.6	*5.7*	*8.5*	Eels (10)
All sites mean	***4.8***	***9.6***	***6.4***	***12.0***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

3.3.4 Burn of Crookadale

Description and proposed wind farm developments

The Burn of Crookadale flows from north to south, joining the sea at the northeast corner of Cat Firth, in South Nesting. The Gill Burn and Burn of Flamister drain the slopes to the east of Burn of Crookadale. These two streams converge at HU436547 before their combined flows merge with Burn of Crookadale at HU435539, some 400m upstream from the sea. The streams are thought to be the main spawning area for sea trout in the Cat Firth locale. The catchment is potentially impacted by developments in the Nesting quadrant. Turbines T112, 125, 127, 135, 137, 138, 139, 145, 147, 152 and 150 are within the catchment. Two stream crossings are proposed at:

- HU425557: Burn of Crookadale between T138 & T145 and
- HU435559: Gill Burn between T139 & T137.

Habitat and survey sites

The Burn of Crookadale is a small stream, some 2m wet width upstream from the confluence with Burn of Flamister. The upper reaches, north of HU424555 flow between steep, incised peat. Current speed is moderate and the stream consists of runs, glides and little pools over mainly peat substrates. The stream then descends more steeply and is torrential in places, but without impassable falls, until the gradient eases above Park of Catfirth (HU424545). The lower reaches of the stream are meandering with good spawning substrate on several bends.

Burn of Flamister was examined only as far upstream as HU438550. These lower reaches meander between low banks and provide good juvenile habitat for trout. The substrates consist of gravel, pebble and cobble with occasional boulders. Substrates are stable, but not set into peat or compacted, and spawning habitat suitable for trout is present.

Gill Burn was examined upstream to HU434549. The lower reaches above the confluence provide suitable habitat for juvenile salmonids and patches of spawning habitat are present. A waterfall near the ruins at HU436547 appears impassable. Further upstream these are numerous small cascades, most of which are likely to be passable. Between these small cascades stream habitats appear well suited to juvenile trout with a good mix of pools and runs with plentiful cover.

Access for migratory fish into all the streams is likely to be impeded by a significant waterfall a short distance up from the sea at HU438538. This waterfall consists of two vertical or near-vertical tiers. The larger of the two drops was estimated to be between 2.0 and 2.5m in height. As the fall is in a small gorge with vertical walls it was difficult to approach closely to get a better estimate of height. A small sea trout (estimated weight <200g) was seen jumping unsuccessfully at the lower fall on 1st September and the fall appears likely to be impassable for such a small fish. There is a small resting pool between the two tiers of the fall, but this appears to become washed through at high flows. This waterfall may be passable to salmon and large sea trout at moderate flows, but it is clearly a significant obstacle. It is unlikely that eels can ascend the fall directly.

Table 16. *Burn of Crookadale, survey sites.*

Site Code	Stream	NGR	Survey type	Description
CRK1	Burn of Crookadale	HU4255 5584	Q	Mainly peat substrates. Pools and runs.
CRK2	Burn of Crookadale	HU4243 5548	SQ	Little pools interspersed with runs and glides. Little patches of spawning suitable for trout.
CRK3	Burn of Crookadale	HU4253 5429	SQ	Unstable gravel and pebble. Mainly glide.
CRK4	Burn of Crookadale	HU4339 5391	FQ	Meandering section with pools and runs.
FLAM1	Burn of Flamister	HU4379 5504	SQ	Nice little burn with stable bed and mixed flows/substrates.
GIL1	Gill Burn	HU4343 5484	SQ	Decent fish habitat with mixed flows and substrates. Above a waterfall.
Gil 2	Gill Burn	HU436547	Q	Mixed juvenile habitat below waterfall.

<u>Fish populations</u>
Four sites were surveyed on the Burn of Crookadale, two on Gill Burn and one on Burn of Flamister (Table 16). Trout were present in all streams. In Burn of Crookadale trout were present up into the higher reaches, with both fry and parr captured at site CRK1, upstream from the proposed crossing between T138 and 145. No trout were present at the single site above the waterfall on Gil Burn, but trout were present at site Gil2 immediately downstream from the falls. The only other fish species identified was eels, with one specimen captured from Burn of Crookadale. It is probable that the lower waterfall limits eel access into the catchment.

Table 17. *Trout abundance and number of other fish species, Burn of Crookadale.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
CRK1	present	present	present	present	-
CRK2	3.3	11.7	4.1	14.8	-
CRK3	0.0	5.3	0.0	6.8	Eels (1)
CRK4	30.0	5.2	*39.1*	*14.3*	-
FLAM1	49.0	7.0	60.7	8.9	-
GIL1	0.0	0.0	0.0	0.0	-
Gil 2	present	present	present	present	-
All sites mean	***16.5***	***5.8***	***20.8***	***9.0***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Trout density varied widely in the catchment. Fry densities were poor-fair at site CRK2. The lack of fry at site CRK3 may be because the better spawning habitat is further downstream. Fry densities at the lowest site, CRK4, were excellent as they were at site FLAM1 on Burn of Flamister. Parr density varied less between sites and average parr density was fair.

3.3.5 Burn of Quoys

Description and proposed wind farm developments

Burn of Quoys is a small stream, some 3km in length with a wet width of 3.5m in its lower reaches. In has one significant unnamed tributary, which converges from the northwest at HU446555. The catchment is potentially impacted by developments in the Nesting quadrant. Proposed turbines T131, 140, 143 and 148 are within the catchment. Two stream crossings are proposed at

- HU446558: Burn of Quoys tributary between T143 and T131 and
- HU448560: Burn of Quoys between T143 & T140.

Habitat and survey sites

With the exception of the bottom 200m, the lower 0.7km of the Burn of Quoys runs through gorge-like habitat with bedrock and boulder substrates. The presence of boulder cover creates adequate habitat for trout parr in these reaches, but spawning substrate is lacking. Habitat quality improves further upstream, with gravel areas on bends providing some spawning opportunities and run/pool sequences creating mixed habitat for juvenile salmonids. Undercut peat banks provide additional cover. The western tributary is about 1m wide in its lower reaches and at low flows it will be much smaller. Much of this stream is peat-based with very few opportunities for spawning. Little pools filled with *Potamogeton sp*. are present in the low gradient sections. Three sites were surveyed (Table 18).

***Table 18**. Burn of Quoys, survey sites.*

Site Code	Stream	NGR	Survey type	Description
QOY1	Unnamed western tributary	HU4449 5538	SQ	Pools and runs in small stream. Mainly peat substrate. Trout confined to pools.
QOY2	Burn of Quoys	HU4473 5535	SQ	Run and glide with boulder, cobble and pebble substrate.
QOY3	Burn of Quoys	HU4439 5436	FQ	Shallow riffle/run and shallow glide. Cobble and pebble. 150m up from sea.

Fish populations

Trout and eels were present at all sites (Table 19). Flounders were present at the lowest site, which was situated around 150m up from the sea.

***Table 19**. Trout abundance and number of other fish species, Burn of Quoys.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
QOY1	0.0	2.6	0.0	3.3	Eels (1)
QOY2	1.1	6.0	1.3	7.6	Eels (2)
QOY3	1.3	10.8	*3.4*	*12.1*	Eels (49), Flounder (11)
All sites mean	***0.8***	***6.4***	***1.6***	***7.6***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Average trout fry and parr densities were 1.6 and 7.6 fish.100m^{-2} respectively. Parr were more abundant than fry at all sites, suggesting a weak 2008 trout year class. Average fry and parr densities were poor and fair respectively.

Small eels, mainly 10-15cm in length, were abundant at the lower site.

3.4 Kergord

3.4.1 Burn of Kirkhouse

Description and proposed wind farm developments

The Burn of Kirkhouse flows from south into the eastern end of Olna Firth, at the village of Voe (Figure 3). It has one large tributary; Patrick's Burn which joint from the east at HU400612. The smaller Burn of Forse converges from the west. The catchment is potentially impacted by developments in the Kergord quadrant. None of the proposed turbines is fully located within the catchment. However turbines 65 and 69 lie on the Mid-Kame ridge, on the watershed between the Kirkhouse and Sandwater catchments. A single stream crossing over Burn of Forse, is proposed at HU390613 on the proposed access track to T72.

Habitat and survey sites

Stream habitats were examined from the estuary to around 200m upstream from the Burn of Forse confluence. In the upstream part of the survey area the burn is meandering and deep, flowing in a channel incised through peat. Downstream from the confluence there are short sections where substrates are dominated be cobble and the banks are lower and less steep. However, much of the cobble is set into peat, providing poor cover for young fish and likely to support a low abundance of invertebrate food. Habitat quality for salmonids is further reduced by the presence of large areas of bedrock. Deep pools are present, likely to hold trout parr and adults.

A fish pass has been installed at the bridge apron where the stream flows below the B9071 (HU402627). Unfortunately the drop from the lower pool of the fish pass is onto shallow rock, with no suitable pool from which fish can make the jump to the pass. Access would be improved by deepening the pool below the fish pass.

***Table 20**. Burn of Kirkhouse, survey sites.*

Site Code	Stream	NGR	Survey type	Description
KIR1	Burn of Kirkhouse	HU3996 6152	SQ	Small peaty channel with a few patches of gravel. Mainly glide with lots of undercut banks.
KIR2	Burn of Forse	HU3979 6156	SQ	Small peaty channel with little hard substrate. Lots of undercut banks.
KIR3	Burn of Kirkhouse	HU4002 6203	FQ	Cobbles & boulders embedded in peat. Much bedrock. Typical of area.

Three sites were surveyed (Table 20): one a short distance upstream from the Burn of Forse confluence (KIR1), one on the lower Burn of Forse (KIR2) and one downstream from the confluence (KIR3).

***Table 21**. Trout abundance and number of other fish species, Burn of Kirkhouse.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
KIR1	3.3	2.2	4.1	2.8	-
KIR2	2.7	8.0	3.3	10.2	-
KIR3	20.2	4.0	*25.6*	*6.7*	Eels (1)
All sites mean	***8.7***	***4.8***	***11.0***	***6.6***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Fish populations

Two species were present at electric fishing sites, trout and eels. Only one eel was counted during the survey, a single specimen around 15cm in length at site KIR3. Trout were present at all sites with mean densities of fry and parr of 11.0 fish.100m^{-2} and 6.6 fish.100m^{-2} respectively. Fry were scarce at sites KIR1 and KIR2 but the density at KIR3 was good.

3.4.2 *Burn of Sandwater*

Description and proposed wind farm developments

This large stream drains north to south, flowing into the sea at Loch of Strom, HU406506. It is some 10km in length with two lochs along its course, the Petta Water (HU4159) and Sand Water (HU4154). Between these two lochs, the watercourse is known as the Burn of Pettawater. There are no major tributaries. The catchment is potentially impacted by developments in the Nesting quadrant. Proposed turbine T68 lies within the catchment. In addition, the turbines along Mid Kame lie on the watershed between the Sandwater and the Weisdale and Kirkhouse catchments. No stream crossings are proposed within the Sandwater catchment.

Habitat and survey sites

No surveys took place downstream of Sand Water. The Burn of Pettawater was inspected from upstream from Petta Water at HU597415 to the Sand Water inflow at HU415552. The inflow streams to Petta Water are little more than shallow channels through peat, lacking in hard substrates. Sea trout and salmon have been recorded in Petta Water, but it seems likely that they must drop back downstream to spawn as no suitable habitat is present upstream from the loch. Immediately below the loch the watercourse consists of a steep-sided channel incised through peat. Substrate is largely peat, covered with a thin layer of coarse sand. Few larger substrates are present, limiting spawning opportunities for salmonids. In the middle reaches there are long sections where big stable cobbles and boulders are set into the peat. These are surrounded by sand and gravel. The stable bed supports growth of various macrophytes; these and undercut banks provide good cover for fish. As the stream continues south, the proportion of medium sized substrates such as gravel, pebble and cobble increases. Run and pool sequences are present and the stream opens out, with lower banks and greater light penetration. In places the larger substrates are compacted in the underlying peat, but spawning habitat is present on some bends and in pools tails. The lower 0.4km immediately upstream from Sand Water is deep, slow flowing and canal-like with some macrophyte growth – suited mainly to trout parr and adults.

No obstacles to upstream migration were identified on the Petta Water. Sea trout and salmon are believed to have access into the Petta Water, although members of the SAA expressed concerns regarding the design of the fish pass in the lower catchment at HU408511. Nevertheless, Burn of Petta Water is considered an important sea trout stream (SAA 2006) and salmon have been recorded. The Shetland Anglers Association stocked trout fry into the Petta Water during 2007 (4000 fry) and 2008 (1200 fry).

Table 22. *Burn of Sandwater catchment, survey sites.*

Site Code	Stream	NGR	Survey type	Description
PW1	Burn of Petta Water	HU4173 5846	SQ	Peat channel with a thin layer of sand - very poor salmonid habitat but typical of area.
PW2	Burn of Petta Water	HU4172 5715	SQ	Runs and pools with stable boulder and peat. Cover mainly in macrophytes and along undercut banks.
PW3	Burn of Petta Water	HU4159 5553	FQ	Weed covered cobble and boulder set in peat and surrounded by coarse sand.

Fish populations
Three species were recorded in the Burn of Pettawater, eels, trout and three-spined stickleback. Three-spined sticklebacks were recorded at all three sites while eels and trout were present only at the lower two sites.

Mean density of trout fry and parr was 23.8 fish.100m^{-2} (good) and 4.3 fish.100m^{-2} (fair-poor) respectively. The relative paucity of trout parr may suggest that many drop down into Sand Water, although this is conjectural. Only three fry were identifiable as stocked, these having typical fin deformities. However, the quality of fry stocked into the stream is thought to be good with little fin damage (D. Pottinger, SAA, pers. comm..) and so the contribution of stocked trout to measured densities at survey sites cannot be assessed.

Table 23. *Trout abundance and number of other fish species, Burn of Sandwater catchment.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
PW1	0.0	0.0	0.0	0.0	3 sp. stickleback (>100)
PW2	18.1	4.3	22.5	5.5	Eels (2), 3 sp. stickleback (1)
PW3	41.4	7.5	*48.8*	*7.5*	Eels (15), 3 sp. stickleback (1)
All sites mean	***19.8***	***3.9***	***23.8***	***4.3***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

3.4.3 *Burn of Weisdale*

Description and proposed wind farm developments
The Burn of Weisdale runs north to south, draining the Valley of Kergord and entering the sea at the head of Weisdale Voe (HU393523). In its upper reaches it is known as the Burn of Kergord. There are no lochs in the catchment and only one major tributary, the Burn of Droswall, entering the main channel at South Setter (HU401548). The catchment is potentially impacted by developments in the Nesting quadrant. Turbines T72, 78, 85, 91, 111, 122 and 136 lie within the catchment. In addition, the turbines along Mid Kame lie on the watershed between the Weisdale catchment and the catchments to the east. A single stream crossing is proposed, on the access track off the B9075 at HU400557 (Burn of Droswall).

Habitat and survey sites
The middle reaches of the stream were inspected from HU405568 (1km north of upper Kergord) downstream to the old dam at HU400542. The whole of this section provides good quality juvenile salmonid habitat. Substrates are stable cobble and boulder with some weed growth. Additional cover is present along the banks, mainly in undercuts. Spawning gravels are present. The gradient is moderate throughout and there are no natural waterfalls or other obstructions to fish passage. The dam shown on the Ordnance Survey Explorer sheet 467 at HU400542 has been removed.

The weir at Weisdale Mill HU396531 was inspected. This weir backs up a considerable pond, providing the water supply for the fish hatchery at the same location. The weir was originally constructed to provide waterpower for Weisdale Mill. There are two possible routes for fish to ascend the weir, one toward the left bank and one toward the right. Both are channels with flow controlled by gates. The largest flow is to the right banks and this offers the best access. However, as the tailrace from this channel is some 20m downstream from the face of the weir fish may have difficulty finding it. The right channel carries less water, but fish do ascend it especially during periods of elevated flow (Paul Featherstone, Shetland Sea Trout, Weisdale, pers. comm.). It is clear that the weir is not an insurmountable barrier to upstream migration. Nevertheless it seems likely that it could be improved and a full assessment is desirable.

The Burn of Kergord and Burn of Weisdale are considered to be important sea trout spawning streams. Three sites on the Burn of Weisdale were surveyed (Table 24).

Table 24*. Burn of Weisdale, survey sites.*

Site Code	Stream	NGR	Survey type	Description
WEI1	Burn of Weisdale	HU4053 5779	SQ	Slow flowing. Small glides with weed cover.
WEI2	Burn of Weisdale	HU4051 5672	SQ	Bank very eroded. Unstable stream bed with only a few big boulders.
WEI3	Burn of Weisdale	HU4013 5421	FQ	Very stable weed covered rocks.

Fish populations

Two species were identified at the survey sites, trout and eels. Trout were present at three sites and eels at two (Table 25).

Table 25*. Trout abundance and number of other fish species, Burn of Weisdale.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
WEI1	26.2	14.5	32.4	18.5	-
WEI2	14.8	5.9	18.4	7.5	Eels (1)
WEI3	1.6	23.6	*3.1*	*34.6*	Eels (16)
All sites mean	***14.2***	***14.7***	***18.0***	***20.2***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Trout fry were most abundant at the uppermost sites, WEI1 and WEI2 where good densities were present. Trout fry were less abundant at site 3 where the density was poor, nevertheless the average density of 18.0 trout fry.100m^{-2} is good by national standards. In contrast, trout parr were most abundant at site WEI3, which carried an excellent density. As with fry, average trout parr density was classified as good. Eels were plentiful at the lower site, mainly in the length range 10-20cm.

3.4.4 Burrafirth

This sprawling, complex catchment drains westward into Aith Voe at HU366577. There are two main sub-catchments, the South Burn of Burrafirth and the Burn of Lunklet. The South Burn of Burrafirth drains Maa Water and Truggles Water via the Burn of Truggles Water. The Burn of Atlascord joins this burn from the south, forming the South Burn of Burrafirth. The Burn of Lunklet drains Loch of Lunklet. The burn has two large tributaries, the Burn of Marrofield Water from the north and the Burn of Lambawater from the south. The Burn of Lunklet and South Burn of Burrafirth converge at HU367574, some 400m upstream from the sea.

Thirty-one of the proposed Kergord quadrant turbines lie within the catchment. Nine stream crossings are proposed, six of which are small feeder stream of lochs within the catchment:

- HU368544: Burn of Truggles Water between T157 & T159;
- HU375544: unnamed inflow to Truggles Water between T156 & T160;
- HU379533: Burn of Atlascord T165 & T168;

- HU380546: unnamed inflow to Maa Water between T154 & T156;
- HU380547: unnamed inflow to Maa Water between T154 & T156;
- HU381548: unnamed inflow to Maa Water between T154 & T153;
- HU384554: unnamed inflow burn to Lamba Water between T146 & T153;
- HU388556: unnamed inflow to Lamba Water between T146 & 136 and
- HU385555: unnamed inflow to Lamba Water between T146 & T153.

<u>Habitat and survey sites</u>
South Burn of Burrafirth provides large areas of good quality juvenile salmon and trout habitat. Gradient is moderate and substrates are a mix of cobble, pebble and boulder. The stream is moderately stable and spawning areas are present throughout. Between the Truggles Water confluence and its confluence with the Burn of Lunklet, the South Burn of Burrafirth is between 2 and 4m in width and spawning habitat is suitable for both trout and salmon. Good quality habitat continues upstream into the Burn of Atlascord and spawning sites remain plentiful, but suited more to trout than to salmon. The Burn of Atlascord was inspected only as far upstream as HU364543. Judged by gradient, it is probable that suitable juvenile salmonid habitat extends a further 1.5 to 2km upstream.

The Burn of Truggles Water is a small stream, around 1.2m wet width. It provides some areas of good quality juvenile habitat, particularly in its meandering lower reaches, but spawning opportunities appear limited. Further upstream the gradient is steep, and there is an awkward obstacle at HU36825443 where a small waterfall with a choke stone makes upstream access difficult.

The small stream flowing into Truggles Water from the east is tiny (~30cm wet width). Even immediately upstream from the loch, parts of it flow beneath the peat. No spawning substrate was noted and the base of the burn is mainly peat. A waterfall 150m upstream from the loch may be impassable. The main inflow to Truggles Water is from Maa Water. The stream between these two lochs is around 0.7m in width. The gradient is moderate and substrates consist of stable cobble and pebble covered in algae and peat deposits. Spawning substrates appear scarce but the stream is well suited to juvenile trout with plentiful cover in little pools and along undercut banks draped in heather. The main inflow stream to Maa Water is at the southeast corner of the loch. Average width in the lower reaches is 1m and substrates are mainly cobbles set into peat. No spawning habitat was noted in the lower reaches, although the presence of fry suggests some may be present further upstream.

No obstacles of note are present on the South Burn of Burrafirth and migratory fish have clear access at least as far as Burn of Atlascord. Accessibility on Burn of Atlascord was not assessed upstream from HU364543.

Access for migratory salmonids into the Burn of Lunklet side of the catchment is restricted to the lower 300m above the confluence with South Burn of Burrafirth by an impassable waterfall at HU370573. The lower reaches of Burn of Lunklet and Burn of Marrofield Water were inspected during electric fishing surveys. The Burn of Lamba Water was inspected throughout its length. Burn of Vats-houll, the main inflow stream to Lamba Water, was inspected in its lower 500m.

Upstream from the waterfall the Burn of Lunklet provides suitable habitat for juvenile trout, with moderate flows over cobble, pebble and boulder substrates. The banks are quite heavily grazed, but undercuts provide some cover. Upstream from HU375574 the gradient is steeper and substrate includes a high proportion of bedrock, providing poor fish habitat.

The lower reaches of the Burn of Marrofield Water are quite steep and unstable, with several reaches that are dominated by bedrock. This habitat is adequate for trout parr but poor for fry and spawning opportunities are limited. The gradient eases further upstream, towards Marrofield Water.

Burn of Lambawater is an attractive little trout stream with a moderate gradient. The meandering course comprises riffle, run pool sequences providing diverse habitats for trout fry and parr. Spawning substrate is widespread, but in places is slightly unstable.

Burn of Vats-houll is a dark peaty stream, with a channel incised through blanket peat. Substrate in the lower reaches is scattered boulders set into peat. No spawning habitat was noted.

Survey sites in the catchment (n=15) are listed in Table 26.

Table 26. *Burn of Burrafirth, survey sites.*

Site Code	Stream	NGR	Survey type	Description
MAA1	Maa Water inflow.	HU3797 5492	SQ	Peat channel with a few boulders. No obvious spawning habitat present.
TRU1	Between Truggles Water & Maa Water	HU3726 5490	SQ	Little pools and runs with stable cobble and pebble covered in algae. Bank cover in undercuts.
TRU2	Truggles Water inflow	HU3722 5443	Q	Tiny stream with mainly peat substrate. No spawning habitat seen. Poor juvenile habitat.
TRU3	Truggles Water outflow	HU3661 5451	SQ	Decent habitat for trout with patches of spawning.
ATL1	Burn of Atlascord	HU3644 5431	SQ	Nice little trout stream typical of lower reaches of B. of Atlascord.
SBF1	S. Burn of Burrafirth	HU3648 5473	SQ	Mixed habitat of runs, riffles and pools. Undercut banks.
SBF2	S. Burn of Burrafirth	HU3640 5559	SQ	Loose gravel, pebble and angular rather unstable cobble. Run, riffle and glide.
SBF3	S. Burn of Burrafirth	HU3670 5689	FQ	Stable boulder and cobble filled round with less stable sand and gravel. Mainly run.
SBF4	Burrafirth	HU3668 5750	FQ	Typical of river below Lunklet confluence. Good cover but lacks spawning.
LAM1	Burn of Vats-houll - Lamba Water inflow	HU3844 5589	Q	Peat and boulder with few or no smaller substrates. Very poor fish habitat.
LAM2	Burn of Lamba Water	HU3749 5681	SQ	Good juvenile habitat with mixed flows and depths.
LAM3	Burn of Lamba Water	HU3743 5710	SQ	Good fry habitat at top end and pools for parr.
LUN1	Burn of Lunklet	HU3744 5732	SQ	Gentle gradient with good instream cover.
LUN2	Burn of Lunklet	HU3731 5731	FQ	Some bedrock, especially in lower part of section. Top is decent habitat. Two pools and some fast riffles.
MAR1	Marrofield Water	HU3746 5802	SQ	Mainly parr habitat. Poor for fry. Fair bit of bedrock but good bouldery pools.

<u>Fish populations</u>
Five species were recorded. The most widely distributed was trout, present at 14 of 15 survey sites followed by eels (9 sites), salmon (3 sites), three-spined sticklebacks (2 sites) and flounders (1 site).

Average trout fry abundance for the catchment was 21.8 fish.100m^{-2}, good by national standards. There was little difference in mean fry densities between the Lunklett side of the catchment (inaccessible to migratory stocks) and the south Burrafirth side (accessible), with mean fry densities of 23.2 and 19.5 fish.100m^{-2} respectively. Mean trout parr abundance for the catchment was 9.4 fish.100m^{-2} (fair) with densities of 10.4 and 7.8 fish.100m^{-2} for the Lunklet and South Burrafirth sub-catchments respectively.

Table 27a. *Trout abundance and number of other fish species, Burn of Burrafirth.*

Site Code	TROUT DENSITY (fish.100m^{-2})				Other fish species (number caught)
	Single run		Absolute		
	0+	*1++*	*0+*	*1++*	
MAA1	22.2	0.0	27.6	0.0	3 sp. stickleback (1)
TRU1	51.7	5.7	64.1	7.3	3 sp. stickleback (1)
TRU2	present	absent	present	absent	-
TRU3	13.9	12.8	17.2	16.3	Eels (11)
ATL1	29.5	11.3	36.6	14.4	Eels (6)
SBF1	6.5	13.0	8.1	16.5	Eels (18)
SBF2	15.2	9.8	18.8	12.5	Eels (7)
SBF3	8.0	4.5	*9.8*	*8*	Eels (5)
SBF4	3.1	4.9	*3.6*	*8.5*	Eels (43), Flounder 92)
VH1	absent	absent	absent	absent	-
LAM1	23.8	2.2	29.5	2.7	-
LAM2	25.9	3.0	32.1	3.8	Eels (1)
LUN1	18.4	9.2	22.8	11.7	Eels (1)
LUN2	10.9	5.5	*13.1*	*8.7*	Eels (3)
MAR1	0.0	9.5	0.0	12.1	-
All sites mean	***17.6***	***7.0***	***21.8***	***9.4***	

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

Table 27b. *Salmon abundance and number of other fish species, Burn of Burrafirth.*

Site Code	SALMON DENSITY (fish.100m^{-2})			
	Single run		Absolute	
	0+	*1++*	*0+*	*1++*
MAA1	0.0	0.0	0.0	0.0
TRU1	0.0	0.0	0.0	0.0
TRU2	absent	absent	absent	absent
TRU3	0.0	0.0	0.0	0.0
ATL1	0.0	0.0	0.0	0.0
SBF1	0.0	0.0	0.0	0.0
SBF2	0.0	1.5	0.0	2.0
SBF3	0.0	3.6	*0.0*	*3.6*
SBF4	0.0	3.6	*0.0*	*5.8*
VH1	absent	absent	absent	absent
LAM1	0.0	0.0	0.0	0.0
LAM2	0.0	0.0	0.0	0.0
LUN1	0.0	0.0	0.0	0.0
LUN2	0.0	0.0	*0.0*	*0.0*
MAR1	0.0	0.0	0.0	0.0
All sites mean	***0.0***	***0.7***	***0.0***	***0.9***

Note: Absolute density figures in italics are Zippin estimates. All other absolute densities were calculated using correction factors given in Figure 4.

On the South Burrafirth sub-catchment, trout densities were generally highest at the upper sites, including Burn of Truggles Water and Burn of Atlascord. In the Lunklet sub-catchment trout fry densities were good in the Burn of Lamba Water and the upper site on Burn of Lunklet (LUN1). Fry were absent at the survey site on Burn of Marrofield Water; however parr density at this site was good and the lack of fry is likely to reflect the nature habitat in the lower parts of this stream.

Salmon were found at only three sites and densities at all of these were poor. The fry year class was absent at all sites and all the parr caught (n=19) were aged 1+ i.e. from spawning of winter 2006-07. These data suggest that successful salmon spawning in the catchment is sporadic.

4 DISCUSSION

4.1 Fish populations

The survey streams sustain a rather limited array of species (Table 27), as would be predicted from published accounts of freshwater fish distribution in the Northern Isles. Brown trout were widely distributed, present in all survey streams and at the great majority of sites. Eels were similarly widespread, but occurred at fewer sites. Other species encountered species were three-spined stickleback, which occurred in three catchments, salmon, and flounder, both of which occurred in two.

Table 27. *Species occurrence by catchment.*

Catchment	Eel	Trout	Salmon	3-spined stickleback	Flounder
Laxobigging	X	X			
Skella Dale		X			
Wester Filla		X			
Laxo	X	X	X	X	
Grunnafirth	X	X			
Crookadale	X	X			
Quoys	X	X			X
Kirkhouse		X			
Sandwater	X	X		X	
Weisdale	X	X			
Burrafirth	X	X	X	X	X

Given that only a small number of sites were surveyed in each catchment, it is possible that some species may have been missed. However, it is very unlikely that any species not listed in Table 27 is present in any of the streams. The most likely species to have been overlooked would be eels, three-spined stickleback and flounder. Eels occurred at low densities at most sites and their absence from survey sites in the Skelladale, Wester Filla and Kirkhouse catchments cannot be assumed to indicate their complete absence from these systems. Similarly, occasional flounders and three-spined sticklebacks may occur in the lower reaches of any of the streams, as these species occupy saltwater as well as freshwater habitats.

Based on data recorded in the NBN Gateway, salmon have previously been recorded in the Burn of Weisdale, Burn of Sandwater, Burn of Kirkhouse, Laxo Burn, Burn of Grunnafirth and Burrafirth catchments. The lower reaches of the Burns of Weisdale and Sandwater were not included in the present survey, due to their distance from any proposed wind farm development. The potential presence of small numbers of salmon in the lower reaches of these two streams cannot be discounted. In contrast, it is probable that the survey would have identified the presence of salmon in the Kirkhouse and Grunnafirth catchments were they present. Salmon may have been extirpated from these streams or may always have been only sporadically present. Furthermore it has not been possible to ascertain whether salmon were stocked into any of the streams in the past either deliberately, for instance using excess farmed fry or accidentally through escapes of farmed salmon. In the two systems where salmon were recorded in the present survey, the Laxo and Burrafirth, their numbers were very low and in the case of the Burrafirth system there appeared to have been no successful spawning during winter 2007-08. While it cannot be determined on the basis of available information that these two populations are truly wild (i.e. not the progeny of farmed escapes), this should be assumed to be the case and they are must be considered of regional importance.

Trout are very widespread in Shetland and where they have access to the sea it is probable that a proportion of the population will exist as migratory sea trout. The genetic basis for migration is the subject of ongoing research (reviewed by Ferguson 2006), but it is clear that there is considerable flexibility in trout life history strategy (Walker 2006) and that sea and brown trout may freely interbreed. Homing in sea trout has traditionally been considered to be less well developed than in salmon. However recent genetic evidence suggests considerable variation in sea trout populations in different rivers. Hansen and Mensberg (1998) showed that populations within rivers tended to be more closely related to each other than to populations from other nearby rivers. Levels of genetic difference were related to geographic distance, suggesting some localised gene flow. This pattern is not universal however, and other studies show no correlation between genetic and geographic distance (Ferguson 2006). What is largely consistent across studies is that sea trout show considerable genetic differentiation among populations. This differentiation can only be sustained by a relatively high degree of fidelity to river of origin and a low degree of straying. The genetic structure of Shetland's sea trout populations is not known. On the basis of current knowledge of stock structure, it is probable that the trout stocks of each stream should be considered of local importance. The stocks within the four wind farm quadrants when taken together would be of considerable regional importance, both in terms of the likely genetic diversity they represent (both in migratory and non-migratory form) and for their value as a recreational resource.

4.2 Survey limitations

The present survey described fish populations at 66 sites and provides a broad baseline against which future change may be assessed. Two main weaknesses exist: (i) a single survey may be inadequate as a baseline against which to assess future change (ii) data were collected from a small number of sites in each catchment.

The use of a single survey as a baseline may lead to incorrect conclusions relating to trends in fish populations pre- and post-construction. Additional pre-construction survey will be required in order to assess 'natural' annual variation in fish abundance.

The number of sites surveyed on each catchment is likely to be adequate to give a broad indication of the density and distribution of trout and salmon, the main target species. However, it is clear from the data that juvenile trout abundance is highly variable, even over a relatively small spatial scale. This variability inevitably means that unless a large number of sites are surveyed, the magnitude of any change in population would have to be considerable before a statistically significant difference could be shown with any reasonable degree of confidence[1]. Given that the species present in most of the watercourses exclude those covered by Habitats Directive and other conservation regulations, this may be acceptable. However, the trout resource on Shetland is of value as an angling resource and increased survey effort should be targeted at the following areas in any follow-up survey:

- Grunnafirth: additional qualitative sites on upper Burn of Forse to confirm absence of trout above waterfalls;
- Burn of Crookadale: additional fully quantitative site below confluence of Gil Burn and Burn of Flamister;
- South Burn of Burrafirth: additional site in Burn of Atlascord, potentially an important rearing area for sea trout;
- Burn of Weisdale and Burn of Sandwater: additional downstream survey sites to determine to determine current status of salmon and increase precision of baseline assessment.

[1] Bohlin *et al* (1990) provide details of how to calculate the number of survey sites required to measure populations to a known level of precision.

4.3 Recommendations

4.3.1 Construction and operation of wind farm

The scale of the proposed wind farm is very large and both turbine construction and the construction of access tracks will result in the exposure or large quantities of soil. The potential exists for widespread siltation of streams, which could cause damage to fish habitats and direct mortality to fish and ova. Similar or greater impacts may be expected in the event of any peat slide resulting from the development. Should the scheme proceed, the management of silt and suspended solids will undoubtedly present a major challenge. Mitigation measures are beyond the scope of this report, but will clearly have to be carefully planned, robust and enforceable. Contingency planning will be required for e.g. storms and heavy rain, which may increase the rate of sediment transport or the risk of localised peat slide.

Numerous stream crossings are proposed as part of the wind farm scheme. This study has shown that trout are present in the upper reaches of many of the survey streams, indeed some of the highest trout densities recorded during the present survey were in small, headwater areas and these habitats are important to the maintenance of healthy trout populations. Both migratory and non-migratory trout undergo spawning migrations and access to spawning areas must not be restricted. Although their movements may be of lesser magnitude than those of sea trout, artificial barriers that restrict movements can damage brown trout through population fragmentation leading to loss of genetic diversity and reduction in fitness (Antunes *et al* 1999).

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4.3.2 Habitat and species management

<u>Trout habitats</u>

While no formal or detailed habitat surveys were carried out during the study, it is apparent that riparian habitats have been significantly affected by centuries of grazing, mainly by sheep. In the few fenced areas where livestock are completely excluded e.g. the exclosures in lower reaches of Burn of Lunklet and Burn of Crookadale, the regeneration of riparian trees, shrubs and herbs is striking. Regeneration of riparian vegetation may be of benefit to trout populations through provision of cover in the form of draped vegetation, roots and debris. Stream productivity including invertebrate abundance may also increase through inputs of organic material originating from trees and shrubs. Furthermore, terrestrial food may be of importance to trout in streams where aquatic invertebrate abundance is low, as it is in the study streams (Aquaterra 2008) and terrestrial invertebrate abundance may be enhanced where structural and species diversity in the riparian strip is high.

There is a strong relationship between bank-side cover such as undercuts, roots or draped vegetation and high trout abundance (e.g. Wesche *et al*, 1987, Summers *et al* 2005). Regeneration of the riparian strip may be of greatest benefit to trout in the lower reaches of Shetland's streams, since cover in upper reaches is generally plentiful in the form of undercut peat turf. In contrast, the lower reaches of stream such as the Burn of Grunnafirth, South Burn of Burrafirth, Laxo, Seggie and Laxobigging are rather open and lacking in both cover and shade. Consultation with landowners and tenants may identify areas where the promotion of riparian regeneration, mainly be stock exclusion, might benefit fish populations.

While the greatest local impact on fish numbers may be expected in the lower reaches of streams, improving the structure and diversity of riparian vegetation in middle and upper reaches may also be beneficial. Allochthonous nutrient input in the form of leaf litter potentially increases both in stream and terrestrial invertebrate diversity and abundance.

Stocking and fisheries data

At present, the main direct ongoing management of Shetland's sea trout and brown trout fisheries is through stocking. Due to lack of resources, stocking is guided primarily by local knowledge, but without objective data relating e.g. to juvenile abundance or habitat quality in receiving waters that would help guide strategy to ensure maximum benefit. A review of the stocking programme, in partnership with the Shetland Anglers Association would be useful and may help identify strategic projects and data needs that might be subject to external funding. Such a review might include sources of broodstock, life stages for stocking, identification of target areas for stocking, methods of stocking and assessment of associated benefits and risks.

Specific recommendations

Two man made barriers were identified during the survey, the easing of which would aid fish passage.

The dam on the Burn of Laxobigging at HU417727 apparently serves no purpose. Its removal, or the installation of a fish pass, would open up approximately 1km of habitat upstream, most of which is good juvenile habitat with spawning potential. Should the waterfalls at HU411720 be passable by sea trout, the removal of the dam would permit access all the way into the upper reaches of the catchment.

The fish pass on the lower Kirkhouse Burn where the stream flows below the B9071 (HU402627) should be modified. The drop from the lower pool of the fish pass is onto shallow rock, with no suitable pool from which fish can make the jump to the pass. Access would be improved by deepening the pool below the fish pass.

A further man-made obstacle, the weir at Weisdale Mill (HU396531) should be fully assessed. While the weir is passable, it clearly impedes fish passage at certain flows and fish trapped below the weir may be vulnerable to predation. Indeed, this was a favoured poaching area in past years and had to be closely watched (Paul Featherstone, pers. comm.). The weir is an integral part of the hatchery operation at Weisdale. Any modification to water flows or to the structure of the weir should be with the full consultation and co-operation of all stakeholders.

The fish pass on the lower Sandwater (HU408511) was not inspected during the current survey. However concerns were expressed by members of the SAA, who felt that its efficacy should be assessed.

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Appendix 1. Electric fishing survey site dimensions and locations.

Code	Catchment	Stream	NGR	Length	Width	Area	Location
LBG1	Burn of Laxobigging	Burn of Laxobigging	HU3975 7059	59.2	1.4	82.9	Downstream: bedrock sticking out from right bank at top of pool. Upstream: sharp S-bend with bedrock sricking out from right bank.
LBG2	Burn of Laxobigging	Burn of Laxobigging	HU4025 7073	48.5	1.6	77.6	Upstream: 10m down from Oxnabool confluence.
LBG3	Burn of Laxobigging	Burn of Laxobigging	HU4082 7118	58.2	2.7	157.1	Downstream: tail of pool above bedrock fall.
LBG4	Burn of Laxobigging	Burn of Laxobigging	HU4171 7271	42.0	3.4	142.8	Downstream: 50m high drop at left bend. Upstream: line of stones across stream 3m up from top of pool.
LBG5	Burn of Laxobigging	Burn of Laxobigging	HU4114 7311	43.0	2.9	124.7	Upstream: 10m upstream from wooden rails and straining post on left bank.
STN1	Burn of Laxobigging	Stenswall Burn	HU4292 7296	61.0	0.6	38.4	Downstream: road bridge. Upstream: small waterfall above shallow pool.
MOF1	Burn of Laxobigging	Burn of Moorfield	HU4257 7276	47.0	0.8	37.6	Downstream: road bridge. Upstream: large boulders both banks and wee torrent.
NB1	Burn of Laxobigging	North Burn	HU4188 7337	70.0	1.0	72.8	Downstream: 4m up from broken stone footbridge.
SK1	Burn of Skelladale	unnamed tributary	HU3851 6726	74.0	0.7	51.8	Downstream: 60m up from confluence.
SK2	Burn of Skelladale	Burn of Skelladale	HU3856 6741	54.0	1.5	81.0	Downstream: 18m upstream from confluence. Upstream: 30m high bedrock shelf.
SK3	Burn of Skelladale	Burn of Skelladale	HU3820 6747	50.0	2.0	100.0	Downstream: pointed bedrock. Upstream: well defined riffle.
SK4	Burn of Skelladale	Burn of Skelladale	HU3679 6721	42.0	2.9	121.8	Downstream: huge flat boulder jutting from right bank. Upsream: bottom end of riffle (ledge).
WF1	Wester Filla	Wester Filla Burn	HU4153 6113	60.5	1.4	84.7	Downstream: boulder midstream. Upstream: deep pool where stream narrows (peat cliff left bank).
WF2	Wester Filla	Wester Filla Burn	HU4153 6236	52.0	1.1	57.2	Downstream: first gravel bar up from old road. Upstream: Tiny tributary running through grass, left bank.
EF1	Laxo	Easter Filla Burn	HU4240 6154	NA	NA	NA	Series of small pools 50m down from confluence.
EF2	Laxo	Easter Filla Burn	HU4242 6180	64.5	1.0	64.5	Downstream: boulder projecting from right bank. Upstream: top of pool with undercut left bank.
EF3	Laxo	Easter Filla Burn	HU4242 6233	59.0	2.6	153.4	Downstream: 4m up from hairpin bend that is immediately up from fence.
TJB1	Laxo	Thomas Jamieson's B.	HU4316 6251	NA	NA	NA	Approximately 100m upstream from confluence.
GOS1	Laxo	Burn of Dale	HU4349 5996	83.0	1.2	99.6	Upstream grid ref HU43467 59878 (no physical distinguishing features)
GOS2	Laxo	Corgill Burn	HU4353 6022	18.4	0.9	16.6	Bottom of site is approximately 5m downstream from sharp left bend.
GOS3	Laxo	Gossawater Burn	HU4370 6254	44.0	2.3	101.2	Downstream: apex of U bend.
SEG1	Laxo	Seggie Burn	HU4253 6556	34.0	1.1	37.4	Upstream: top of junction pool at confluence.
SEG2	Laxo	Seggie Burn	HU4265 6500	88.0	1.4	123.2	Downstream: sharp S bend 10m up from break in peat bank (rb). Upstream: well defined run on right bend.

contd.

Appendix 1 contd. Electric fishing survey site dimensions and locations.

Code	Catchment	Stream	NGR	Length	Width	Area	Location
SEG3	Laxo	Seggie Burn	HU4354 6486	55.5	3.1	172.1	Downstream: tail of glide 13.5m down from fence at Kingshouse. Upstream: line of huge boulders below left bend.
SEG4	Laxo	Seggie Burn	HU4395 6377	33.0	3.6	118.8	Downstream: line of 4 large boulders extending out from right bank. Upstream: 1m up from block of stone set in righ tbank, above apex of left bend.
LAX1	Laxo	Laxo Burn	HU4372 6277	30.0	4.5	135.0	Upstream: confluence of Gossawater Burn.
LAX2	Laxo	Laxo Burn	HU4416 6343	39.0	6.9	269.1	Downstream: large, round green-topped midstream boulder. Upstream: 6m upstream from big stone block set in right bank.
FOR1	Burn of Grunnafirth	Burn of Forse	HU4362 5798	56.5	1.4	79.1	Downstream: immediately above sharp left bend. Upstream: confluence.
FOR2	Burn of Grunnafirth	Burn of Forse	HU4423 5799	57.0	1.8	102.6	Downstream: riffle at right bend above glide. Upstream: left bend 8m down from high peat face (left bank).
FOR3	Burn of Grunnafirth	Burn of Grunnafirth	HU4519 5802	42.0	2.1	88.2	Downstream: large boulder near right bank (7m d.s. from huge stone block by l.b.).
GRU1	Burn of Grunnafirth	Burn of Grunnafirth	HU4574 5885	49.0	3.1	151.9	Downstream: 2 large boulders by right bank above sharp left bend. Upstream: bottom of glide by walled platform.
GRU2	Burn of Grunnafirth	Burn of Grunnafirth	HU4606 5946	45.0	3.9	175.5	Downstream: pipe marked by concrete marker right bank. Upstream: 1m down from prominent bedrock emerging midstream.
CRK1	Burn of Crookadale	Burn of Crookadale	HU4255 5584	NA	NA	NA	Approximately 100m upstream from proposed crossing point.
CRK2	Burn of Crookadale	Burn of Crookadale	HU4243 5548	60.0	1.0	60.0	Downstream: at grid ref HU4243 5548
CRK3	Burn of Crookadale	Burn of Crookadale	HU4253 5429	80.5	0.7	56.4	Downstream: bottom end of sharp left bend.
CRK4	Burn of Crookadale	Burn of Crookadale	HU4339 5391	36.5	2.1	76.7	Downstream: tail of riffle above pool. Upstream: tail of long pool
FLAM 1	Burn of Crookadale	Burn of Flamister	HU4379 5504	71.5	1.2	85.8	Downstream: boulder set into left bank. Upstream: water gate.
GIL1	Burn of Crookadale	Gill Burn	HU4343 5484	87.0	1.0	87.0	Downstream: start in pool above bedrock fall. Upstream: top of pool where burn turns right.
QOY1	Burn of Quoys	Burn of Quoys	HU4449 5538	90.0	1.3	117.0	Downstream: pool at sharp left bend. Upstream: top of deep pool.
QOY2	Burn of Quoys	Burn of Quoys	HU4473 5535	80.0	2.3	184.0	Upstream: fence line
QOY3	Burn of Quoys	Burn of Quoys	HU4439 5436	42.5	3.5	148.8	Downstream: 3m down from mature willow left bank (2m up from cliff right bank). Upstream: run into shallow glide/pool.
KIRK1	Burn of Kirkhouse	Burn of Kirkhouse	HU3996 6152	90.0	1.0	90.0	Downstream: end of sharp left bend. Upstream: sharp bend.

contd

Appendix 1 contd. Electric fishing survey site dimensions and locations.

Code	Catchment	Stream	NGR	Length	Width	Area	Location
KIRK2	Burn of Kirkhouse	Burn of Kirkhouse	HU3979 6156	53.5	0.7	37.5	Downstream: pool 30m up from confluence. Upstream: tiny waterfall.
KIRK3	Burn of Kirkhouse	Burn of Kirkhouse	HU4002 6203	28.5	2.6	74.1	Downstream: top of glide above sharp right bend. Upstream: line of bedrock at downstream end of glide.
PW1	Sand Water	Burn of Petta Water	HU4173 5846	95.0	0.8	76.0	Downstream: peat bridge where stream flows underground.
PW2	Sand Water	Burn of Petta Water	HU4172 5715	69.0	2.0	138.0	Downstream: 1m upstream from tiny tributary at left bank (marked by big grey mossy boulder in right bank).
PW3	Sand Water	Burn of Petta Water	HU4159 5553	67.0	2.2	147.4	Downstream: left bend at bottom of first stony run upstream from footbridge.
WEI1	Burn of Weisdale	Burn of Weisdale	HU4053 5779	86.0	1.2	103.2	Downstream: bottom of glide where tributary joins at right bank. Upstream: narrow small torrent.
WEI2	Burn of Weisdale	Burn of Weisdale	HU4051 5672	43.5	3.1	134.9	Downstream: 10m down from tributary on right bank. Upstream: riffle at tail of long glide.
WEI3	Burn of Weisdale	Burn of Weisdale	HU4013 5421	38.5	3.3	127.1	Downstream: riffle above ditch. Upstream: eroded left bank at riffle above dried out back channel.
MAA1	Burrafirth	Maa Water inflow.	HU3797 5492	40.5	1.0	40.5	Downstream: 15m upstream from loch where peat channel joins right bank.
TRU1	Burrafirth	Between Truggles & Maa Waters	HU3726 5490	29.0	0.6	17.4	Approximately 100m upstream from Truggles Water.
TRU2	Burrafirth	Truggles Water inflow	HU3722 5443	NA	NA	NA	Alongside ruin.
TRU3	Burrafirth	Truggles Water outflow	HU3661 5451	72.0	1.3	93.6	Downstream: apex of sharp meander.
ATL1	Burrafirth	Burn of Atlascord	HU3644 5431	49.0	1.8	88.2	Downstream: 10m below small bedrock cliff/outcrop on right bank (where wet flush comes in at left bank).
SBF1	Burrafirth	S. Burn of Burrafirth	HU3648 5473	44.0	2.1	92.4	Downstream: at rock cliff on right bank (on left bend in stream). Upstream: 4m down from confluence.
SBF2	Burrafirth	S. Burn of Burrafirth	HU3640 5559	40.0	3.3	132.0	Downstream: top end of hairpin bend. Upstream: little cascade over bedrock shelf.
SBF3	Burrafirth	S. Burn of Burrafirth	HU3670 5689	28.0	4.0	112.0	Downstream: huge midstream boulder. Upstream: Large rock set into right bank.
SBF4	Burrafirth	Burrafirth	HU3668 5750	36.5	6.1	222.7	Downstream: point of bedrock approx 30m upstream from bridge.
LAM1	Burrafirth	Burn of Vats-houll	HU3844 5589	NA	NA	NA	Start 20m upstream from loch.
LAM2	Burrafirth	Burn of Lamba Water	HU3749 5681	42.0	1.1	46.2	
LAM3	Burrafirth	Burn of Lamba Water	HU3743 5710	77.2	1.3	100.4	Downstream: midstream boulder below Z-bend. Upstream: large boulder right bank.
LUN1	Burrafirth	Burn of Lunklet	HU3744 5732	50.7	1.5	76.1	Downstream: watergate. Upstream: small drop over 2 boulders (good stopper).
LUN2	Burrafirth	Burn of Lunklet	HU3731 5731	31.6	2.9	91.6	Downstream: top of bedrock run (start at white boulder left bank). Upstream: confluence of three tributaries.
MAR1	Burrafirth	Marrofield Water	HU3746 5802	52.5	2.2	115.5	Downstream: midstream triangular rock. Upstream: confluence of small stream left bank.

Appendix 2. Length (mm) of trout at electric fishing sites.

Laxobigging								**Skelladale**				**W. Filla**	
LBG1	LBG2	LBG3	LBG4	LBG5	STN1	MOF1	NB1	SK1	SK2	SK3	SK4	WF1	WF2
57	57	65	53	55	152	53	65	120	42	47	85	34	41
59	62	66	55	59		56	75		42	49	85	40	42
60	63	91	56	60		62	129		45	52	85	41	42
60	67	92	59	62		67	137		50	85	87	45	42
61	98	97	59	66		68	147		56	95	88	45	43
62	98	100	60	67		70	155		58	97	88	49	43
62	100	101	61	67		71	205		58	101	95	49	43
64	100	106	62	68		72			59	102	100	50	44
64	102	107	63	70		109			60	119	100	50	44
65	103	109	66	70		123			91	130	100	50	44
90	103	114	*74*	71		174			91	132	102	52	45
91	103	132	*75*	71					92	140	102	52	45
102	110	133	*77*	72					120	150	105	54	45
104	111	134	*78*	74					130	162	107	54	46
104	115	136	*78*	75					133		107	54	46
107	119	154	*81*	76					138		108	54	46
110	148	158	*81*	76					148		112	55	46
114	153	165	*86*	76					170		113	56	47
130	163	178	*86*	78							114	56	47
132	166		*86*	79							116	57	47
151	188		*86*	79							126	57	48
162			*87*	*85*							131	58	49
165			*88*	*93*							145	58	49
168			*88*	*94*							155	58	50
235			*88*	*100*							174	59	50
			88	*100*								59	50
			89	*100*								60	50
			91	*102*								60	50
			91	103								61	50
			92	106								61	51
			93	*110*								61	51
			94	110								62	51
			100	110								63	51
			101	110								63	53
			103	112								63	54
			107	116								64	54
			107	118								64	55
			110	120								66	56
			115	120								66	56
			120	121								66	57
			127	121								67	57
			133	123								67	58
			136	124								69	58
			140	126								70	59
			155	130								70	60
			163	130								109	61
				133								115	62
				150								119	63
				163								120	63
				164								121	63
				184								137	63
												173	64
												192	65
													65
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													110
													115
													123
													125
													129
													134
													265

Italics indicate fish that appeared to be stocked. NM: fish counted but not measured.

Appendix 2 contd. Length (mm) of trout at electric fishing sites.

Laxo														Grunnafirth				
EF1	EF2	EF3	TJB1	GOS1		GOS2	GOS3	SEG1	SEG2	SEG3	SEG4	LAX1	LAX2	FOR1	FOR2	FOR3	GRU1	GRU2
NM	50	58	NM	35	59	NM	80	NM	52	58	72	73	62			58	57	62
	52	64		38	59		113		54	61	72	77	66			58	58	69
	59	66		39	59		121		55	63	75	78	67			63	62	70
	60	66		39	60		127		57	65	76	81	69			63	68	71
	60	67		39	60		130		57	68	79	85	73			64	70	74
	60	67		39	60		130		61	68	81	110	73			64	70	74
	62	67		40	60		134		61	69	106	110	74			65	88	75
	62	67		40	61		137		62	70	107	115	74			65	93	77
	63	67		40	61		174		62	71	113	116	75			66	99	79
	64	67		40	61		185		63	72	113	119	75			66	100	81
	64	68		40	62		225		64	72	122	122	76			68	100	106
	65	68		41	62				66	72	123	130	76			68	103	115
	65	69		42	63				70	74	128	144	77			69	104	116
	67	69		42	63				72	74	128	155	78			69	105	118
	67	70		43	63				75	74	130	164	78			70	107	120
	68	71		43	64				103	75	133		79			72	110	121
	68	71		44	64				107	77	153		*90*			73	110	126
	69	71		44	64				108	78	156		97			73	118	128
	71	71		44	66				108	80	164		*98*			73	119	142
	72	72		44	67				109	89	164		*99*			92	126	162
	72	72		45	67				110	100	165		*102*			93	130	163
	73	74		45	67				112	105	177		*104*			98	130	171
	74	74		45	68				112	110			104			99	140	180
	74	75		45	69				113	113			105			100	151	206
	75	76		45	70				115	116			106			101	155	
	76	76		45	70				118	118			*107*			102	157	
	77	76		45	70				129	118			*108*			103	181	
	103	76		46	72				132	121			110			105		
	112	76		46	73				133	122			110			105		
	117	77		46	75				136	124			*111*			105		
	155	78		46	79				140	124			111			107		
		78		46	85				141	126			112			113		
		79		48					142	142			113			115		
		80		48					142	146			115			115		
		81		48					144	152			116			115		
		84		48					148	156			117			117		
		84		48					148	158			120			118		
		114		48					151	158			120			121		
		114		48					153	194			121			122		
		116		49					157	205			124			124		
		116		49					158				124			130		
		124		49					160				124			134		
		194		50					164				148			137		
		210		50					168				*157*			138		
				50					173				184			140		
				50					178							170		
				51					189							174		
				51					190							202		
				51					220							232		
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Italics indicate fish that appeared to be stocked. NM: fish counted but not measured.

Appendix 2 contd. Length (mm) of trout at electric fishing sites.

Crookadale							Quoys			Kirkhouse			Sandwater				Weisdale		
CRK1	CRK2	CRK3	CRK4	FLAM1	GIL1	GIL2	QOY1	QOY2	QOY3	KIRK1	KIRK2	KIRK3	PW1	PW2	PW3		WEI1	WEI2	WEI3
NM	69	129	48	51		NM	115	86	55	64	70	60		58	67	136	40	52	67
	71	152	48	56			131	91	62	66	121	61		61	67	141	45	55	69
	106	187	52	57			165	105	62	72	124	63		62	68	147	51	57	69
	107		52	59				106	65	109	139	63		62	68	147	52	58	70
	114		52	59				112	71	117		65		64	69	148	53	58	89
	116		52	60				115	95			65		66	70	151	54	60	90
	125		54	60				117	96			66		66	70	154	55	62	91
	129		55	62				131	97			66		66	71	177	56	63	92
	154		55	62				134	98			66		66	71	183	58	63	94
			55	65				138	101			67		67	71		60	64	99
			57	66				144	106			69		67	72		60	65	100
			57	66				165	108			70		67	72		61	66	101
			57	67					109			71		67	72		61	66	101
			57	67					110			71		68	72		61	67	101
			58	67					111			73		71	73		61	68	102
			58	69					113			76		71	73		62	68	103
			59	70					113			76		75	74		64	69	105
			60	73					114			76		76	74		66	70	105
			60	73					120			80		77	74		66	70	107
			60	73					124			115		79	76		68	70	109
			60	74					128			117		81	76		68	91	114
			61	75					138			119		82	76		69	93	114
			61	76					140			131		85	77		69	98	115
			64	76								165		86	77		73	104	115
			64	76										125	77		73	110	117
			64	77										136	78		74	116	118
			66	78										137	78		78	122	119
			69	78										140	79		101	158	120
			71	78										145	79		104		120
			85	79										154	79		105		121
			106	79											80		105		121
			107	81											80		107		123
			107	82											80		107		123
			109	82											81		108		124
			114	82											82		116		125
			116	83											82		123		126
			141	84											83		124		128
			162	84											83		126		129
			189	85											84		128		132
				85											84		129		132
				87											84		136		133
				89											84		141		139
				116											84				140
				118											85				142
				122											86				151
				123											86				152
				167											86				181
				191											86				
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															122				

Italics indicate fish that appeared to be stocked. NM: fish counted but not measured.

Appendix 2 contd. Length (mm) of trout at electric fishing sites.

Burrafirth														
MAA1	TRU1	TRU2	TRU3	ATL1	SBF1	SBF2	SBF3	SBF4	VH1	LAM1	LAM2	LUN1	LUN2	MAR1
NM	NM	NM	66	57	NM	49	49	52		NM	54	55	60	94
			67	58		49	52	57			58	56	63	97
			71	59		53	57	60			62	58	66	97
			72	62		55	60	60			62	61	67	98
			72	63		58	60	61			64	63	69	101
			73	63		58	62	62			64	66	69	106
			74	64		59	62	64			66	67	70	110
			74	65		59	64	69			68	67	72	112
			74	65		59	65	106			69	68	73	115
			75	65		61	66	106			69	68	76	126
			76	65		62	66	108			70	68	80	192
			78	67		62	94	108			70	69	82	
			81	67		62	102	113			72	70	101	
			102	67		65	102	114			72	72	102	
			104	67		66	103	118			73	93	111	
			106	67		67	109	119			74	102	117	
			108	67		68	109	120			74	105	125	
			110	68		71	109	124			76	119	130	
			113	68		73	114	127			76	120	140	
			114	68		73	126	134			76	120	141	
			117	70		95		137			79	151		
			121	70		95		145			79			
			122	70		104		150			80			
			122	72		107		151			80			
			154	72		108		151			80			
				73		110		169			80			
				99		111					122			
				102		116					158			
				104		117					176			
				105		121								
				107		122								
				108		149								
				111		167								
				118										
				122										
				158										

Appendix 3. Length (mm) of salmon at electric fishing sites.

Laxo			Burrafirth		
GOS3	SEG3	LAX1	SBF2	SBF3	SBF4
83	110	77	112	96	95
125	123	79	122	102	96
129	131	84		105	98
142		85		110	99
		91			100
					100
					102
					102
					109
					110
					112
					112
					113

Note: only sites with salmon present are shown.

Appendix 4 Survey equipment and conditions.

All sites surveyed using Electracatch backpack units model WFC911 with 40cm anode ring and 3 - 5m long braided copper cathodes.

Catchment	Code	Survey date	Volts	Conductivity $\mu.cm^{-1}$	Temperature °C	Water Level
Burn of Laxobigging	LBG1	04/09/2008	200	110	11.9	moderate
Burn of Laxobigging	LBG2	04/09/2008	190	114	12.4	low-moderate
Burn of Laxobigging	LBG3	04/09/2008	190	115	14.9	low-moderate
Burn of Laxobigging	LBG4	07/09/2008	200	155	11	low-moderate
Burn of Laxobigging	LBG5	07/09/2008	180			low-moderate
Burn of Laxobigging	STN1	04/09/2008	190	148	11.6	low-moderate
Burn of Laxobigging	MOF1	04/09/2008	190	131	12.4	low-moderate
Burn of Laxobigging	NB1	07/09/2008	150	198	11	low-moderate
Burn of Skelladale	SK1	30/08/2008	240			low
Burn of Skelladale	SK2	30/08/2008	280			low
Burn of Skelladale	SK3	30/08/2008	250			low
Burn of Skelladale	SK4	30/08/2008	250			low
Wester Filla	WF1	02/09/2008	160	182		moderate
Wester Filla	WF2	02/09/2008	210	155		moderate
Laxo	EF1	01/09/2008				moderate-high
Laxo	EF2	02/09/2008	210	135	13.9	moderate
Laxo	EF3	01/09/2008	220	117	14	moderate
Laxo	TJB1	07/09/2008				low
Laxo	GOS1	06/09/2008	180	150	13	low
Laxo	GOS2	06/09/2008				
Laxo	GOS3	06/09/2008	200	200	13.1	low
Laxo	SEG1	31/08/2008	160	279	12.2	low
Laxo	SEG2	31/08/2008	160			low
Laxo	SEG3	31/08/2008	180	260	13	low
Laxo	SEG4	31/08/2008	180	280	13	low
Laxo	LAX1	07/09/2008	160	174	11	low-moderate
Laxo	LAX2	29/08/2008	180	232	13	low
Burn of Grunnafirth	FOR1	31/08/2008	250			low
Burn of Grunnafirth	FOR2	31/08/2008	220	183		low
Burn of Grunnafirth	FOR3	31/08/2008	220	172		low
Burn of Grunnafirth	GRU1	31/08/2008	220	175		low
Burn of Grunnafirth	GRU2	02/09/2008	220	130	12	low
Burn of Crookadale	CRK1	07/09/2008	160			low
Burn of Crookadale	CRK2	07/09/2008	160			low
Burn of Crookadale	CRK3	03/09/2008	160	143	14.3	low
Burn of Crookadale	CRK4	03/09/2008		158	13.4	moderate
Burn of Crookadale	FLAM1	03/09/2008	200	132	11.8	low
Burn of Crookadale	GIL1	03/09/2008	180	144	12.9	low
Burn of Crookadale	GIL2	03/09/2008				low
Burn of Quoys	QOY1	01/09/2008	220	124		high
Burn of Quoys	QOY2	01/09/2008	220	107		high
Burn of Quoys	QOY3	02/09/2008	220	150	12.5	moderate
Burn of Kirkhouse	KIRK1	02/09/2008	180	111	13.5	moderate
Burn of Kirkhouse	KIRK2	02/09/2008	190	114	13.5	moderate
Burn of Kirkhouse	KIRK3	02/09/2008	190			moderate
Sand Water	PW1	30/08/2008	160			low
Sand Water	PW2	30/08/2008	160	260	1.2	low
Sand Water	PW3	30/08/2008	160	290	13.9	low

Catchment	Code	Survey date	Volts	Conductivity µ.cm^{-1}	Temperature °C	Water Level
Burn of Weisdale	WEI1	03/09/2008	200	125	13.3	low
Burn of Weisdale	WEI2	03/09/2008	210	155	13.7	low
Burn of Weisdale	WEI3	05/09/2008	170	166	13.7	low
Burrafirth	MAA1	28/08/2008	200	145	14	low
Burrafirth	TRU1	28/08/2008				
Burrafirth	TRU2	28/08/2008				
Burrafirth	TRU3	28/08/2008	200	155	14	low
Burrafirth	ATL1	28/08/2008	200	185	13	low
Burrafirth	SBF1	28/08/2008				low
Burrafirth	SBF2	28/08/2008	200			low
Burrafirth	SBF3	28/08/2008	220	160		low
Burrafirth	SBF4	29/08/2008				
Burrafirth	VH1	09/09/2008				low
Burrafirth	LAM1	09/09/2008				low
Burrafirth	LAM2	05/09/2008	210	113	14.1	low
Burrafirth	LUN1	05/09/2008	210	116	13	low
Burrafirth	LUN2	05/09/2008	210	118	13.1	low-moderate
Burrafirth	MAR1	05/09/2008	210	106	12.1	low

APPENDIX 8.8: FRESH WATER INVERTEBRATE SURVEY

The information contained within Fresh Water Invertebrate Survey that supported the 2009 ES was seen as relevant and thus was included in the 2018 EIA.

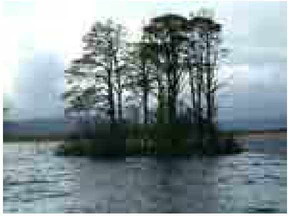
VIKING WIND FARM:

FRESHWATER INVERTEBRATES

Report to: EnviroCentre

September 2008

Aquaterra Ecology

Aquaterra Ecology Crombie Cottage, Aberchirder, Huntly, Aberdeenshire AB54 7QU

Table of Contents

Viking Wind Farm, Shetland: Freshwater Invertebrate Surveys 2008

1 Summary

1.1 Background

The Viking Energy Partnership (VEP: a partnership between Scottish & Southern Energy (SSE) and Viking Energy Limited) is developing a proposal for a 554MW, 154 turbine wind farm on Mainland, Shetland. The planning application will be accompanied by an Environmental Statement (ES) and this report provides information for the ES on the freshwater invertebrates in catchments within the proposed development area.

Macroinvertebrate communities were sampled using standard kick sampling methods (SEPA 2001) from thirty sites in eleven catchments (Figure 1). Sampling took place in the period 23rd – 28th August 2008 mainly in conditions of low flow. Samples were identified to family level and indices of water quality (BMWP, ASPT scores) were produced.

At each site three Surber samples were taken to provide quantitative measures of invertebrate abundance and biomass. Major groups were identified to species level to identify presence of rare species and to provide data for production of biological indices: Water Chemistry Status and Index of Acidity.

Environmental variables including bed width, depth, flow and substrate profile were recorded at each site and GPS generated grid references and photographs taken to enable future site identification.

1.2 Main findings

- Invertebrate communities largely consisted of species common and widespread in Scottish watercourses and no rarities were identified.
- The relative proportions of invertebrate groups indicated moderately clean and well-oxygenated conditions with no significant organic enrichment.
- Diversity was low in all watercourses, probably as a result of Shetland's isolation. Abundance and biomass were low to moderate.
- ASPT scores indicated that 22 sites had good (A2) water quality and 8 sites had fair (B) water quality.
- Water Chemistry Status Scores indicated that 18 sites were slightly acidic, 11 circum-neutral and one possibly significantly acidic.
- Overall the water quality, invertebrate communities and productivity should support sustainable salmonid populations if other environmental factors are suitable.

2 Introduction

2.1 Bio-monitoring

Many aquatic invertebrates have specific habitat requirements, including a limited range of water chemistry, and these species can be used as biological indicators to both broadly assess the general quality of freshwater burns and rivers, and to assess more specific chemical status, for example acidity. The production of biotic indices to assess water quality is an established method using the BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scoring system. These scores were primarily developed for identifying organic pollution, but they are widely used as indicators of general stream health.

Biotic indices can be used to overcome the difficulties associated with direct monitoring of pH, which tends to fluctuate markedly in acidic streams. Macroinvertebrates integrate recent (weeks to months) pH conditions at a site (Davy-Bowker *et al* 2005) and are therefore well suited for bio-monitoring where the sampling frequency is constrained. In general the relationship between the tolerance of most acid-sensitive invertebrates and that of salmonid fish is fairly close, although trout can survive slightly more acid conditions than some of the invertebrate indicators (Patterson and Morrison 1993).

Assessment of macroinvertebrates can therefore both augment the interpretation of chemical analysis of water quality and monitor the biological consequences of changes in water chemistry.

Quantitative assessments of macroinvertebrates will also provide accurate characterisations of the community, and a measure of biodiversity and productivity of the watercourse. Total invertebrate biomass will be used as an indication of total productivity of invertebrate fauna, potentially important in sustaining salmonid populations.

2.2 Objectives

The freshwater invertebrate survey of the Shetland watercourses provides:

i) A description of the macroinvertebrate community including species level identification in most major groups (Malacostraca, Ephemeroptera, Trichoptera, Plecoptera, Mollusca [excepting Sphaeriidae], Odonata and adult Coleoptera)

ii) BMWP and ASPT scores as an assessment of water quality (SEPA 2001)

iii) Indices of acidity: Water Chemistry Status (Patterson & Morrison 1993) and Index of Acidity (Clyde River Purification Board 1995)

iv) Quantitative sampling to assess invertebrate abundance and to provide a measure of biodiversity and productivity

v) A description of the environmental variables at each monitoring site including depth, width, flow, substrate profile, estimates of in-stream vegetation and canopy cover.

3 Methods

3.1 Field sampling

Kick

Sampling was based on standard kick sampling methodologies employed by Scottish Environment Protection Agency (SEPA). A 25cm wide kick sample net with a 1mm mesh was used at all sites. Kick sampling at all sites was conducted in riffle-type habitat.

The sampling procedure involved a total of 3 minutes of kick sampling at each site. Sampling covered the whole width of the stream. The net was held vertically, downstream from the sampler's feet and resting on the river bed. The sampler disturbed the river bed vigorously with the heels, by kicking or rotating, to dislodge the substrate to a depth of about 10cm. Dislodged invertebrates were washed into the sampling net.

A further 1 minute period of hand sampling was carried out at all sites, searching on and under stones and rocks for attached invertebrates such as molluscs and cased caddis.

Samples from kicking and hand collecting were preserved together in 70% Industrial Methylated Spirits (IMS) in sealed plastic containers.

Surber

Surber samples were taken to quantitatively assess invertebrate abundance. A standard Surber sampler with an area of approximately 0.1m² and a 500µm mesh net was placed in a suitable riffle-type habitat, on hard substrates with a depth of 5-20cm. The leading edge of the net of the sampler was made level with the substrate, to prevent loss of invertebrates, after which the entire sampler frame was established in the substrate. If stones restricted placement of the sampler they were moved and included in the sample if >50% of the stone was in the sample area.

Sampling involved the removal of any invertebrates from surface stones followed by agitation of the substrate, the disturbed invertebrates being swept by the current into the net. Plants present were either picked over and washed or included in the sample for laboratory invertebrate searching. The sampling procedure ceased when all substrates within the sampler frame had been thoroughly washed into the net. Surber sampling was conducted at riffle areas. Invertebrate distribution can be very patchy at all scales and therefore three samples were taken at each site.

3.2 *Sites*

Eleven catchments with potential for impacts from proposed development activities were identified. These were selected primarily where new road or track crossings would be constructed over watercourses within the catchment.

Sample sites were selected with riffle habitat wherever possible. Riffles are one of the most productive habitats in rivers and streams and are the standard habitat for water quality bio-monitoring (SEPA 2001). Sites were mainly chosen in downstream parts of the catchment to both provide suitable habitat unavailable in small upstream channels and to reduce the number of sample sites required. Sampling at these points would therefore in many cases monitor the cumulative effects of multiple crossings in the catchment.

Sites were coded in a downstream direction (Table 1) and accurately recorded using photographs and ten figure GPS grid references (Garmin etrex, accuracy of <15 metres RMS). Physical environmental factors including stream width, depth, flow and substrate profiles (using Wentworth scale) were recorded for both the kick habitat and the sample area within the Surber samplers (Tables 3 & 4). Water temperature and pH were recorded with a portable meter Hannah HI 98129, resolution 0.1ºC and 0.01 pH, accuracy ± 0.5ºC and ± 0.1 pH. Data was recorded on standard fieldsheets (Appendix 7).

3.3 *Invertebrate identification*

Invertebrates were examined using a Wild binocular microscope at 6-50X magnification and a Brunel compound microscope at 100X. Identification used standard keys (Brooks & Lewington 1999, Edington & Hildrew 1995, Elliot, Humpesch & Macan 1988, Elliot, & Mann 1979, Friday 1988, Hynes 1977, Killeen *et al* 2004, Macan 1959, Macan 1977, Nilsson 1996, 1997, Reynoldson & Young 2000, Timm & Veldhuijzen van Zanten 2002 and Wallace, Wallace & Philipson 1990).

Specimens from kick samples were identified to the appropriate taxonomic level to provide a biological assessment of water quality using BMWP (Biological Monitoring Working Party) and ASPT (Average Score Per Taxon) scores. Specimens from Surber samples were identified to species level in major groups and the total abundance was recorded.

3.4 *BMWP and ASPT Indices*

These scores were primarily developed for identifying organic pollution, but they are widely used as indicators of general stream health.

Biological Monitoring Working Party (BMWP) scores were calculated for each invertebrate sample from each site. The scoring system is based on the pollution sensitivity of each invertebrate family. The scale is 1-10 and a score of 1 is allocated to the most pollution tolerant families and 10 to the most pollution sensitive (Appendix 1). The BMWP score is the sum of the group scores for the sample. The ASPT (Average Score Per Taxon) score is the average score for each group present in the sample.

Low BMWP or ASPT scores indicate possible pollution, high scores indicate good water quality. A simplified version of the Scottish River Classification Scheme (1997) used by SEPA is set out below.

The physical nature of the watercourse and the sampling effort of different individual samplers can influence the BMWP score. ASPT is viewed as a more stable and reliable index of pollution.

The number of scoring taxa is also an indicator of water status. A fall in the number of taxa is a general index of ecological damage, including overall pollution encompassing organic, toxic and physical pollution such as siltation, and damage to the habitats or the river channel, (General Quality Assessment of Rivers, Environment Agency website).

Simplified Scottish River Classification Scheme as used by SEPA.

Class	Description	BMWP	ASPT	Comments
A1	Excellent	≥85	≥6.0	Sustainable* salmonid population
A2	Good	70-84	5.0-5.9	Sustainable* salmonid population
B	Fair	50-69	4.2-4.9	Salmonids may be present
C	Poor	15-49	3.0-4.1	Fish may be present
D	Seriously Polluted	<15	<3.0	Fish absent or seriously restricted

* If other environmental variables are suitable

3.5 *Water Chemistry Status*

Patterson and Morrison (1993) developed a Definition of Classes for water chemistry status based on the presence of invertebrate indicator groups. Two indicator groups are used: Group 1 taxa with a normal minimum pH of 6.0 and Group 2 with a normal minimum pH of 5.5 (Appendix 2). Three classes were defined:

Class	**Description**	**Comment**
Class 1	Circumneutral	Group 1 taxa present. The water chemistry is suitable for the great majority of plants and animals. Alkalinity should be sufficient to buffer against most acid spate waters and the mean pH is ≥6.0 and unlikely to drop below 5.6. Salmonid fish are not stressed by the water chemistry.
Class 2	Not significantly acidified	Group 1 absent, group 2 present. The water chemistry is suitable for all except the most sensitive taxa. The mean pH is likely to be 5.6 or above. Where heavy metal and aluminium levels are low and/or organic content is high mean pH could be as low as 5.3. The water chemistry is likely to be suitable for salmonid fish but such streams may be vulnerable to future acidification.
Class 3	May be acidified	Groups 1 and 2 absent. Water chemistry may be acid to the point where wildlife is significantly affected including reduction of invertebrate diversity and reduction of salmonid fish populations, especially salmon. Further survey and chemical analysis is recommended to improve the diagnosis.

3.6 *Index of Acidity*

An Index of Acidity Classes was developed by the Clyde River Purification Board as an indication of the probability and likely magnitude of acidification of freshwaters (Clyde River Purification Board 1995). Although developed for streams in Ayrshire and Argyll, the system has been applied by SEPA for more northern rivers and has shown good correspondence with juvenile salmon densities (Ian Milne, SEPA Dingwall, pers. comm.). As with the index of Water Chemistry Status, this index is based on the presence or absence of taxa with varying degrees of acid sensitivity from two lists, A and B (Appendix 2.). For samples collected between May and October the definitions used are:

Class	**Description**	**Comment**
Class I	Non-acid or slightly acid	At least three taxa from both Lists A and B present. Salmonid populations probably undamaged.

Class II	Intermediate	One or two List A taxa present or if List A taxa absent more than two List B taxa are present. Salmonid populations may show some signs of acid damage, for example reduced densities and missing or weak age classes.
Class III	Acid	List A absent and two or fewer List B taxa present. Trout populations reduced or absent and probably unable to sustain juvenile salmon.

3.7 Biomass

Invertebrate samples were dried in glass vials at a constant temperature of 60ºC for 48 hours in a Binder drying oven. The dried sample was then weighed on an Ohaus Explorer Pro analytical balance (readability 0.1mg) to produce a biomass gm/m² (dry weight) (Table 2).

4 Results and Discussion

4.1 Sites: Environmental Factors

The grid references and sampling dates for sites are found in Table 1. Environmental factors recorded at kick sample sites, and within the Surber samplers are recorded in Tables 3 and 4.

Overview

The proposed development area is largely sited on metamorphic Dalradian rocks with bands of limestone running in an approximately north to south direction. Erosion of these limestone bands has produced Petta Dale and the Valley of Kergord. The Burn of Pettawater flows through Petta Dale and the Wester Filla Burn is located at the northern end of the valley. Both the Burn of Weisdale and the Burn of Kirkhouse flow through the Valley of Kergord. Rocks are usually overlaid with peat through which the water permeates. These solid and drift geologies are important in determining the characteristics of the stream chemistries. Land use in the area is mainly sheep grazing and the intensification of this with the associated use of fertilisers and the possible erosion from high stocking densities have been identified as two areas of concern for water quality (Hardy 2004).

The watercourses surveyed were small to medium burns varying in bed width from 0.9 metres (North Burn NB1) to 8.5 metres (Laxo Burn LB2), with a mean width of 3.4 metres. Depth in the centre of the channel at sample sites was less than 30cm varying from 2cm in the Burn of Flamister to 30cm in the Seggie Burn (mean 10.8cm).

Substrate

At 28 sites the main component of stream substrate was cobbles (40%-70%, mean 59%). The exceptions were the two Burn of Pettawater sites where pebbles were the main component (mean 60%). Silt was only recorded at two sites, North Burn NB1 and the upstream site of Burn of Crookadale BC1. Most substrates appeared to be stable.

Macrophytes and Canopy Cover

A characteristic feature of the watercourses was the lack of canopy cover at all sites. The absence of riparian woodland allows light into the burns promoting growth of macrophytic in-stream vegetation where other factors are suitable. Macrophyte cover varied from 2% in the Burn of Flamister and Burn of Lunklet to 65% in the Burn of Weisdale BW2 (mean 26%).

The main constituent of the macrophyte cover was either vascular plants, bryophytes or algae. Vascular plants were prominent at Laxo Burn LB1 with 30% cover of *Juncus sp*. and *Potamogeton sp*. and Burn of Pettawater with 60% cover of *Myriophylum alterniflorum*, *Iris pseudocarus* and *Caltha palustris.* The open structure of Myriophylum can provide good attachment points for invertebrates including the pupal stages of Simulidae.

The most widespread and abundant bryophyte was *Fontinalis antipyretica*, with smaller amounts of *Platyhypnidium riparioides* and *Scapania undulata.* *Fontinalis* had 40% coverage at North Burn and 50% coverage at Burn of Pettawater PW2. Mosses provide a microhabitat within the riffle and have a proportionately different invertebrate community to uncovered areas (Egglishaw 1969). Englund (1991) found that overturning moss covered stones to mimic spate events resulted in thirteen of sixteen invertebrate taxa present decreasing their density.

Significant algal cover was found at several sites, 50% at burn of Weisdale BW1 and BW2, 40% at Wester Filla Burn and Burn of Crookadale BC2, and 30% at Burn of Kirkhouse BK1 and BK2. The growth and subsequent decay of algae can be a significant organic input to the system.

The watercourses were open and bank-side vegetation consisted mainly of herbaceous vascular plants. The allochthonous (from outside the system, i.e. terrestrial) input of organic matter from bank-side vegetation is an important source of food for invertebrates and positive correlations between food abundance and benthic consumer densities are a common result of comparisons between streams (Richardson 1993). Input is the lowest for herbaceous habitats compared to trees or shrubs (Delong & Brusven 1994) but is still considered an important food resource (Menninger & Palmer 2007). In small watercourses, such as the majority of the Shetland burns allochthonous input is proportionately higher than large watercourses (Conners & Naiman 1984). This input of leaf litter provides the detritus that many invertebrates feed on and Egglishaw (1964) showed that plant detritus in a stream was a causal factor in determining the distribution of some invertebrates including *Baetis rhodani*, abundant in many of the Shetland burns.

4.2 Invertebrate Communities

The groups recorded from each kick sample are shown in Appendix 3. The numbers of invertebrate species present in the Surber samples are shown in Appendix 6.

Overview

One important characteristic of the burns was the low biodiversity of the invertebrate communities. The main reason for this in lotic waters is probably the isolation of Shetland (Hardy 2004). Low diversity was present in most groups, only one species of Ephemeroptera (mayflies) was present, two genera of Plecoptera (stoneflies) and seven species of Trichoptera (caddis flies). Many of the taxa associated with the fast flowing well-oxygenated water of riffles on the Scottish mainland were absent. These included the Plecoptera families Perlidae and Perlodidae, the Ephemeroptera family Heptageniidae and the riffle beetles Elmidae.

Interpretation of the invertebrate community data in Shetland has therefore to be viewed with some caution, in particular when used for the generation of biotic indices.

Relative Proportions of Invertebrate Groups

The proportional abundances of invertebrate groups in Surber samples (mean of three) are shown in Figure 2 (expressed as percentages of the total population).

The categories in Figure 2 represent the groups Ephemeroptera, Plecoptera, Trichoptera, Diptera and Other. Diptera contains the chironomids which are very tolerant of organic pollution or enrichment. The ‘Other' Category contains a wide mixture of groups including Coleoptera (beetles), Mollusca, Oligochaeta (worms) and Hirudinea (leeches). They are mainly moderately tolerant of organic pollution.

Macroinvertebrate communities of flowing water typical of large areas of upland Britain are dominated by the aquatic stages of the insect orders Ephemeroptera, Plecoptera and Trichoptera (Ormerod *et al* 1993).

Stoneflies are generally found in fast flowing, clean, cold well oxygenated streams and an abundance of mayflies is generally a sign of reasonably healthy and productive water (FIN Abundance and Indicator Taxa, Environmental Change Network website).

The families Heptageniidae and Baetidae and species from these families are consistently used as acid sensitive indicators and are known to be vulnerable to both chronic and episodic acidification (Merret *et al* 1991, Ormerod *et al* 1993, Patterson & Morrison 1993 and Rutt *et al* 1990).

Ephemeroptera, Plecoptera and Trichoptera (EPT) combined were dominant (>50% total invertebrates) at half of the sites (LX1, LX2, SD1, SD2, WF1, GW1, EF1, BG1, BF2, BQ1, BC1, FL1, BB1, BB3, BL1) indicating well-oxygenated clean conditions. In most of these 15 sites the largest component of EPT was Plecoptera. Plecoptera was the largest component group overall at 12 sites and since some species of this order can tolerate a pH of 4.0 or less they are usually dominant in the fauna of acid streams (Patterson & Morrison 1993). The nymphs were mainly small early stage Leuctra and species level identification was not possible with confidence.

Diptera dominated one site on the Burn of Burrafirth (59%, BB2) and were a large proportion of the community at both Burn of Pettawater sites (49% & 47%), Burn of Quoys BQ2 (45%), Burn of Kirkhouse BK1 (44%) and Burn of Weisdale BW1(42%). The main component of the Dipteran community was Chironomids indicating some limited organic enrichment.

The Burn of Laxobigging LX1 site was atypical with the 'Other' category dominant (82%). This was a result of the presence of large numbers of the amphipod *Gammarus zaddachi*. However this can be attributed to the site being just below the normal tidal limit (NTL).

In general the invertebrate communities present were indicative of clean watercourses with good water quality and a small degree of organic enrichment.

<u>Invertebrate Abundance, Diversity and Biomass</u>
The number of taxa, total numbers of invertebrates and biomass of invertebrates present in Surber samples are shown in Table 2. Invertebrate abundance (per m^2) and biomass are also shown graphically in Figures 3 and 4.

The invertebrate abundance varied from 363 per m^2 in the Burn of Quoys BQ2 to 4347 per m^2 in the Wester Filla Burn (mean 1397 per m^2). This suggests a low to moderate abundance. The burns of Petta Dale and the Valley of Kergord all had abundances at the high end and this may be partly a result of buffering from underlying limestone.

The number of taxa per site at the level of identification used in this study varied from 7.3 (mean of three Surber samples) Burn of Quoys BQ2 to 21.7 Burn of Kirkhouse BK2. The mean of all Surber samples was 13.1. Direct comparison with other work is not possible as different levels of taxonomic identification are used in different studies but the invertebrate diversity appears low. This is supported by the low BMWP scores, see below.

Biomass is seasonally variable but it can give an indication of productivity of watercourses. The biomass at sites (mean of three Surber samples) varied from 0.047gm dry weight per m^2 at Burn of Quoys BQ2 to 1.558gm dry weight per m^2 at Burn of Kirkhouse BK2. The mean biomass was quite low at 0.456gm dry weight per m^2. At sites where biomass was highest the main components were either Lumbricid worms or caseless caddis, in particular *Rhyacophila dorsalis* and *Hydropsyche siltalai*. Larval caddis flies often represent the highest biomass of the macroinvertebrate communities of streams (Giller & Malmqvist 1998).

The diversity, abundance and biomass overall were sufficient to support sustainable salmonid populations.

4.3 Biological Indices

Biological Indices scores (BMWP, ASPT, Water Chemistry Status [Water Class] & Index of Acidity) are shown in Tables 1 and 2. Scoring taxa present in samples for BMWP, Water Chemistry Status and Index of Acidity are found respectively in Appendices 3-5.

<u>BMWP and ASPT scores</u>
BMWP scores indicated 12 sites with fair (B) water quality and 18 sites with poor (C) water quality. However sites of low invertebrate diversity produce low BMWP scores and in Shetland the scores may not truly reflect water quality. ASPT scores are more reliable and

they indicated 22 sites with good (A2) water quality and 8 with fair (B) water quality. The sites with fair water quality all had ASPT scores of 4.8 or 4.9 at the top end of the fair water quality band. SEPA have found the monitoring results of RIVPACS unreliable in Shetland because of low diversity (David Okill, pers comm.).

The ASPT scores showed mainly good water quality and it is probable that the scores are reduced by the low diversity present. It is therefore likely that the water quality will sustain salmonid fish populations.

Water Chemistry Status
Note that the scores recorded in Table 2 are generated from the combined invertebrates present in all three Surber samples at each site.

Eleven sites scored Class 1 (mean pH ≥ 6.0), 18 sites scored Class 2 (mean pH >5.6) and one site, Burn of Quoys BQ2, scored Class 3 suggesting the possibility of acidification. However the other Burn of Quoys site recorded Class 1.

These results showed that burns were not significantly acidified.

Index of Acidity
Note that the scores recorded in Table 2 are generated from the combined invertebrates present in all three Surber samples at each site.

Acidity Index scores were Class II at 12 sites showing intermediate conditions and Class III at 18 sites indicating acid conditions. Unlike the Water Chemistry scores the Index of Acidity indices are generated by the presence/absence of a wide range of species. If diversity is reduced by factors other than acidification then this scoring system may be unreliable.

Morris (1987) found there was little evidence of acidification of Shetland streams and the water chemistry results and pH records of this survey support this.

pH
The pH records are shown in Table 3.

The pH records varied from 6.35 in the Gossawater Burn to 8.01 in the Burn of Weisdale. The mean pH for all sites was 7.50. The only two sites recording <pH 7.0 were both sampled on the one day when water levels were significantly elevated from recent rainfall.

4.4 Survey Limitations

This survey was conducted in the autumn only. Because of the variation in phenology of freshwater benthic invertebrates it is recommended to sample twice in the year, both spring and autumn, and systems like RIVPACS are based on this. BMWP scores may therefore be lower than if two sampling periods were used.

The survey was based on a single habitat and comments on diversity, abundance and biomass reflect the species present in this habitat. However this habitat is used for the collection of invertebrate samples for water quality and is a much studied habitat in lotic waters. Invertebrates may also occupy different habitats at times of the year, for example *Ecdyonurus* spp. were found in greater concentrations in pools than riffles in April but the reverse was so in September (Egglishaw & Mackay 1967).

5 Conclusion

5.1 Current status

The invertebrate communities present in the watercourses consisted mainly of common and widespread species and no rarities were found. Diversity was low probably as a result of Shetland's isolation. In general communities were typical of those found in moderately clean and well-oxygenated water. The relative proportions of invertebrate groups indicated no significant organic enrichment. Where enrichment was indicated it is likely to be the result of natural allochthonous inputs. Abundance and biomass of invertebrates appeared to be low to moderate in all watercourses.

ASPT scores indicated that the water quality of the watercourses was fair or good. Water Chemistry Status Scores indicated that the watercourses were either slightly acidic or circum-neutral

Overall the water quality, invertebrate communities and productivity should support sustainable salmonid populations if other environmental factors are suitable.

5.2 Monitoring

The study has produced adequate baseline data to inform the design of any future monitoring programme. If the current design proposal is accepted then a minimum of three control burns will be selected for monitoring, one in each area of Delting, Nesting and Kergord. Most sites produced sufficient abundance and diversity of invertebrates for monitoring changes from impacts. The low diversity of species in Shetland burns may have contributed to lower water quality scores but as the principal purpose of monitoring is to detect change this will not invalidate monitoring results. The Index of Acidity should not be used in future monitoring however. pH values were only ascertained for low flows in most cases and if data is not available pH should be recorded for spate flows also.

The minimum monitoring programme recommended is a pre-construction year baseline followed by post construction monitoring immediately after completion of works and again three years later.

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Figure 1 *Invertebrate Sampling Sites: Delting*

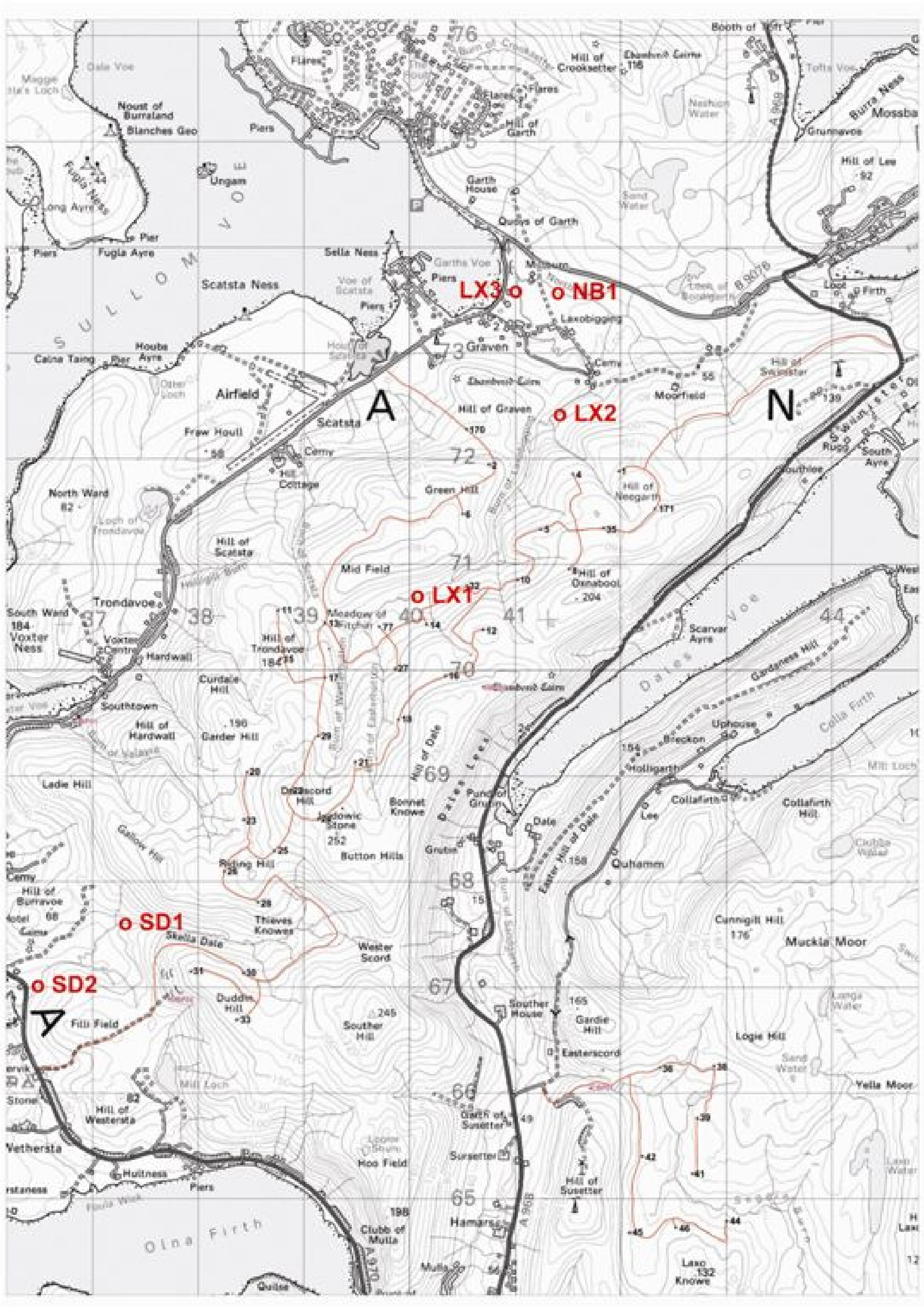

Figure 1 contd. *Invertebrate Sampling Sites: Nesting*

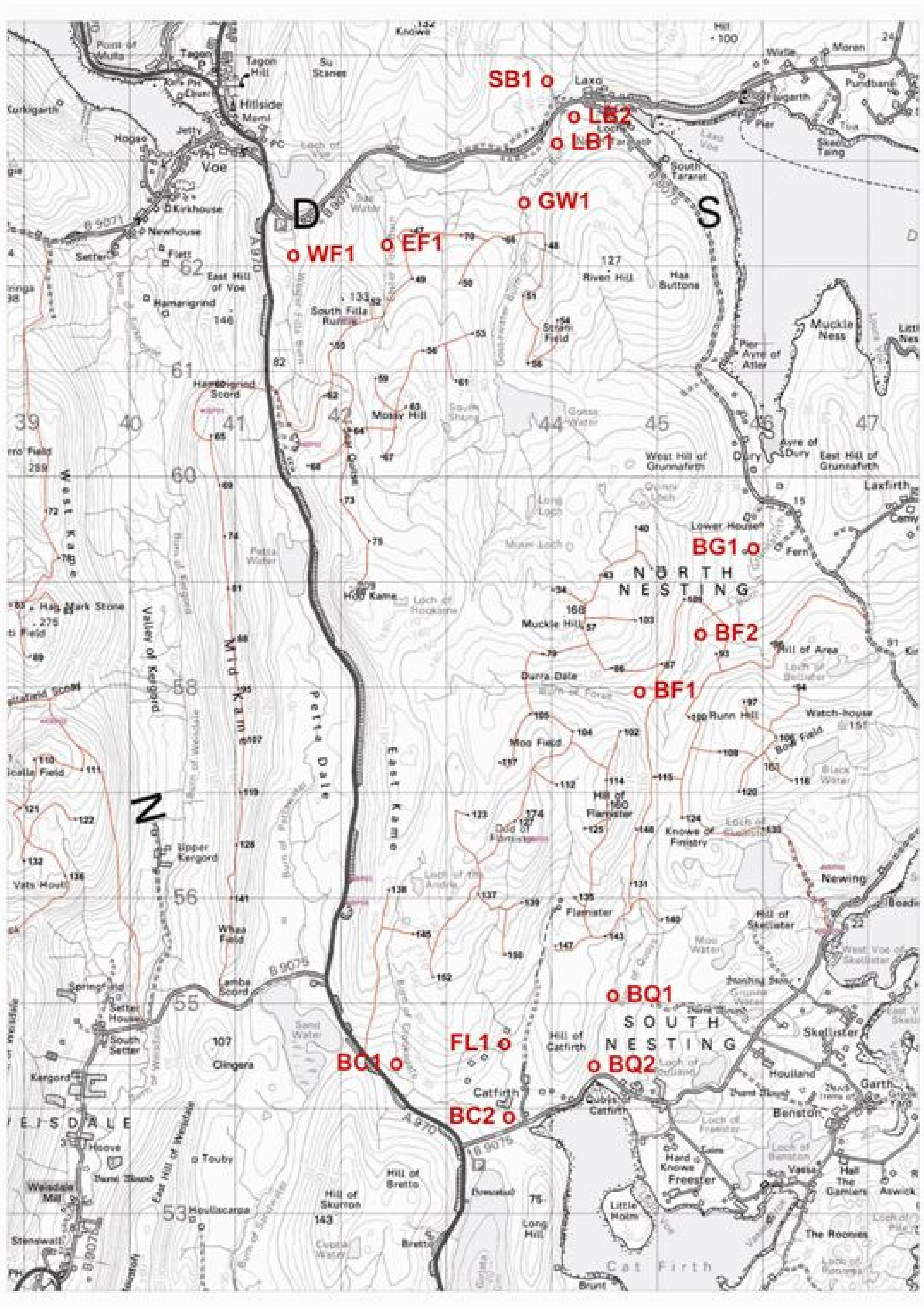

Figure 1 contd. *Invertebrate Sampling Sites: Nesting*

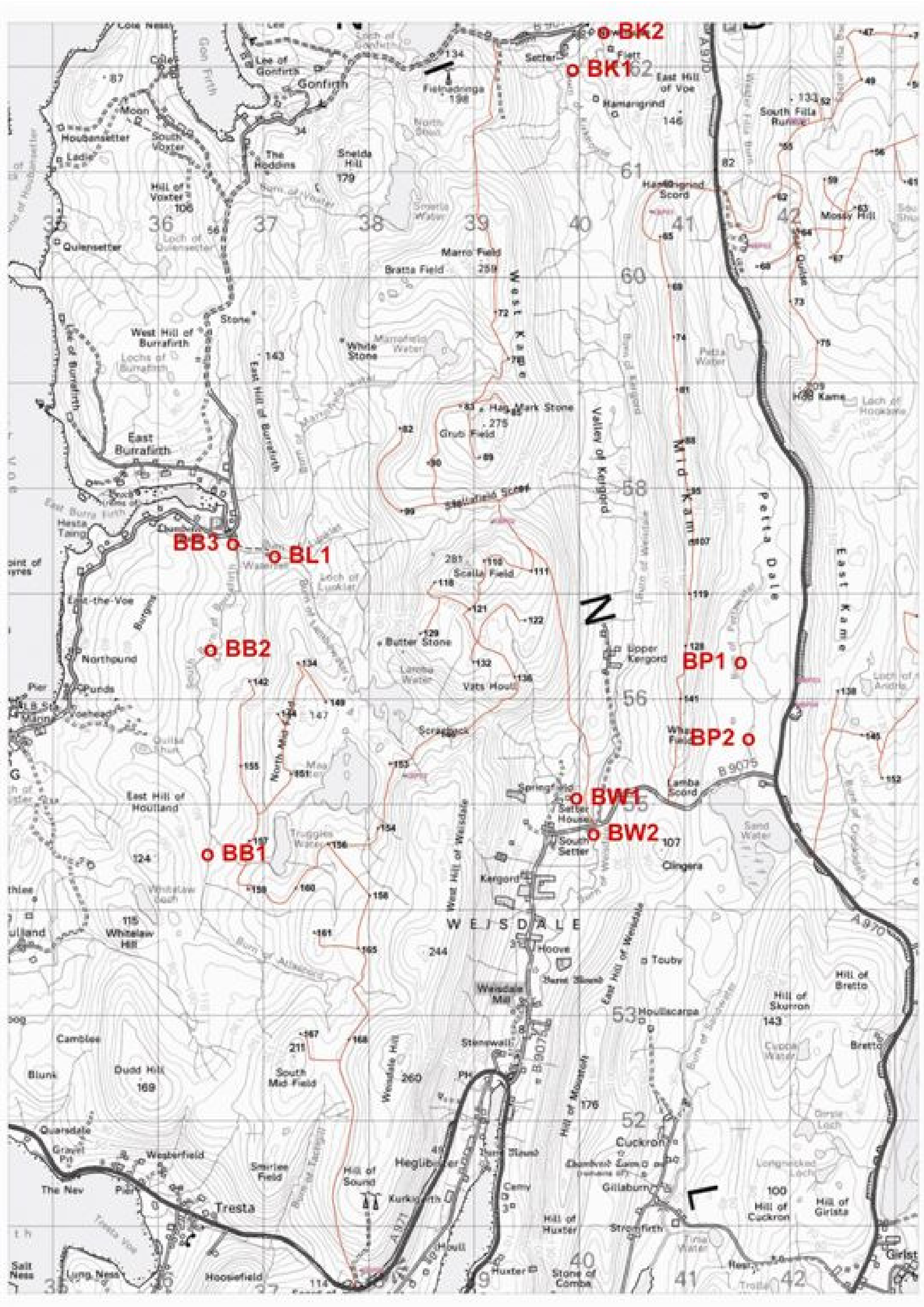

Figure 2 *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

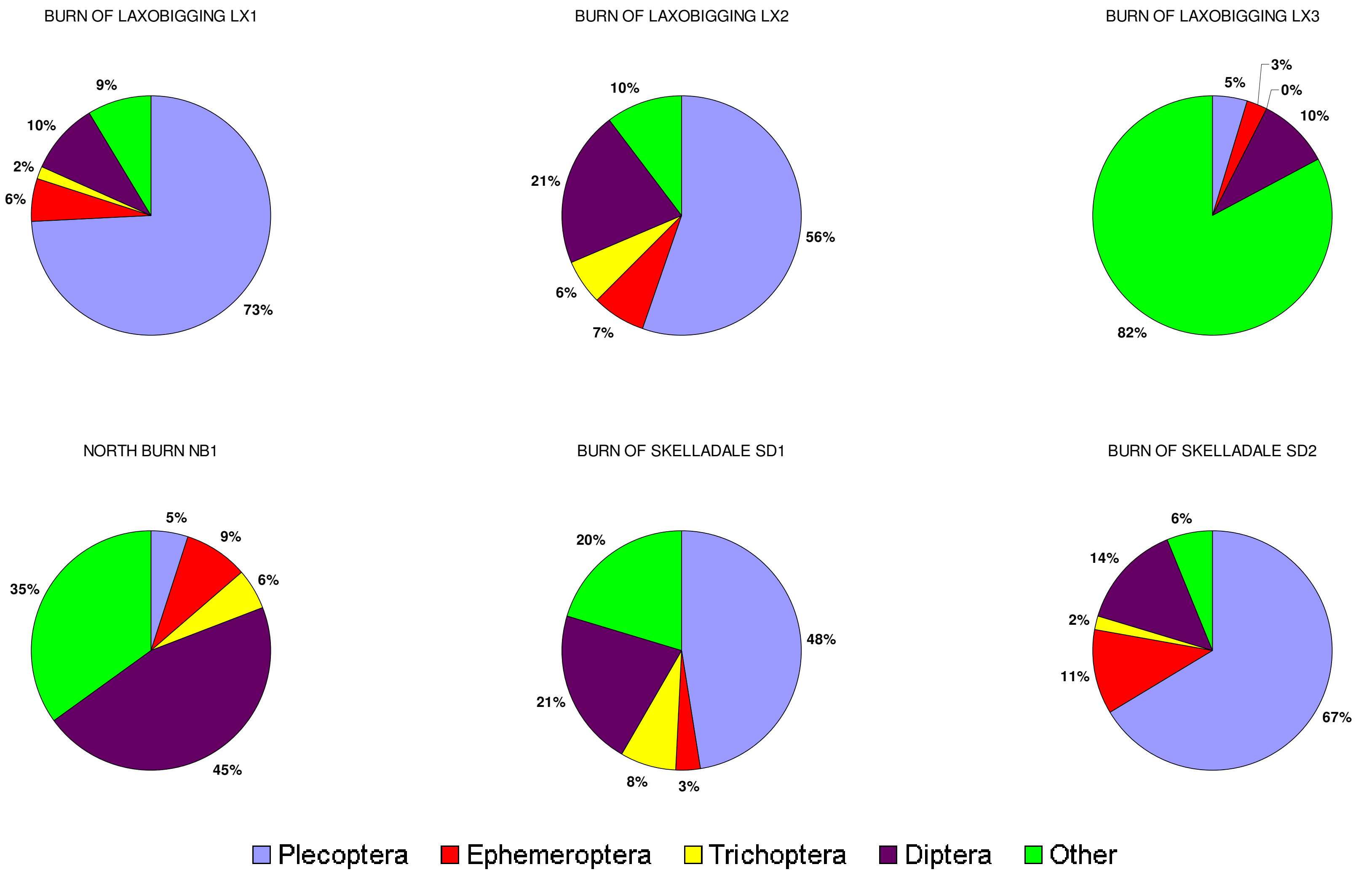

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

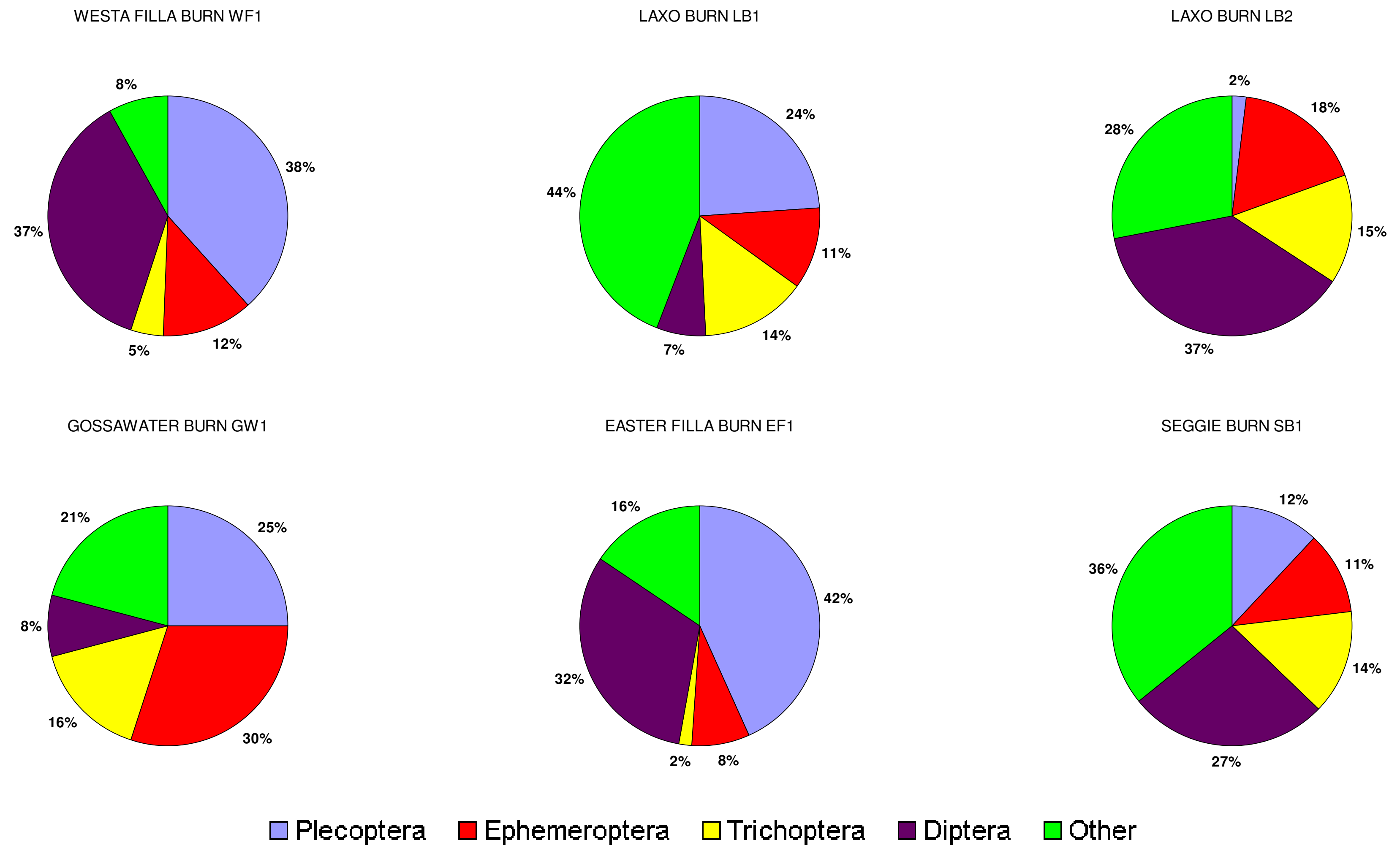

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

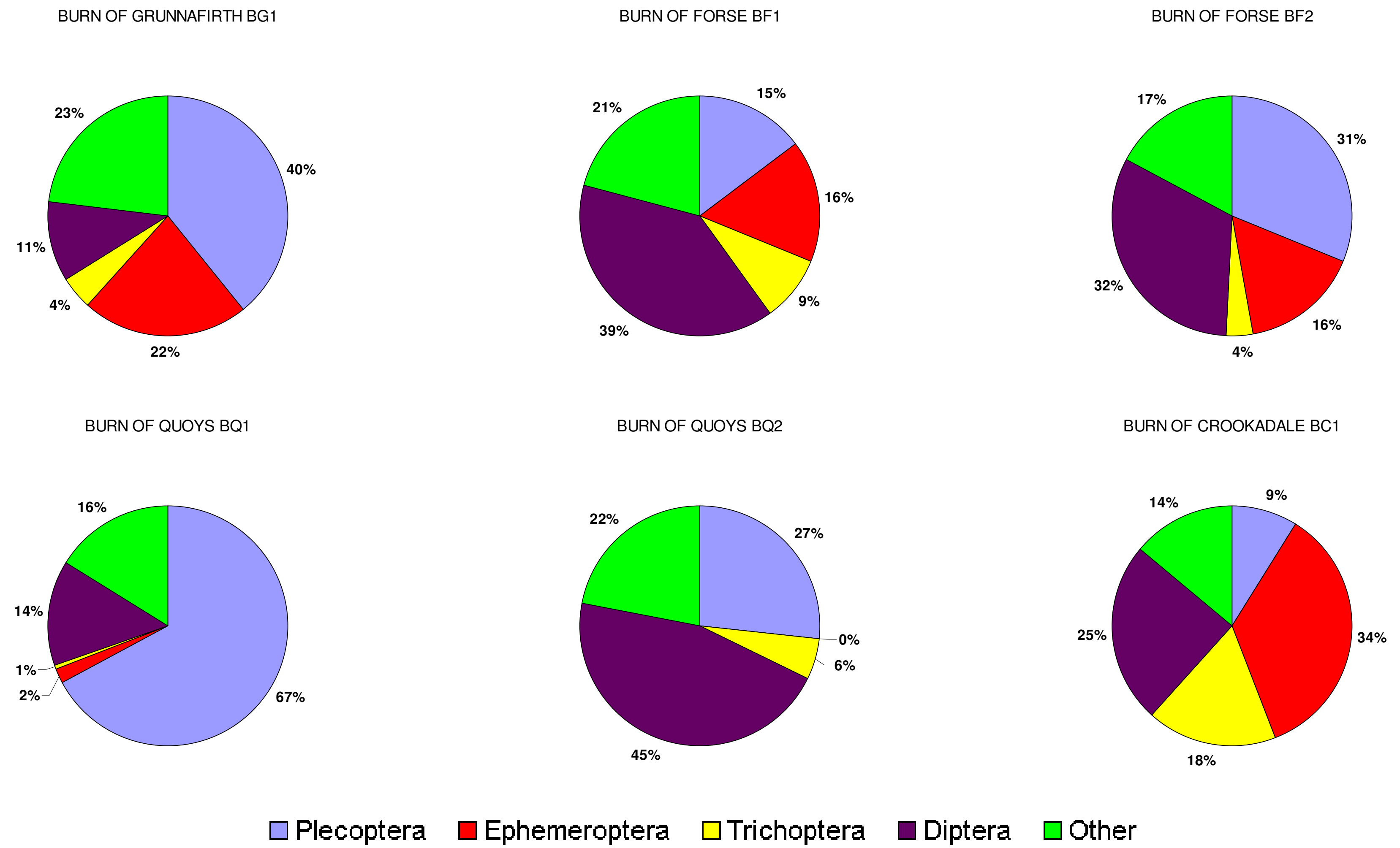

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

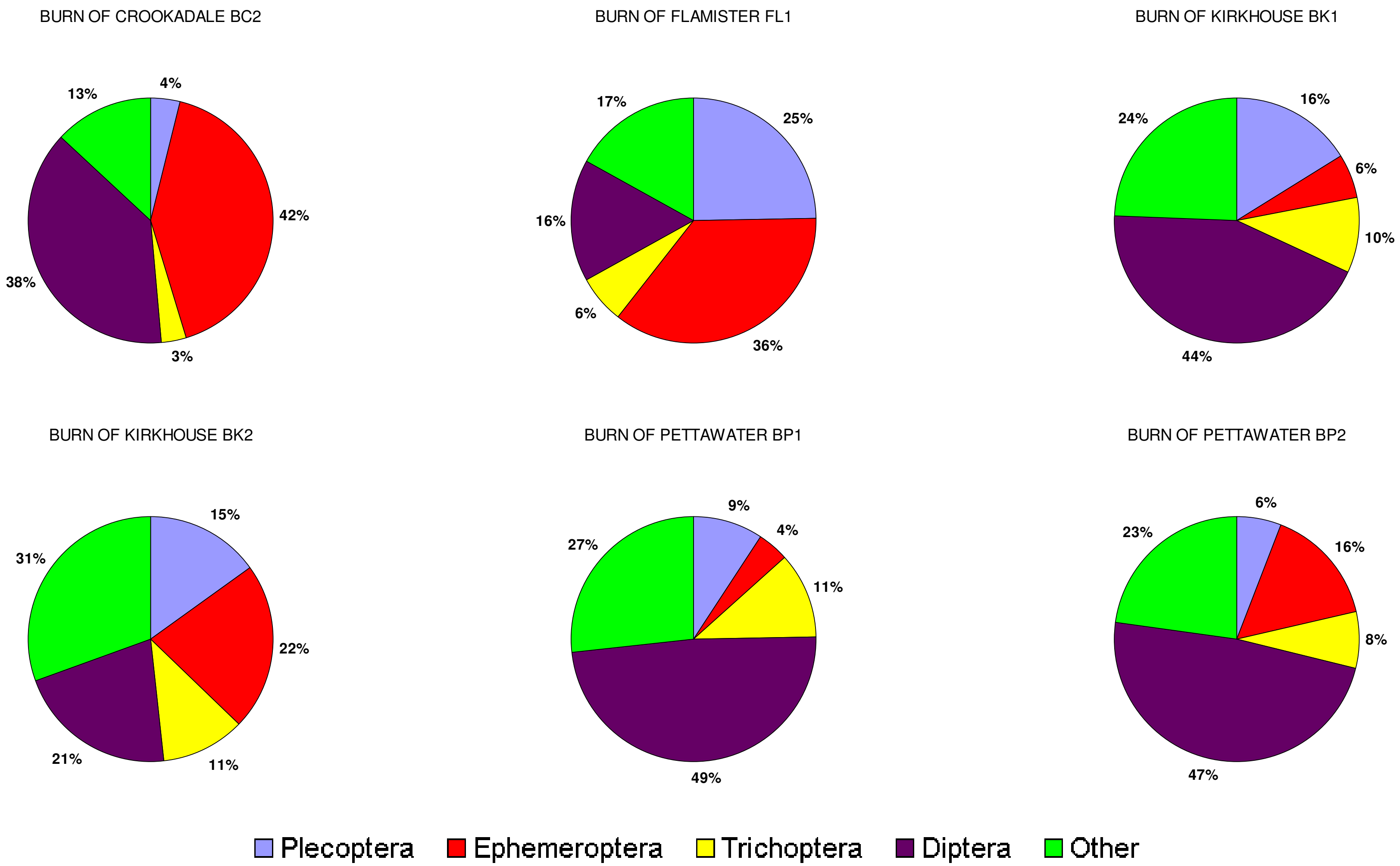

Figure 2 contd. *Invertebrate Groups: Percentages of Total Population in Surber Samples (Mean of three samples)*

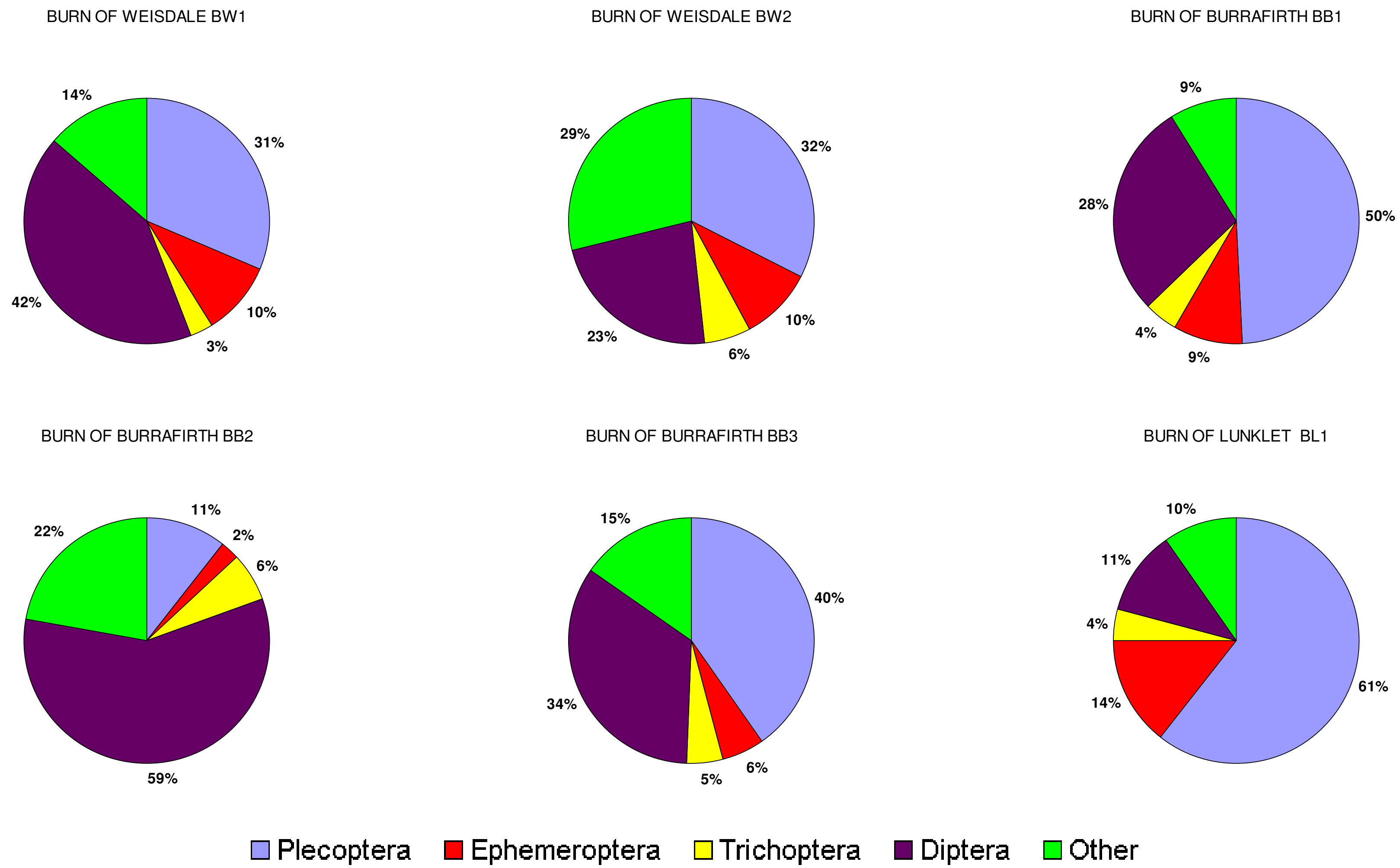

Figure 3 *Mean density (number/m²) of invertebrates in Surber samples (three per site)*

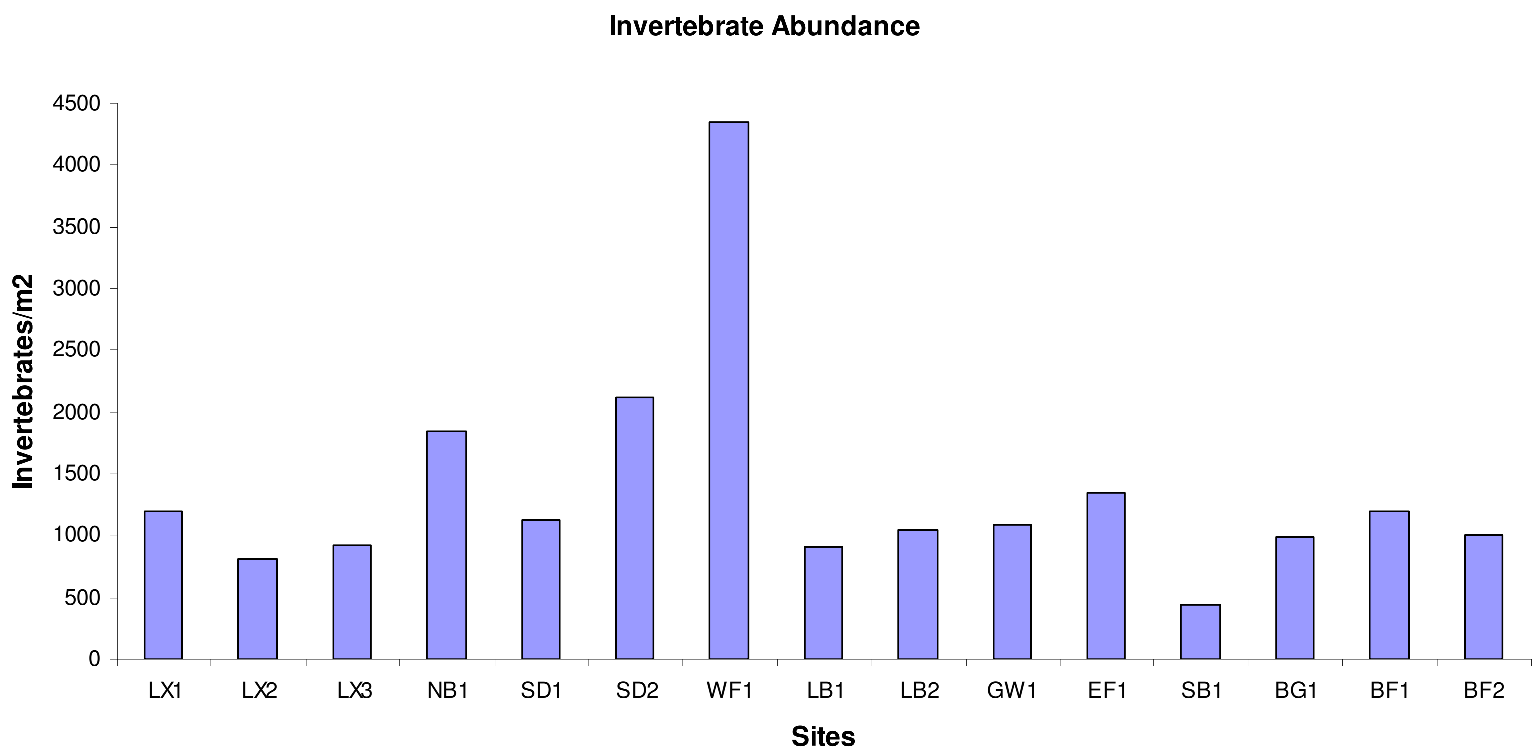

Figure 3 contd. *Mean density (number/m²) of invertebrates in Surber samples (three per site)*

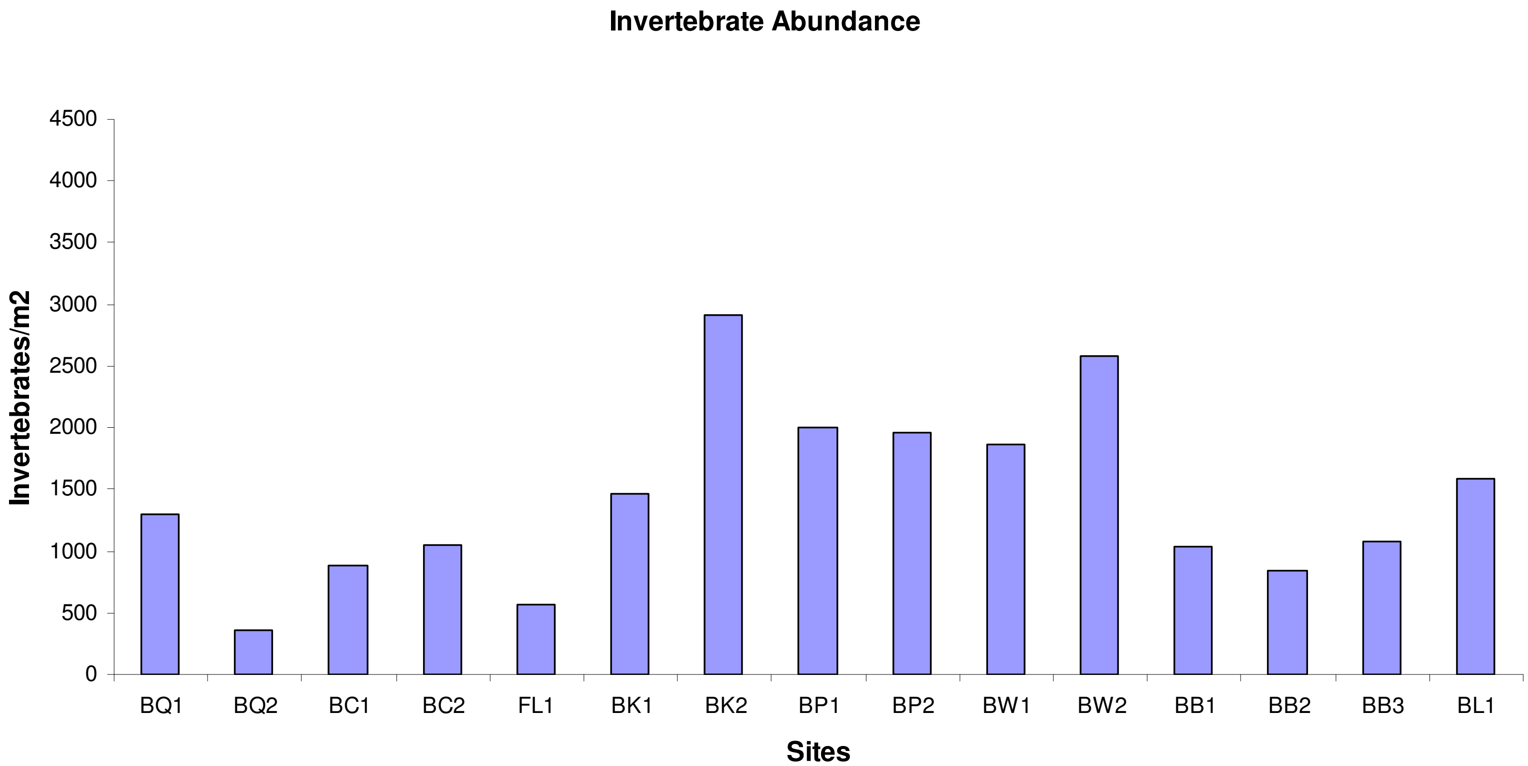

Figure 4 *Mean biomass (dry weight gm/m²) of invertebrates in Surber samples (three per site)*

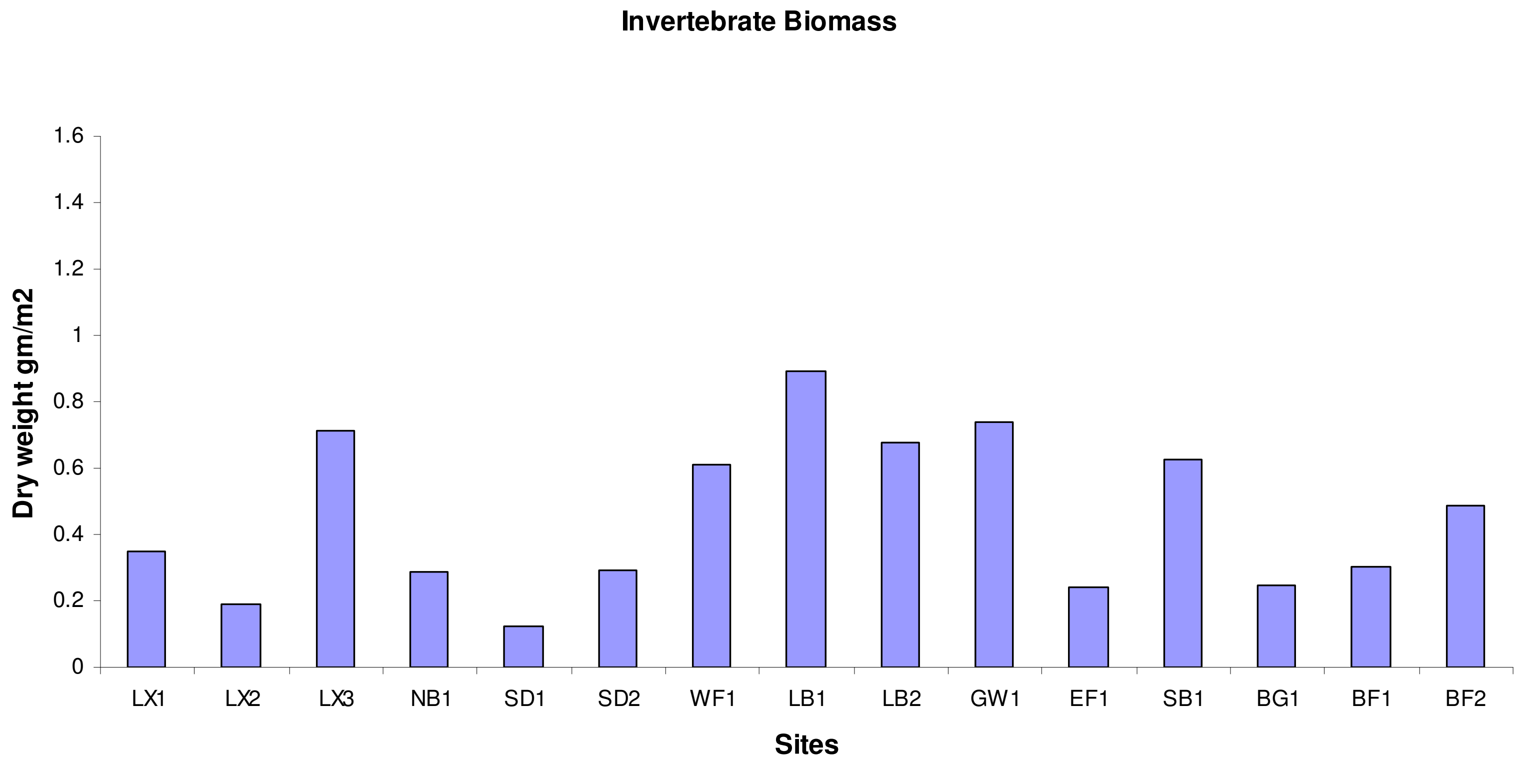

Figure 4 contd. *Mean biomass (dry weight gm/m²) of invertebrates in Surber samples (three per site)*

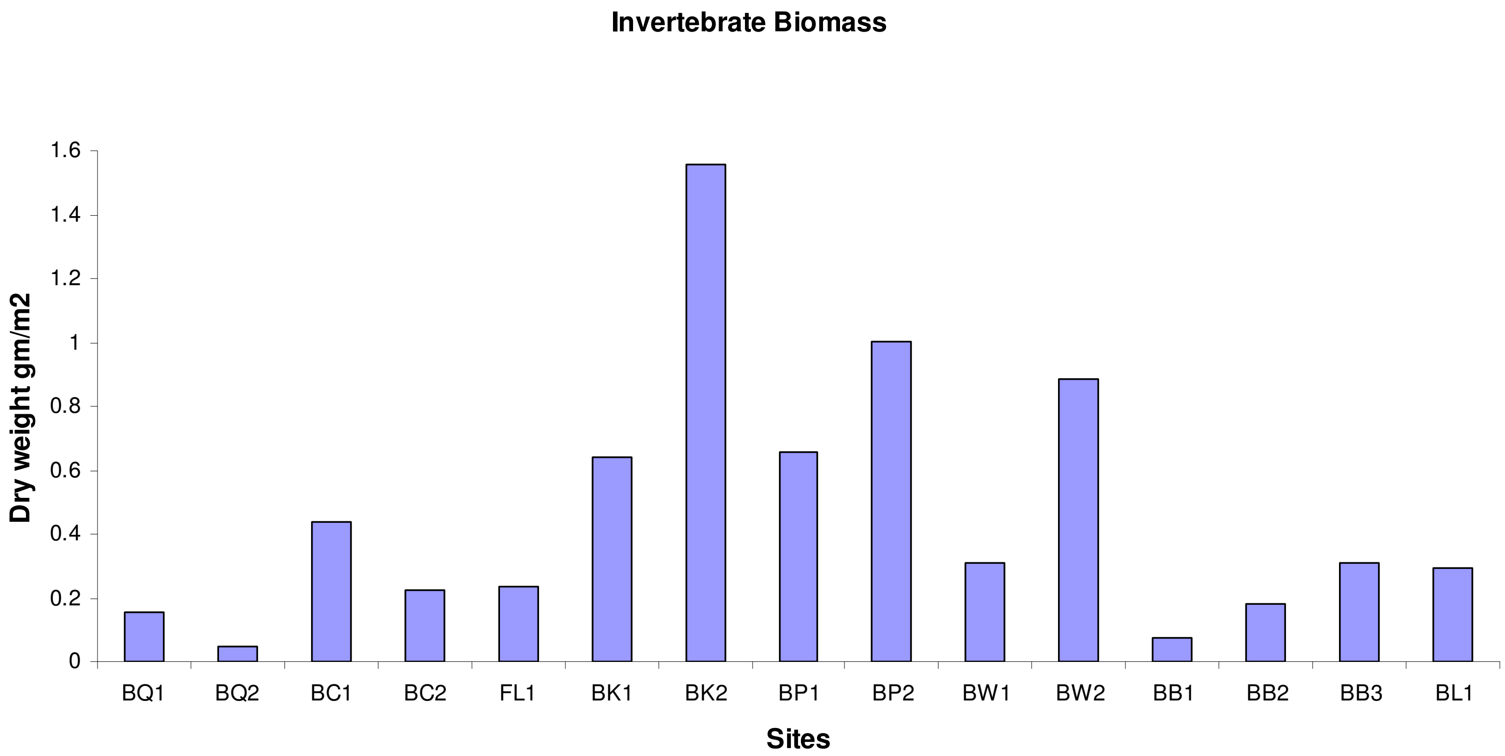

***Table 1** Kick Samples: Monitoring Scores*

Watercourse	Sample Codes	Grid Reference Square	East	North	Sampling Date	BMWP score	Number of scoring taxa (n)	ASPT Score
Delting								
Laxobigging								
Laxobigging	LX1	HU	40084	70665	27/08/2008	39	7	5.6
Laxobigging	LX2	HU	41384	72397	27/08/2008	52	10	5.2
Laxobigging	LX3	HU	40982	73595	27/08/2008	47	9	5.2
North Burn	NB1	HU	41326	73600	27/08/2008	62	11	5.6
Skelladale								
Skelladale	SD1	HU	37252	67575	27/08/2008	49	9	5.4
Skelladale	SD2	HU	36484	67002	27/08/2008	43	8	5.4
Nesting								
Wester Filla								
Wester Filla Burn	WF1	HU	41547	62104	25/08/2008	59	12	4.9
Laxo								
Laxo Burn	LB1	HU	44051	63172	25/08/2008	53	11	4.8
Laxo Burn	LB2	HU	44187	63422	25/08/2008	39	8	4.9
Burn of Gossawater	GW1	HU	43732	62549		39	8	4.9
Easter Filla	EF1	HU	42411	62251	25/08/2008	48	9	5.3
Seggie Burn	SB1	HU	43961	63789	25/08/2008	62	12	5.2
Grunnafirth								
Burn of Grunnafirth	BG1	HU	45908	59296	28/08/2008	46	9	5.1
Burn of Forse	BF1	HU	44830	57917	28/08/2008	62	11	5.6
Burn of Forse	BF2	HU	45386	58492	28/08/2008	51	9	5.7
Quoys								
Burn of Quoys	BQ1	HU	44568	55033	24/08/2008	46	8	5.8
Burn of Quoys	BQ2	HU	44393	54376	24/08/2008	39	8	4.9
Crookadale								
Burn of Crookadale	BC1	HU	42502	54354	23/08/2008	46	9	5.1
Burn of Crookadale	BC2	HU	43608	53888	23/08/2008	49	9	5.4
Burn of Flamister	FL1	HU	43641	54440	24/08/2008	42	8	5.3
Kergord								
Kirkhouse								
Burn of Kirkhouse	BK1	HU	39955	61950	26/08/2008	39	8	4.9
Burn of Kirkhouse	BK2	HU	40247	62364	26/08/2008	59	12	4.9
Pettawater								
Burn of Pettawater	BP1	HU	41500	56312	24/08/2008	51	10	5.1
Burn of Pettawater	BP2	HU	41588	55564	24/08/2008	41	8	5.1
Weisdale								
Burn of Weisdale	BW1	HU	39972	55004	28/08/2008	57	11	5.2
Burn of Weisdale	BW2	HU	40080	54734	24/08/2008	57	11	5.2
Burrafirth								
Burn of Burrafirth	BB1	HU	36457	54567	26/08/2008	31	6	5.2
Burn of Burrafirth	BB2	HU	36472	56432	26/08/2008	44	9	4.9
Burn of Burrafirth	BB3	HU	36713	57461	26/08/2008	41	8	5.1
Burn of Lunklet	BL1	HU	37063	57342	26/08/2008	54	10	5.4

Table 2 *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Delting								
Laxobigging								
Burn of Laxobigging	LX1-1	85	9	III	2	1203	0.0081	0.348
Burn of Laxobigging	LX1-2	66	12	-	-		0.0399	
Burn of Laxobigging	LX1-3	210	11	-	-		0.0565	
Burn of Laxobigging	LX2-1	132	15	II	2	810	0.0280	0.188
Burn of Laxobigging	LX2-2	66	13	-	-		0.0201	
Burn of Laxobigging	LX2-3	45	10	-	-		0.0082	
Burn of Laxobigging	LX3-1	145	12	III	2	927	0.1363	0.711
Burn of Laxobigging	LX3-2	40	6	-	-		0.0283	
Burn of Laxobigging	LX3-3	93	6	-	-		0.0486	
North Burn	NB1-1	161	13	III	2	1847	0.0177	0.289
North Burn	NB1-2	84	14	-			0.0207	
North Burn	NB1-3	309	18	-			0.0482	
Skelladale								
Burn of Skelladale	SD1-1	97	13	III	2	1130	0.0086	0.125
Burn of Skelladale	SD1-2	122	14	-	-		0.0134	
Burn of Skelladale	SD1-3	120	13	-	-		0.0154	
Burn of Skelladale	SD2-1	444	16	III	2	2120	0.0491	0.293
Burn of Skelladale	SD2-2	138	15	-	-		0.0292	
Burn of Skelladale	SD2-3	54	8	-	-		0.0096	
Nesting								
Wester Filla								
Wester Filla Burn	WF1-1	264	15	II	1	4347	0.0389	0.611
Wester Filla Burn	WF1-2	455	16	-	-		0.0639	
Wester Filla burn	WF1-3	585	17	-	-		0.0804	
Laxo								
Laxo Burn	LB1-1	50	13	II	1	903	0.0790	0.892
Laxo Burn	LB1-2	102	14	-	-		0.0964	
Laxo Burn	LB1-3	119	20	-	-		0.0922	
Laxo Burn	LB2-1	75	14	II	1	1043	0.0203	0.676
Laxo Burn	LB2-2	89	18	-	-		0.0746	
Laxo Burn	LB2-3	149	19	-	-		0.1078	
Gossawater Burn	GW1-1	87	15	III	2	1090	0.0400	0.737
Gossawater Burn	GW1-2	118	13	-	-		0.0560	
Gossawater Burn	GW1-3	122	14	-	-		0.1252	

Table 2 contd. *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Easter Filla Burn	EF1-1	111	14	III	2	1353	0.0237	0.240
Easter Filla Burn	EF1-2	121	11	-	-		0.0260	
Easter Filla Burn	EF1-3	174	11	-	-		0.0222	
Seggie Burn	SB1-1	75	11	III	2	447	0.0816	0.626
Seggie Burn	SB1-2	40	12	-	-		0.0841	
Seggie Burn	SB1-3	19	8	-	-		0.0221	
Grunnafirth								
Burn of Grunnafirth	BG1-1	119	11	III	2	993	0.0255	0.246
Burn of Grunnafirth	BG1-2	92	15	-	-		0.0362	
Burn of Grunnafirth	BG1-3	87	9	-	-		0.0121	
Burn of Forse	BF1-1	82	13	III	2	1193	0.0080	0.305
Burn of Forse	BF1-2	187	14	-	-		0.0462	
Burn of Forse	BF1-3	89	15	-	-		0.0373	
Burn of Forse	BF2-1	89	11	III	2	1010	0.0691	0.485
Burn of Forse	BF2-2	114	11	-	-		0.0451	
Burn of Forse	BF2-3	100	15	-	-		0.0313	
Quoys								
Burn of Quoys	BQ1-1	134	11	II	1	1300	0.0243	0.155
Burn of Quoys	BQ1-2	113	10	-	-		0.0171	
Burn of Quoys	BQ1-3	143	9	-	-		0.0051	
Burn of Quoys	BQ2-1	16	4	III	3	363	0.0097	0.047
Burn of Quoys	BQ2-2	53	11	-	-		0.0028	
Burn of Quoys	BQ2-3	40	7	-	-		0.0017	
Crookadale								
Burn of Crookadale	BC1-1	127	13	III	2	883	0.0481	0.437
Burn of Crookadale	BC1-2	128	12	-	-		0.0778	
Burn of Crookadale	BC1-3	10	6	-	-		0.0051	
Burn of Crookadale	BC2-1	109	10	III	2	1043	0.0118	0.224
Burn of Crookadale	BC2-2	109	12	-	-		0.0211	
Burn of Crookadale	BC2-3	95	13	-	-		0.0343	
Burn of Flamister	FL1-1	78	11	III	2	567	0.0508	0.237
Burn of Flamister	FL1-2	46	4	-	-		0.0026	
Burn of Flamister	FL1-3	46	8	-	-		0.0177	

Table 2 contd. *Surber Samples: Abundance, Acidity Indices and Biomass*

Watercourse	Sample Codes	Total abundance (n)	Number of Taxa Present	Index of Acidity	Water Class	Abundance number/m²	Biomass gm dry weight	Biomass gm/m²
Kergord								
Kirkhouse								
Burn of Kirkhouse	BK1-1	119	11	II	1	1457	0.0189	0.641
Burn of Kirkhouse	BK1-2	213	14	-	-		0.1192	
Burn of Kirkhouse	BK1-3	105	15	-	-		0.0543	
Burn of Kirkhouse	BK2-1	336	22	II	1	2907	0.1733	1.558
Burn of Kirkhouse	BK2-2	305	22	-	-		0.1794	
Burn of Kirkhouse	BK2-3	231	21	-	-		0.1146	
Pettawater								
Burn of Pettawater	BP1-1	188	15	II	1	2007	0.0507	0.658
Burn of Pettawater	BP1-2	107	16	-	-		0.0812	
Burn of Pettawater	BP1-3	307	17	-	-		0.0655	
Burn of Pettawater	BP2-1	194	18	II	1	1957	0.0967	1.005
Burn of Pettawater	BP2-2	228	16	-	-		0.1751	
Burn of Pettawater	BP2-3	165	14	-	-		0.0298	
Weisdale								
Burn of Weisdale	BW1-1	278	22	II	1	1867	0.0187	0.307
Burn of Weisdale	BW1-2	150	14	-	-		0.0280	
Burn of Weisdale	BW1-3	132	17	-	-		0.0455	
Burn of Weisdale	BW2-1	293	15	II	1	2587	0.1502	0.884
Burn of Weisdale	BW2-2	198	15	-	-		0.0560	
Burn of Weisdale	BW2-3	285	17	-	-		0.0589	
Burrafirth								
Burn of Burrafirth	BB1-1	188	12	III	2	1040	0.0193	0.077
Burn of Burrafirth	BB1-2	103	8	-	-		0.0024	
Burn of Burrafirth	BB1-3	21	8	-	-		0.0014	
Burn of Burrafirth	BB2-1	135	12	II	1	843	0.0092	0.181
Burn of Burrafirth	BB2-2	50	14	-	-		0.0176	
Burn of Burrafirth	BB2-3	68	15	-	-		0.0276	
Burn of Burrafirth	BB3-1	142	14	III	2	1073	0.0358	0.310
Burn of Burrafirth	BB3-2	74	9	-	-		0.0308	
Burn of Burrafirth	BB3-3	106	16	-	-		0.0263	
Burn of Lunklet	BL1-1	265	13	III	2	1590	0.0239	0.294
Burn of Lunklet	BL1-2	69	12	-	-		0.0450	
Burn of Lunklet	BL1-3	143	14	-	-		0.0193	

Table 3 Environmental factors: Kick Samples

Sample Code	Depth (cm) 1/4	1/2	3/4	Bed Width (m)	Wet Width (m)	Macrophyte % cover	Clarity	Flow (ms-1)	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)	pH	˚C	Canopy Cover %
Delting																			
Laxobigging																			
Laxobigging LX1	5	15	11	1.6	1.6	10	clear brown	0.3	0	0	0	10	25	64	1	0	7.17	13.7	0
Laxobigging LX2	18	15	11	2.9	2.9	17	clear brown	0.7	0	0	0	5	15	65	15	0	7.40	13.7	0
Laxobigging LX3	8	12	10	3.4	3.4	15	clear brown	0.7	0	0	0	10	25	60	5	0	7.61	15.4	0
North Burn NB1	14	18	19	0.9	0.9	45	clear brown	0.7	10	0	0	9	30	50	1	0	7.35	13.9	0
Skelladale																			
Burn of Skelladale SD1	16	14	5	3.9	3.3	10	clear brown	0.4	0	0	0	10	20	50	20	0	7.53	12.8	0
Burn of Skelladale SD2	9	8	8	4.4	3.4	5	clear brown	0.5	0	0	0	5	15	60	20	0	7.55	13.7	0
Nesting																			
Wester Filla																			
Wester Filla Burn WF1	6	4	3	2.7	1.7	41	clear brown	0.3	0	0	0	10	30	60	0	0	7.82	13.2	0
Laxo																			
Laxo Burn LB1	11	15	20	7.0	7.0	40	clear brown	0.5	0	0	5	15	20	50	10	0	6.74	14.0	0
Laxo Burn LB2	13	27	23	8.5	8.5	25	clear brown	0.4	0	0	0	10	20	60	10	0	7.18	13.7	0
Gossawater Burn GW1	20	12	6	2.3	2.3	10	clear brown	0.7	0	0	0	10	15	65	10	0	6.35	14.4	0
Easter Filla Burn EF1	8	10	8	2.1	2.1	40	clear brown	0.7	0	0	0	0	10	80	10	0	7.54	12.5	0
Seggie Burn SB1	40	30	10	6.1	5.9	20	clear brown	0.4	0	0	5	5	10	60	20	0	7.53	13.0	0
Grunnafirth																			
Burn of Grunnafirth BG1	12	10	3	3.2	2.6	10	clear brown	0.3	0	0	5	5	20	60	10	0	7.71	13.7	0
Burn of Forse BF1	4	6	7	5.5	3.4	25	clear brown	0.3	0	0	0	5	15	70	10	0	7.57	11.9	0
Burn of Forse BF2	8	6	5	5.0	5.0	5	clear brown	0.2	0	0	0	5	25	60	10	0	7.69	12.6	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 3 contd. *Environmental factors: Kick Samples*

Sample Code	Depth (cm) 1/4	1/2	3/4	Bed Width (m0	Wet Width (m)	Macrophyte % cover	Clarity	Flow (ms-1)	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)	pH	˚C	Canopy Cover %
Quoys																			
Burn of Quoys BQ1	2	4	2	3.0	1.7	10	clear brown	0.25	0	0	0	10	20	50	10	10	7.55	13.4	0
Burn of Quoys BQ2	7	7	5	4.8	3.6	4	clear brown	0.25	0	0	0	10	15	70	5	0	7.8	14.7	0
Crookadale																			
Burn of Crookadale BC1	3	3	5	1.1	1.1	20	clear brown	0.25	0	10	5	15	30	40	0	0	7.31	12.7	0
Burn of Crookadale BC2	7	10	12	2.1	2.1	55	clear brown	0.4	0	0	0	10	20	60	10	0	7.35	13.3	0
Burn of Flamister FL1	2	2	3	1.6	1.6	2	clear brown	0.2	0	0	0	15	25	60	0	0	7.77	15.9	0
Kergord																			
Kirkhouse																			
Burn of Kirkhouse BK1	10	10	9	1.7	1.7	40	clear brown	0.5	0	0	0	10	15	60	5	10	7.56	13.3	0
Burn of Kirkhouse BK2	10	11	10	1.8	1.8	31	clear brown	0.5	0	0	5	10	24	60	1	0	7.45	11.9	0
Pettawater																			
Burn of Pettawater BP1	14	11	3	1.9	1.9	60	clear brown	0.4	0	0	5	5	80	10	0	0	7.8	16.1	0
Burn of Pettawater BP2	18	11	7	2.7	2.7	60	clear brown	0.2	0	0	10	20	40	20	10	0	7.95	16.1	0
Weisdale																			
Burn of Weisdale BW1	10	15	4	1.6	1.2	55	clear brown	0.3	0	0	0	5	20	70	5	0	7.81	13.9	0
Burn of Weisdale BW2	7	3	5	3.4	3.4	65	clear brown	0.4	0	0	0	5	40	55	0	0	8.01	18.5	0
Burrafirth																			
Burn of Burrafirth BB1	14	5	8	2.5	2.0	11	clear brown	0.2	0	0	0	10	25	55	10	0	7.46	16.8	0
Burn of Burrafirth BB2	4	7	9	4.5	4.5	30	clear brown	0.2	0	0	0	5	20	70	5	0	7.37	18.7	0
Burn of Burrafirth BB3	16	15	7	6.0	6.0	10	clear brown	0.4	0	0	0	5	5	60	20	10	7.49	16.4	0
Burn of Lunklet BL1	15	9	13	4.6	4.2	2	clear brown	0.3	0	0	5	10	20	45	20	0	7.45	14.8	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
Delting											
Laxobigging	14	0	riffle	0	0	0	0	10	90	0	0
LX1-1	12	5	riffle	0	0	0	0	20	80	0	0
LX1-2	6	10	riffle	0	0	0	5	25	70	0	0
LX1-3	12	5	riffle	0	0	0	0	0	100	0	0
LX2-1	10	5	riffle	0	0	0	0	10	90	0	0
LX2-2	12	0	riffle	0	0	0	0	30	70	0	0
LX2-3	10	0	riffle	0	0	0	5	15	80	0	0
LX3-1	12	0	riffle	0	0	0	10	20	70	0	0
LX3-2	12	0	riffle	0	0	0	5	15	80	0	0
LX3-3	22	55	riffle	0	0	0	5	15	80	0	0
NB1-1	20	42	riffle	0	0	0	20	30	50	0	0
NB1-2	18	41	riffle	0	0	0	20	20	60	0	0
NB1-3											
Skelladale	10	40	riffle	0	0	0	5	15	80	0	0
SD1-1	5	0	riffle	0	0	0	10	20	70	0	0
SD1-2	14	0	riffle	0	0	0	5	15	80	0	0
SD1-3	8	0	riffle	0	0	0	0	70	30	0	0
SD2-1	14	10	riffle	0	0	0	0	20	80	0	0
SD2-2	12	30	riffle	0	0	0	0	10	90	0	0
SD2-3	14	0	riffle	0	0	0	0	10	90	0	0
Nesting											
Wester Filla											
WF1-1	9	30	riffle	0	0	0	10	20	70	0	0
WF1-2	4	60	riffle	0	0	0	0	30	70	0	0
WF1-3	4	30	riffle	0	0	0	10	40	50	0	0
Laxo											
LB1-1	16	10	riffle	0	0	0	20	20	60	0	0
LB1-2	18	0	riffle	0	0	0	10	20	70	0	0
LB1-3	12	5	riffle	0	0	0	20	20	60	0	0
LB2-1	18	45	riffle	0	0	0	0	10	90	0	0
LB2-2	16	30	riffle	0	0	0	5	15	80	0	0
LB2-3	20	30	riffle	0	0	0	5	5	90	0	0
GW1-1	16	20	riffle	0	0	0	5	15	80	0	0
GW1-2	12	10	riffle	0	0	0	5	15	80	0	0
GW1-3	16	3	riffle	0	0	0	10	20	70	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 contd. *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
EF1-1	12	30	riffle	0	0	0	0	10	90	0	0
EF1-2	12	30	riffle	0	0	0	0	10	90	0	0
EF1-3	8	31	riffle	0	0	0	0	20	80	0	0
SB1-1	20	10	riffle	0	0	5	5	10	80	0	0
SB1-2	18	1	riffle	0	0	5	5	10	80	0	0
SB1-3	18	40	riffle	0	0	5	5	20	70	0	0
Grunnafirth											
BG1-1	8	5	riffle	0	0	0	0	20	80	0	0
BG1-2	5	5	riffle	0	0	0	0	20	80	0	0
BG1-3	12	5	riffle	0	0	0	0	20	80	0	0
BF1-1	8	10	riffle	0	0	0	5	25	70	0	0
BF1-2	12	15	riffle	0	0	0	0	10	90	0	0
BF1-3	5	5	riffle	0	0	0	0	10	90	0	0
BF2-1	8	5	riffle	0	0	0	5	25	70	0	0
BF2-2	8	10	riffle	0	0	0	5	25	70	0	0
BF2-3	11	5	riffle	0	0	0	5	25	70	0	0
Quoys											
BQ1-1	5	11	riffle	0	0	10	10	40	40	0	0
BQ1-2	5	1	riffle	0	0	0	10	10	80	0	0
BQ1-3	5	15	riffle	0	0	0	5	15	80	0	0
BQ2-1	7	0	riffle	0	0	0	5	15	80	0	0
BQ2-2	4	2	riffle	0	0	0	5	15	80	0	0
BQ2-3	5	10	riffle	0	0	0	5	15	80	0	0
Crookadale											
BC1-1	10	5	riffle	0	0	0	20	20	60	0	0
BC1-2	6	0	riffle	0	0	0	20	60	20	0	0
BC1-3	3	1	riffle	0	0	10	20	20	50	0	0
BC2-1	8	20	riffle	0	0	5	15	20	60	0	0
BC2-2	10	20	riffle	0	0	0	20	20	60	0	0
BC2-3	10	10	riffle	0	0	0	10	10	80	0	0
FL1-1	4	0	riffle	0	0	0	10	20	70	0	0
FL1-2	4	0	riffle	0	0	0	5	25	70	0	0
FL1-3	4	1	riffle	0	0	0	5	20	75	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Table 4 contd. *Environmental factors: Surber Samples*

Sample Code	Depth (cm)	Macrophyte % cover	Flow type	HO (%)	SI (%)	SA (%)	GR (%)	PE (%)	CO (%)	BO (%)	BE (%)
Kergord											
Kirkhouse											
BK1-1	14	30	glide	0	0	0	0	10	90	0	0
BK1-2	12	40	riffle	0	0	0	5	15	80	0	0
BK1-3	14	30	riffle	0	0	0	0	20	70	0	10
BK2-1	12	40	riffle	0	0	5	5	20	70	0	0
BK2-2	10	20	riffle	0	0	5	10	15	70	0	0
BK2-3	10	30	riffle	0	0	5	15	20	60	0	0
Pettawater											
BP1-1	14	5	glide	0	10	15	20	60	5	0	0
BP1-2	14	30	glide	0	0	10	20	70	0	0	0
BP1-3	12	90	glide	0	50	0	10	30	10	0	0
BP2-1	14	30	riffle	0	0	10	20	30	40	0	0
BP2-2	14	80	riffle	0	0	10	20	30	40	0	0
BP2-3	14	80	riffle	0	0	20	30	50	0	0	0
Weisdale											
BW1-1	10	50	riffle	0	0	0	0	15	85	0	0
BW1-2	10	50	riffle	0	0	0	0	15	85	0	0
BW1-3	7	50	riffle	0	0	0	0	15	85	0	0
BW2-1	11	20	riffle	0	0	0	5	35	60	0	0
BW2-2	9	40	riffle	0	0	0	0	30	70	0	0
BW2-3	7	50	riffle	0	0	0	10	30	60	0	0
Burrafirth											
BB1-1	9	0	riffle	0	0	0	0	20	80	0	0
BB1-2	5	20	riffle	0	0	0	0	20	80	0	0
BB1-3	9	0	riffle	0	0	0	10	20	70	0	0
BB2-1	6	60	riffle	0	0	0	20	30	50	0	0
BB2-2	9	49	riffle	0	0	0	10	20	70	0	0
BB2-3	6	41	riffle	0	0	0	20	30	50	0	0
BB3-1	14	5	riffle	0	0	0	0	20	80	0	0
BB3-2	14	5	riffle	0	0	0	0	5	95	0	0
BB3-3	14	10	riffle	0	0	0	0	5	95	0	0
BL1-1	12	5	riffle	0	0	0	5	20	75	0	0
BL1-2	9	5	riffle	0	0	0	0	10	90	0	0
BL1-3	12	2	riffle	0	0	0	0	10	90	0	0

HO = High organic SI = silt SA = sand GR = Gravel PE = Pebble CO = Cobble BO = Boulder BE = Bedrock

Appendix 1 *BMWP Scoring System*

Common Name	Family	BMWP Score	Common Name	Family	BMWP Score
Flatworms	Planariidae	5	Bugs	Mesoveliidae *	5
	Dendrocoelidae	5		Hydrometridae	5
Snails	Neritidae	6		Gerridae	5
	Viviparidae	6		Nepidae	5
	Valvatidae	3		Naucoridae	5
	Hydrobiidae	3		Aphelocheiridae	10
	Lymnaeidae	3		Notonectidae	5
	Physidae	3		Pleidae	5
	Planorbidae	3		Corixidae	5
Limpets and Mussels	Ancylidae	6	Beetles	Haliplidae	5
	Unionidae	6		Hygrobiidae	5
	Sphaeriidae	3		Dytiscidae	5
Worms	Oligochaeta	1		Gyrinidae	5
Leeches	Piscicolidae	4		Hydrophilidae	5
	Glossiphoniidae	3		Clambidae	5
	Hirudididae	3		Scirtidae	5
	Erpobdellidae	3		Dryopidae	5
Crustaceans	Asellidae	3		Elmidae	5
	Corophiidae	6		Chrysomelidae	5
	Gammaridae	6		Curculionidae	5
	Astacidae	8	Alderflies	Sialidae	4
Mayflies	Siphlonuridae	10	Caddisflies	Rhyacophilidae	7
	Baetidae	4		Philopotamidae	8
	Heptageniidae	10		Polycentropidae	7
	Leptophlebiidae	10		Psychomyiidae	8
	Ephemerellidae	10		Hydropsychidae	5
	Potamanthidae	10		Hydroptilidae	6
	Ephemeridae	10		Phryganeidae	10
	Caenidae	7		Limnephilidae	7
Stoneflies	Taeniopterygidae	10		Molannidae	10
	Nemouridae	7		Beraeidae	10
	Leuctridae	10		Odontoceridae	10
	Capniidae	10		Leptoceridae	10
	Perlodidae	10		Goeridae	10
	Perlidae	10		Lepidostomatidae	10
	Chloroperlidae	10		Brachycentridae	10
Damselflies	Platycnemidae	6		Sericostomatidae	10
	Coenagriidae	6	True flies	Tipulidae	5
	Lestidae	8		Chironomidae	2
	Calopterygidae	8		Simuliidae	5
Dragonflies	Gomphidae	8			
	Cordulegasteridae	8			
	Aeshnidae	8			
	Corduliidae	8			
	Libellulidae	8			

Appendix 2 *Acid intolerant indicators: Water Chemistry Status Groups and Index of Acidity Lists*

Water Chemistry

Species	**Normal Minimum pH**
Group 1	
Gammarus pulex	$\geq$ 6.0
Glossosoma & Agapetus spp.	6.0
Ancylus fluviatilis	6.0
Lymnaea peregra	6.0
Asellus aquaticus	6.0
Group 2	
Hydropsyche	5.5 - 6.0
Baetis sp.	5.5 Occasionally 5.2
Heptageniidae	5.5 Occasionally 5.2

Index of Acidity

List A taxa (absent at pH <6.0)	**List B taxa (absent at pH <5.5)**
Gammarus pulex	*Baetis rhodani*
Lymnaea peregra	*Rhithrogena semicolorata*
Ancylus fluviatilis	*Ecdyonurus spp.*
Potamopyrgus jenkinsi	*Heptagenia lateralis*
Baetis scambus	*Perlodes microcephala*
Baetis muticus	*Chloroperla bipunctata*
Caenis rivulorum	*Hydreana gracilis*
Ephemerella ignita	*Hydropsyche pellucidula*
Perla bipunctata	
Dinocras cephalotes	
Esolus parallelipipidus	
Glossosoma spp.	
Agapetus spp.	
Hydropsyche instabilis	
Silo pallipes	
Odontocerum albicorne	
Philopotamus montanus	
Wormaldia sp.	
Sericostoma personatum	

Appendix 3 *BMWP and ASPT Scoring Taxa present in Kick Samples*

Site Code	LX1	LX2	LX3	NB1	SD1	SD2	WF1	LB1	LB2	GW1	EF1	SB1	BG1	BF1	BF2
Invertebrates															
Plecoptera															
Chloroperlidae	✓			✓	✓									✓	✓
Leuctridae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ephemeroptera															
Baetidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trichoptera															
Hydropsychidae							✓	✓		✓		✓			
Hydroptilidae		✓						✓				✓			
Limnephilidae			✓	✓							✓	✓			
Polycentropodidae		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhyacophilidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diptera															
Chironomidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Simulidae	✓	✓	✓	✓		✓	✓		✓				✓		✓
Tipuloidea		✓	✓			✓	✓	✓			✓	✓	✓	✓	✓
Coleoptera															
Hydraenidae					✓		✓					✓	✓	✓	
Scirtidae		✓					✓				✓				
Crustacea															
Gammaridae			✓	✓										✓	
Mollusca															
Lymnaeidae					✓	✓		✓	✓			✓			
Sphaeriidae				✓			✓	✓		✓				✓	
Oligochaeta	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

Appendix 3. contd. *BMWP and ASPT Scoring Taxa present in Kick Samples*

Site Code	**BQ1**	**BQ2**	**BC1**	**BC2**	**FL1**	**BK1**	**BK2**	**BP1**	**BP2**	**BW1**	**BW2**	**BB1**	**BB2**	**BB3**	**BL1**
Invertebrates															
Plecoptera															
Chloroperlidae	✓									✓	✓				✓
Leuctridae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ephemeroptera															
Baetidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Trichoptera															
Hydropsychidae		✓	✓				✓						✓	✓	
Hydroptilidae															
Limnephilidae				✓											
Polycentropodidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rhyacophilidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Diptera															
Chironomidae	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Simulidae	✓		✓	✓	✓		✓	✓			✓				✓
Tipuloidea						✓	✓	✓	✓	✓			✓	✓	
Coleoptera															
Hydraenidae							✓	✓		✓	✓				
Scirtidae							✓	✓	✓						✓
Crustacea															
Gammaridae				✓	✓										
Mollusca															
Lymnaeidae		✓				✓	✓			✓	✓		✓		
Sphaeriidae			✓							✓	✓				✓
Oligochaeta	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Appendix 4 *Water Chemistry Status: Indicator Taxa Present in Surber Samples*

Sample Code	**LX1-1**	**LX1-2**	**LX1-3**	**LX2-1**	**LX2-2**	**LX2-3**	**LX3-1**	**LX3-2**	**LX3-3**	**NB1-1**	**NB1-2**	**NB1-3**	**SD1-1**	**SD1-2**	**SD1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra															
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Hydropsyche siltalai.															

Sample Code	**SD2-1**	**SD2-2**	**SD2-3**	**WF1-1**	**WF1-2**	**WF1-3**	**LB1-1**	**LB1-2**	**LB1-3**	**LB2-1**	**LB2-2**	**LB2-3**	**GW1-1**	**GW1-2**	**GW1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra					✓	✓	✓	✓	✓	✓	✓	✓			
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai					✓	✓		✓	✓		✓		✓	✓	✓

Sample Code	**EF1-1**	**EF1-2**	**EF1-3**	**SB1-1**	**SB1-2**	**SB1-3**	**BG1-1**	**BG1-2**	**BG1-3**	**BF1-1**	**BF1-2**	**BF1-3**	**BF2-1**	**BF2-2**	**BF2-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra				✓		✓									
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai															✓

Appendix 4 *Water Chemistry Status: Indicator Taxa Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra	✓														
Group 2															
Baetis rhodani	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai							✓	✓							

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai		✓		✓	✓	✓									

Sample Code	**BW2-1**	**BW2-2**	**BW2-3**	**BB1-1**	**BB1-2**	**BB1-3**	**BB2-1**	**BB2-2**	**BB2-3**	**BB3-1**	**BB3-2**	**BB3-3**	**BL1-1**	**BL1-2**	**BL1-3**
Water Chemistry Status															
Group 1															
Lymnaea peregra		✓	✓					✓	✓						
Group 2															
Baetis rhodani	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Hydropsyche siltalai	✓							✓		✓	✓	✓	✓		

Appendix 5 *Index of Acidity: Indicator Taxa Present in Surber Samples*

Sample Code	LX1-1	LX1-2	LX1-3	LX2-1	LX2-2	LX2-3	LX3-1	LX3-2	LX3-3	NB1-1	NB1-2	NB1-3	SD1-1	SD1-2	SD1-3
Index of Acidity															
List A															
Lymnaea peregra															
Potamopyrgus jenkinsi															
Philopotamus montanus				✓											
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
Hydraena gracilis		✓													

Sample Code	SD2-1	SD2-2	SD2-3	WF1-1	WF1-2	WF1-3	LB1-1	LB1-2	LB1-3	LB2-1	LB2-2	LB2-3	GW1-1	GW1-2	GW1-3
Index of Acidity															
List A															
Lymnaea peregra					✓	✓	✓	✓	✓	✓	✓	✓			
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis	✓			✓		✓									

Sample Code	EF1-1	EF1-2	EF1-3	SB1-1	SB1-2	SB1-3	BG1-1	BG1-2	BG1-3	BF1-1	BF1-2	BF1-3	BF2-1	BF2-2	BF2-3
Index of Acidity															
List A															
Lymnaea peregra				✓		✓									
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis		✓			✓										

Appendix 5 contd. *Index of Acidity: Indicator Taxa Present in Surber Samples*

Sample Code	BQ1-1	BQ1-2	BQ1-3	BQ2-1	BQ2-2	BQ2-3	BC1-1	BC1-2	BC1-3	BC2-1	BC2-2	BC2-3	FL1-1	FL1-2	FL1-3
Index of Acidity															
List A															
Lymnaea peregra	✓														
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis								✓							

Sample Code	BK1-1	BK1-2	BK1-3	BK2-1	BK2-2	BK2-3	BP1-1	BP1-2	BP1-3	BP2-1	BP2-2	BP2-3	BW1-1	BW1-2	BW1-3
Index of Acidity															
List A															
Lymnaea peregra		✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
Potamopyrgus jenkinsi				✓	✓					✓	✓	✓			
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis				✓	✓	✓									

Sample Code	BW2-1	BW2-2	BW2-3	BB1-1	BB1-2	BB1-3	BB2-1	BB2-2	BB2-3	BB3-1	BB3-2	BB3-3	BL1-1	BL1-2	BL1-3
Index of Acidity															
List A															
Lymnaea peregra		✓	✓					✓	✓						
Potamopyrgus jenkinsi															
Philopotamus montanus															
List B															
Baetis rhodani	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Hydraena gracilis	✓	✓	✓	✓											

Appendix 6 *Invertebrate Numbers Present in Surber Samples*

Sample Code	LX1-1	LX1-2	LX1-3	LX2-1	LX2-2	LX2-3	LX3-1	LX3-2	LX3-3	NB1-1	NB1-2	NB1-3	SD1-1	SD1-2	SD1-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	1		15	4	5	1	3		1		1	4	6	19	6
Leuctridae															
Early nymphs	54	36	162	68	36	20	9			1	5	16	25	44	61
Ephemeroptera															
Baetidae															
Baetis rhodani	8	7	6	12	4	2	8			12	4	32	4	5	2
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai															
Hydroptilidae															
Oxyethira sp														1	
Limnephilidae															
Early instars										4	2	1			
Potamophylax sp										1	1				
Philopotamidae															
Philopotamus montanus				2											
Polycentropidae															
Plectronemia conspersa					1							1			
Polycentropus flavomaculatus	1	1		4	1	2				5	2	6	7	4	11
Rhyacophilidae															
Rhyacophila dorsalis	2	2		3	1	1				1		7	1		2
Diptera															
Ceratopogonidae							1					1	1		
Chironomidae	13	9	5	24	8	13	18	3	2	68	33	146	16	25	27
Empididae		1		1										1	
Limoniidae															
Dicronota sp							1								
Eloeophila sp												1			
Muscidae															
Limnophora sp				1											
Simulidae	1	1	5	2	2		2			1	2	2			
Tipulidae															
Tipula sp														1	1

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**LX1-1**	**LX1-2**	**LX1-3**	**LX2-1**	**LX2-2**	**LX2-3**	**LX3-1**	**LX3-2**	**LX3-3**	**NB1-1**	**NB1-2**	**NB1-3**	**SD1-1**	**SD1-2**	**SD1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis		1													
Scirtidae															
Elodes sp.			3	3			3								
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra															
Sphaeriidae															
Pisidium sp.										3	1	2			
Crustacea															
Gammaridae															
Gammarus zaddachi							89	32	77						
Ostracoda			1	2	1		1			55	26	76			2
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	3	1	7	2	2	1	9	1	1	1	2	3	2	4	2
Lumbricidae		2	3	3	3	3					2	2			1
Lumbriculidae	2	3	1			1					1	3	2	1	2
Naididae		2			1		1	2	10				20	6	1
Tubificidae										1			1	1	
Nematoda								1				3	2	4	
Hydracarina			2	1	1	1		1	2	8	2	3	10	6	2

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	SD2-1	SD2-2	SD2-3	WF1-1	WF1-2	WF1-3	LB1-1	LB1-2	LB1-3	LB2-1	LB2-2	LB2-3	GW1-1	GW1-2	GW1-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	19	12	2	4	2	14	1		2					3	4
Leuctridae															
Early nymphs	300	68	22	41	116	324	1	19	42	1	2	3	18	32	25
Ephemeroptera															
Baetidae															
Baetis rhodani	40	18	14	7	60	90	4	22	4	17	19	19	23	38	37
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai					2	17		4	7		5		3	3	14
Hydroptilidae															
Oxyethira sp							2		1	2	1	2			
Limnephilidae															
Early instars															1
Potamophylax sp									1			2			
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa									1						
Polycentropus flavomaculatus	3	4	2	9	20	4	4	6	2	5	5	17	4	9	4
Rhyacophilidae															
Rhyacophila dorsalis	1	1	1	2	5	1	2	6	2	1	4	2	2	5	7
Diptera															
Ceratopogonidae		1													
Chironomidae	60	14	9	162	218	70	4	6	6	35	16	50	7	10	8
Empididae	1					1					1	1			
Limoniidae															
Dicronota sp	1					3									1
Eloeophila sp															
Muscidae															
Limnophora sp										1	2				
Simulidae	3	1		2	5	20	1				10	1	1		
Tipulidae															
Tipula sp		1							1		1				

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	SD2-1	SD2-2	SD2-3	WF1-1	WF1-2	WF1-3	LB1-1	LB1-2	LB1-3	LB2-1	LB2-2	LB2-3	GW1-1	GW1-2	GW1-3
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis													1		
Illybius sp															
Dropteridae															
Dryops sp									3						
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis	1			2		2									
Scirtidae															
Elodes sp.	1			2	2	5									
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra					1	1	16	6	1	2	4	12			
Sphaeriidae															
Pisidium sp.							8	7	9		1	5	3		2
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	5	2			3		2	1	2	3	9	10	1	1	
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	1	8	2	3	5	2			7	3	3	3	1	1	1
Lumbricidae	1	2	2	9	2	14	4	14	21	2	4	3	4	4	13
Lumbriculidae		2						2	4	1		4	10	5	4
Naididae	6	1		1		8						2			
Tubificidae				1	1			3		1	1	1	8	6	1
Nematoda				1	1		1	3	1	1		1		1	
Hydracarina	1	3		18	12	9		3	2		1	11	1		

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	EF1-1	EF1-2	EF1-3	SB1-1	SB1-2	SB1-3	BG1-1	BG1-2	BG1-3	BF1-1	BF1-2	BF1-3	BF2-1	BF2-2	BF2-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium				5	2		13	17	1	1	6	1	3		4
Leuctridae															
Early nymphs	17	50	109	7	1	1	40	20	26	8	28	9	21	23	43
Ephemeroptera															
Baetidae															
Baetis rhodani	6	11	14	9	5	1	31	9	27	6	41	11	10	22	17
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai															1
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars															
Potamophylax sp	2	3	1	1								1			
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa											1	1			
Polycentropus flavomaculatus				11	5	2	3	3	4	6	16	4	3	6	1
Rhyacophilidae															
Rhyacophila dorsalis			1				2	1			2	1			
Diptera															
Ceratopogonidae	1									1					
Chironomidae	39	44	31	17	8	8	8	8	9	37	68	28	31	45	16
Empididae	3	1	2	1				2		1				1	
Limoniidae															
Dicronota sp			2		1					1	2				2
Eloeophila sp														1	
Muscidae															
Limnophora sp															
Simulidae			3				1		3						1
Tipulidae															
Tipula sp	2	1			1			1			2				

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**EF1-1**	**EF1-2**	**EF1-3**	**SB1-1**	**SB1-2**	**SB1-3**	**BG1-1**	**BG1-2**	**BG1-3**	**BF1-1**	**BF1-2**	**BF1-3**	**BF2-1**	**BF2-2**	**BF2-3**
Coleoptera															
Dytiscidae															
Agabus guttatus		1													
Agabus sp	2														
Hydroporus tristis															
Illybius sp	2		1												
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis		1			1										
Scirtidae															
Elodes sp.	2														
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra				5		2									
Sphaeriidae															
Pisidium sp.															
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda						1		1			1	2	1		1
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	18	6	7	4	2	3	8	7		7	2	12	8	3	6
Lumbricidae	1	2	3	12	11	1	3	10		1	4	6	1	3	1
Lumbriculidae	1			3	2		8	4	6	2		1		3	2
Naididae										3		1	4		1
Tubificidae	15				1			6	10					2	2
Nematoda								1			1	3	1		
Hydracarina		1					2	2	1	8	13	8	6	5	2

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	4	4													
Leuctridae															
Early nymphs	65	72	117	2	20	7	3	21	1	4	2	6	16	25	1
Ephemeroptera															
Baetidae															
Baetis rhodani	4	1	3				55	40	4	26	63	41	39	11	11
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai							2	7							
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars					2		1								
Potamophylax sp															
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa					1		11				1	1	2		
Polycentropus flavomaculatus		1				2	6	1		4			4		5
Rhyacophilidae															
Rhyacophila dorsalis		1			1			5			3	1			
Diptera															
Ceratopogonidae															
Chironomidae	30	11	11	11	16	22	29	30	1	62	24	21	6	8	13
Empididae	1		1		1					1					
Limoniidae															
Dicronota sp								1			1	1			
Eloeophila sp															
Muscidae															
Limnophora sp															
Simulidae			1				2	5	1		4	6			
Tipulidae															
Tipula sp															

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BQ1-1**	**BQ1-2**	**BQ1-3**	**BQ2-1**	**BQ2-2**	**BQ2-3**	**BC1-1**	**BC1-2**	**BC1-3**	**BC2-1**	**BC2-2**	**BC2-3**	**FL1-1**	**FL1-2**	**FL1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp															
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis								2							
Scirtidae															
Elodes sp.															
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra	2														
Sphaeriidae															
Pisidium sp.							1	2			1				
Crustacea															
Gammaridae															
Gammarus zaddachi										4	4	2	1		1
Ostracoda	4		1			2	1								
Hirudinea															
Glossiphonia complanata															
Helobdella stagnalis															
Oligochaeta															
Enchytraeidae	6	12	4		3	4				2		1	1		
Lumbricidae	7	7		2	2		1	2	1	1	1	1	6		1
Lumbriculidae	1										2	5	1	2	3
Naididae		1		1	3										
Tubificidae						2	13	12	2	2	3	7			11
Nematoda			1		1								1		
Hydracarina	10	3	4		3	1	2			3		2	1		

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	1	23	6	6	11	8	3	5		3			4	4	8
Leuctridae															
Early nymphs	2	36	3	26	22	57	25	7	16	5	24	2	120	22	17
Ephemeroptera															
Baetidae															
Baetis rhodani	4	16	5	83	60	51		1	16	14	38	39	32	13	10
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai		1		13	8	25									
Hydroptilidae															
Oxyethira sp															
Limnephilidae															
Early instars													1		
Potamophylax sp						1									
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa			1												
Polycentropus flavomaculatus	12	14	10	22	19	2	12	18	30	10	9	7	2	3	3
Rhyacophilidae															
Rhyacophila dorsalis	2	2	1	5	1	2	1	3	5	7	10	2	1	6	1
Diptera															
Ceratopogonidae	1			1	2	1							1		1
Chironomidae	88	48	53	90	46	36	67	30	182	94	85	82	77	73	69
Empididae			1	1	1		1		1	5	2		4	4	2
Limoniidae															
Dicronota sp							1	3	2	1	2		1		
Eloeophila sp						1							2		
Muscidae															
Limnophora sp															
Simulidae				1	1	2	1	4	4	2	5	5	1		1
Tipulidae															
Tipula sp							1								

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	**BK1-1**	**BK1-2**	**BK1-3**	**BK2-1**	**BK2-2**	**BK2-3**	**BP1-1**	**BP1-2**	**BP1-3**	**BP2-1**	**BP2-2**	**BP2-3**	**BW1-1**	**BW1-2**	**BW1-3**
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp														1	
Haliplidae															
Haliplus lineaticollis					1										
Hydraenidae															
Hydraena gracilis				1	1	1									
Scirtidae															
Elodes sp.				1		1		1	1				1		
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii				3	1					1	1	1			
Lymnaeidae															
Lymnaea peregra		3	4	10	3	1	3	6	2			2	1	1	2
Sphaeriidae															
Pisidium sp.									1						
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	2	16	3	4	4	3	1	1	3	10	4	2	3	6	1
Hirudinea															
Glossiphonia complanata			1									1			
Helobdella stagnalis					1										
Oligochaeta															
Enchytraeidae		1	2	1	10	3	50	5	12	3	7		3		3
Lumbricidae		25	4	23	19	19	3	10	6	10	19		2	6	4
Lumbriculidae	5	6	2	1	4	2	4	1		1		1	1		1
Naididae				25	6				1	12	3	7	11	1	3
Tubificidae	1	4		5	73	10				3	15	6	3	1	2
Nematoda	1			2		1		1	1	2	1		1		
Hydracarina		18	9	12	11	4	15	11	24	11	3	8	6	9	4

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	BW2-1	BW2-2	BW2-3	BB1-1	BB1-2	BB1-3	BB2-1	BB2-2	BB2-3	BB3-1	BB3-2	BB3-3	BL1-1	BL1-2	BL1-3
Plecoptera															
Chloroperlidae															
Chloroperla torrentium	6	6	13	11		2	5		4	18	6	12	62	17	25
Leuctridae															
Early nymphs	141	25	61	88	50	2	12	3	3	50	14	30	115	28	42
Ephemeroptera															
Baetidae															
Baetis rhodani	41	18	16	16	13			2	4	7	8	3	40	1	28
Trichoptera															
Hydropsychidae															
Hydropsyche siltalai	2							3		2	1	1	2		
Hydroptilidae															
Oxyethira sp					1				1						
Limnephilidae															
Early instars															
Potamophylax sp															
Philopotamidae															
Philopotamus montanus															
Polycentropidae															
Plectronemia conspersa				1		1						1			1
Polycentropus flavomaculatus	1	31	5	10			2	2		2	1	1	5	2	5
Rhyacophilidae															
Rhyacophila dorsalis	2		6			1	2	1	5	3	1	2	1	1	2
Diptera															
Ceratopogonidae	1		1												
Chironomidae	38	73	56	45	21	11	77	18	27	43	34	30	20	11	19
Empididae	1		1				2	2	3						
Limoniidae															
Dicronota sp										1					
Eloeophila sp															
Muscidae															
Limnophora sp															
Simulidae	1	3	2	3	8		14	1	3	1		1	4		
Tipulidae															
Tipula sp									1						

Appendix 6 contd. *Invertebrate Numbers Present in Surber Samples*

Sample Code	BW2-1	BW2-2	BW2-3	BB1-1	BB1-2	BB1-3	BB2-1	BB2-2	BB2-3	BB3-1	BB3-2	BB3-3	BL1-1	BL1-2	BL1-3
Coleoptera															
Dytiscidae															
Agabus guttatus															
Agabus sp															
Hydroporus tristis															
Illybius sp															
Dropteridae															
Dryops sp									1						
Haliplidae															
Haliplus lineaticollis															
Hydraenidae															
Hydraena gracilis	11	1	1	2											
Scirtidae															
Elodes sp.					1								3		
Mollusca															
Hydrobiidae															
Potamopyrgus jenkinsii															
Lymnaeidae															
Lymnaea peregra		1	1					1	3						
Sphaeriidae															
Pisidium sp.														1	1
Crustacea															
Gammaridae															
Gammarus zaddachi															
Ostracoda	3	11	3	1			11	9	7	3		7		3	1
Hirudinea															
Glossiphonia complanata		1	1												
Helobdella stagnalis		1													
Oligochaeta															
Enchytraeidae		3	2	5	8	1	2	3	3	3		4	5	1	7
Lumbricidae	20	2	2	1			1	1	2	3	7	5	2	1	2
Lumbriculidae						1						2		2	2
Naididae										3		1	3		
Tubificidae	20	1	107												
Nematoda							1	2	1			2			1
Hydracarina	5	21	7	5	1	2	6	2		3	2	4	3	1	7

Appendix 7 *Standard Fieldsheet*

Waterbody: **Date:** **Code:**

KICK SAMPLE

E **N:** **Altitude:**

wet width (m): **bed width (m):** **depth: ¼: ½: ¾:**

substrate

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Instream veg (%): **Clarity (cm):** **Flow**:glide/run/rifflle/ torrent
speed (m.s^{-1}): **canopy cover (%):** **Photographs:**

Other (pollution, erosion etc) **pH** **Temperature**

☐ **Stone search competed**

SURBER SAMPLES

1.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

2.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

3.

E **N:**

Mean depth: **Flow**:glide / run / riffle / torrent **Instream veg (%):**

Type	*High org.*	*silt*	*sand*	*gravel*	*pebble*	*cobble*	*boulder*	*bedrock*
%								

Notes:
Photograph

__Appendix 8__ Site Photographs

Burn of Laxobigging LX1

Burn of Laxobigging LX2

Burn of Laxobigging LX3

North Burn NB1

Burn of Skelladale SD1

Burn of Skelladale SD2

Appendix 8 contd. *Site Photographs*


Wester Filla Burn WF1


Laxo Burn LB1


Laxo Burn LB2


Burn of Gossawater GW1


Easter Filla Burn EF1


Seggie Burn SB1

Appendix 8 contd. *Site Photographs*


Burn of Grunnafirth BG1


Burn of Forse BF1


Burn of Forse BF2


Burn of Quoys BQ1


Burn of Quoys BQ2


Burn of Crookadale BC1

Appendix 8 contd. *Site Photographs*

Burn of Crookadale BC2

Burn of Flamister FL1

Burn of Kirkhouse BK1

Burn of Kirkhouse BK2

Burn of Pettawater BP1

Burn of Pettawater BP2

Appendix 8 contd. *Site Photographs*

Burn of Weisdale BW1

Burn of Weisdale BW2

Burn of Burrafirth BB1

Burn of Burrafirth BB2

Burn of Burrafirth BB3

Burn of Lunklet BL1

APPENDIX 8.9: HABITAT MANAGEMENT PLAN

The information contained within the 2016 Habitat Management Plan was seen as relevant and thus was included in the 2018 EIA.

Viking Wind Farm

Habitat Management Plan 2016

Final Version 1

03 November 2016

Project Number: SEC8088

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QUALITY MANAGEMENT

This report has been prepared within the RPS Technical and Development Quality Management System to British Standard EN ISO 9001 : 2008

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CONTENTS

EXECUTIVE SUMMARY

Scottish Ministers issued consent for the 103 turbine Viking Wind Farm, following submission of the original application in 2009 and Addendum in 2010. A condition of consent was the finalisation of the Habitat Management Plan (HMP) to mitigate the residual significant impacts identified in the 2010 Addendum.

For the purposes of this HMP and the information contained herein, the wind farm site is the subjects contained in the S36 Consent boundary extending to 7,040ha (or thereby) (referred to as the ñS36 Siteò); and the exclusive Habitat Management Areas extending to 3,384ha (referred to as the ñOff Site HMP Areasò), which combine to form ñthe Development Siteò.

The specific purpose of this HMP is to mitigate the predicted impact on blanket bog (260ha) and whimbrel. Enhancement measures to benefit red-throated diver, merlin and migratory fish will also be carried out where appropriate and where practical and cost-effective to do so. Restoring blanket bog will also contribute to wider biodiversity enhancement, benefiting a wide range of other moorland species. HMP measures designed to benefit whimbrel are also predicted to benefit other moorland birds.

This HMP document gives the management aims and actions needed to achieve this mitigation, and details the monitoring that will be carried out to assess the effectiveness of the HMP. The results of this monitoring will inform the refinement of the HMP, to ensure its aims are met.

Whilst the primary responsibility of Viking Energy Wind Farm LLP Partnership (VEWF), the implementation of the HMP will draw upon a diverse range of expertise and knowledge from both internal and external sources. VEWF will report all HMP activities on an annual basis to an independent advisory group, the Shetland Windfarm Environmental Advisory Group (SWEAG), as is required as a condition of consent.

VEWF will plan, consult on, and deliver this mitigation, with a commitment to fund the HMP for the life of the project; which currently comprises a period of 25 years, plus a further 3 years for decommissioning and restoration.

1. INTRODUCTION

1.1 Introduction

Following the submission of Viking Energy Partnership's (VEP) original (2009) Section 36 application for a 150 turbine, 540MW wind farm on central and northern Mainland Shetland, the project was subsequently revised to take account of stakeholder comments, with an Addendum submitted in 2010, including a draft Habitat Management Plan (HMP) to mitigate for the potential impacts of the development to ecological receptors. The 2010 modified scheme was for 127 turbines (457.2MW). Following on from VEP's original submission in 2009, and its subsequent Addendum submission in 2010, Scottish Ministers granted consent for 103 turbines, removing development from the Delting part of the original site.

The extent of the consented wind farm site is shown by the 'S36 Site' in Figure 1. The HMP Area itself comprises the 'Land over which HMP works may be carried out in accordance with lease terms' plus the 'Off Site HMP Area', shown in the blue outline in Figure 1.

VEP changed its name to Viking Energy Wind Farm LLP (VEWF) in 2015.

The purpose of this HMP is to deliver, in accordance with Condition 26, the mitigation required to off-set predicted impacts of the Viking Wind Farm. These impacts are identified in the Ornithology and Non-avian Ecology ES 2010 Addendum Chapters (Chapters A11 and A10 respectively), albeit that these relate to the larger 127 turbine scheme, rather than the 103 turbine scheme ultimately consented. However, instead of re-calculating the level of mitigation to match the reduced impacts that will arise from the 103 turbine development, VEWF propose to keep the level of mitigation to cover the impacts predicted in the Addendum. This ensures an additional degree of enhancement is incorporated into the HMP from the outset, whilst ensuring the HMP is proportionate and deliverable.

One further up-date that is relevant in relation to predicted impacts is that since 2010, Scottish Natural Heritage (SNH) has also accepted that the risk of red-throated divers colliding with turbines is significantly lower than previously thought. As a result, SNH has revised the avoidance rate for red-throated divers (and great skua) to 99.5%. This change reduces by fourfold the predicted collision rate from that reported in the 2010 Addendum. In tandem with the reduced number of turbines, the risk of red-throated diver collision impacts with turbines is now therefore predicted to be negligible.

The main effects to be offset by the HMP are therefore restoring 260ha of blanket bog, and collision and habitat loss effects to whimbrel.

The HMP will still encompass measures to enhance habitat for breeding red-throated divers and breeding merlin, where practical and integral with blanket bog restoration (although, as highlighted, no significant impacts were predicted on either of these species), and for migratory fish species (by removing a small number of obstacles to fish migration).

An important consideration in designing the HMP's prescriptions has been the need to integrate measures with existing agricultural practices, and this has been fully taken into account when designing mitigation works. In order to be most effective, blanket bog restoration areas need protection from grazing and physical trampling by sheep, especially over its establishment period. Where grazing control will be implemented, this has been formulated at a scale and timespan which will not prevent continuation of grazing in the long term, with no common grazing area affected by more than 10% of the total area of the grazing at any one time.

Finally, it is important to note that the HMP is not intended to specify or orchestrate measures to protect habitats or birds during construction (or decommissioning). Whilst there will certainly be integration, these measures are implemented through specific Construction Method Statements, the Site Environmental Management Plan(including an Ecological (Habitats and Species) Protection Plan), and through the deployment of an Ecological Clerk of Works (all of which are also subject to specific planning conditions).

1.2 The Nature of this Document

The HMP is a working document, and is therefore intentionally kept short. For details on wind farm layout, site characteristics, birds, habitats, protected species present, and predicted ecological and ornithological impacts, reference should be made to the relevant sections of the Environmental Statement and Addendum.

1.3 The Timeframe for the Viking Wind Farm

The development programme for the Viking Wind Farm is currently for site investigation works to begin in 2016/2017, the interconnector station to start construction in 2017, the wind farm to be constructed between 2018 and 2022 and fully operational by late 2023. (the Applicant expects final commissioning to take place during 2021). The consent for the wind farm is 25 years after the Final Commissioning of the development, i.e. from 2021 until 2046, at which point decommissioning would be anticipated, and likely to take approximately three years (2047 and 2049 inclusive).

VEWF is committed to implement and fund HMP works for the life of the project; a period of at least 25 years. This includes monitoring, which will be used to inform progress with restoration and to assess its outcomes. Once the HMP is approved, works will commence prior to commissioning of the development, and will continue until 2046, as a minimum, and likely to also extend through the decommissioning period.

1.4 The HMP in Context: Other Relevant Planning Conditions and Documents

This section explains how the HMP fits in with the other documents and Plans that are also required by conditions of consent. By taking all of these into account, the aim of ensuring these are all appropriately cross-referenced and integrated are:

- it avoids duplication and makes the inter-relationships between the various documents and Plans clearer for all involved;
- the delivery of all environmental commitments is transparent and well-orchestrated from the outset;
- the resulting clarity and integration makes it easier for consultees to review the documents and provide comprehensive comments;
- ensures that from the pre-commencement surveys onwards, lines of responsibility are clear and that there is effective teamwork by all involved in construction (specialist technical consultants, the VEWF engineering, legal, environment and community liaison teams, the Ecological Clerk of Works, and the balance of plant contractor); and
- ensures continuity between the construction team and operations team, following completion of the wind farm.

Table 1, identifies the key aspects of the planning conditions and associated Plans that will integrate at various points with the HMP[1]. The relevant planning conditions are provided in full for ease of reference in Appendix 1.

[1] The conditions are from Part 2 of the Consent Notice ‘Conditions applying to deemed planning permission’ dated 4.4.2012

TABLE 1 – KEY PLANNING CONDITIONS WHICH WILL REQUIRE INTEGRATION WITH THE HMP		
Planning Condition	**Requirements where there is potential overlap in relation to HMP, peat, habitats, or species (please refer to Appendix 1 for the full planning condition and accompanying reason)**	**Timing**
2	The required reinstatement of access tracks, borrow pits, construction compound areas and other construction areas at the end of the construction period (although primarily to protect visual amenity) provides the opportunity for peat use and habitat re-instatement that is complimentary to blanket bog restoration, taking account of ecological opportunities as well as visual impacts.	Progressively through wind farm construction until completion.
3	The use of seed mixes and re-use of turfs is to be approved in consultation with Shetland Island Council (SIC) and SNH, providing the opportunity to ensure any seeding or re-use of turfs is carefully orchestrated so that both contribute to overall coherent habitat re-instatement on site, notably blanket bog restoration.	Progressively through wind farm construction until completion.
5	The Decommissioning Method Statement is to detail aftercare following site restoration. The aim of restoration will be the recolonization of disturbed areas, as far as hydrological and environmental conditions allow, by peat-forming plant species to enable development of blanket bog over time.	At decommissioning
6	The above Statement is to be produced in consultation with SNH, to ensure satisfactory reinstatement.	At decommissioning
10	The Construction Method Statement encompasses procedures and detailed plans to ensure construction proceeds in accordance with "good practice", including best practice methods associated with developments on peatland. The Geotechnical Clerk of Works, required under this condition, to address the risk of peat slide, will also be of assistance advising on the HMP's larger scale peatland restoration works, in relation to peat stability and requirements for bunding. The condition also determines the approach to borrow pit restoration, which will also contribute to overall habitat re-instatement on site.	Progressively through wind farm construction until completion.
22	The Site Environmental Management Plan (SEMP) is an over-arching document that sets out the good practice measures to be integrated with a range of activities (incl. waste management, pollution prevention, species and habitats protection etc.) and the implementation of mitigation requirements from the ES, the ES Addendum, the planning process and/or other licensing or consenting processes. Therefore, responsibilities for minimising impacts on blanket bog and for blanket bog restoration will be included in the SEMP's Environmental Communication Plan. The Site Induction Schedule will include provision of tool box talks on protection of all priority species and habitats. The formulation of the Drainage Management Plan will integrate the protection and restoration requirements for blanket bog, so as not to contribute to the drying out of this habitat in the long-term, or compromise the effectiveness of on-site blanket bog restoration works. The Excavated Materials and Reinstatement Plan will incorporate best practice in turf and peat handling, storage and re-instatement, with detailed input from the ECoW, Geotechnical Clerk of Works, and, if necessary, additional peatland specialists. The Environmental Incident and Emergency Response Plan will include guidance in the event that an incident has the potential to affect blanket bog. Finally, the Ecological (Habitats and Species) Protection Plan will orchestrate all these inputs, plus the construction-related on-site activities listed above, to ensure on-site work to minimise impacts on blanket bog, and maximise re-instatement and restoration. The Blanket Bog section of the Ecological (Habitats and Species) Protection Plan will therefore marry-up with the HMP, with the two documents forming the combined strategy to protect, restore and enhance this priority habitat.	Progressively through wind farm construction until completion.
23	The appointment and work of the ECoW team will ensure they are able to ensure delivery of the Ecological (Habitats and Species) Protection Plan, which will include all the measures necessary to protect and restore blanket bog on site.	From SI works, and through wind farm construction until completion (including site-re-instatement).
24	This condition includes completing an assessment of artificial barriers to fish passage as identified within the ES, and providing proposals to remove or modify those structures which	The assessment is underway, as part of pre-commencement

TABLE 1 – KEY PLANNING CONDITIONS WHICH WILL REQUIRE INTEGRATION WITH THE HMP		
Planning Condition	**Requirements where there is potential overlap in relation to HMP, peat, habitats, or species (please refer to Appendix 1 for the full planning condition and accompanying reason)**	**Timing**
	result in poor ecological status as part of a HMP. This assessment, provision of such proposals and their implementation, will be delivered through the HMP.	enhancement, and the removal of impediments will be carried out over the wind farm construction period.
26	The Condition determining the scope and requirements of this HMP	The HMP period spans pre-commencement mitigation works, through the operational lifetime of the wind farm, and likely to extend to the end of decommissioning.
27	Prior to the commencement of construction, details of the constitution, terms of reference (including procedures for the review of the HMP, membership and working arrangements of the Shetland Wind Farm Environmental Advisory Group (SWEAG) shall be submitted to and approved in writing by the Planning	The fulfilment of this Condition will be in 2016. It is envisaged that SWEAG will operate from pre-commencement mitigation works through to lifetime of the wind farm, and the end of decommissioning.
29	The Bird Protection Plan (BPP) will be produced in accordance with the commitment in the ES Addendum (Section 11.4.2.b) which states óA Bird Protection Plan would be drawn up each year and executed. The BPP would provide a mechanism that allows windfarm construction and other activities to comply with wildlife legislation and ensure that disturbance to breeding Schedule 1 species is minimised. The BPP will identify the types and location of windfarm activities that are likely to disturb the nesting/chick rearing/roosting routine of Schedule 1 birds and, in consultation with SNH, identify appropriate temporary exclusion zones or other mitigation procedures to prevent such disturbanceô The BPP will be developed in consultation with SNH. In keeping with legal requirements and best practise, the BPP protocols and measures will aim to prevent or reduce disturbance of breeding birds during construction (including SI works), operation and decommissioning. The monitoring methods, analysis and reporting of the BPP will be fully integrated with the HMP. Pre-commencement breeding bird surveys will be undertaken in 2016 and 2017 to inform the identification of sensitive locations. The BPP will be subject to regular revision to take account of year-to-year changes in the distribution of breeding sites of priority species as determined through on-going survey work.	The BPP period spans the lifetime of the wind farm including SI works, and to the end of decommissioning.

1.5 Associated Planning Applications Encompassed by The HMP

Whilst part of the overall Viking Wind Farm development, there are two associated planning applications being submitted in relation to wind farm access. These are the Sandwater Road B9075 Up-grade and construction of an enhanced Kergord Access Track.

Subject to approval from SIC and consultees, it is proposed that any habitat-related consent conditions from these applications are linked in to the main Wind Farm conditions, given the sites are contiguous and effects to species and habitat overlap. This would enable the pre-commencement surveys, mitigation and restoration requirements from the up-grade of the road and construction of the enhanced access track to be integrated with the Viking Wind Farm HMP, avoiding unnecessary proliferation of documents and facilitating integration.

1.6 HMP Aim and Actions

The HMP sets out the aims and actions through which predicted habitat and ornithological impacts will be mitigated. Specifically, it:

- provides the HMP's aims and the desired outcomes;
- specifies the Management Actions that will be carried out to mitigate the Wind Farm's predicted significant impacts;
- provides the schedule for implementing these actions, and the HMP as a whole;
- outlines the monitoring necessary to determine the success or otherwise of the Management Actions; and
- specifies the HMP review process.

Whilst the main focus of the HMP is on blanket bog and whimbrel, there are also small scale localized enhancements included for breeding merlin, red-throated divers and for improvement of watercourses, by removal or modification to a small number of barriers that impede fish migration.

The Viking fish survey (see Appendix 10.6 of the ES) identified three priority species within the study area: Eurasian eel, brown/sea trout and Atlantic salmon. Brown/sea trout are present in all 11 Viking study area catchments, whereas salmon were only recorded in two catchments: Burrafirth and Laxo. The key project activities to protect these species are the extensive pollution prevention and mitigation measures incorporated into the Construction Method Statement and Site Environmental Management Plan, rather than the HMP. However, the HMP does include measures to assess, and where practically feasible, to remove/modify impediments to migration at the small number of locations identified during the ES and Addendum (see Table 1, Condition 24). The removal/modification of artificial barriers to the movement of fish within these waters is important, in relation to the migratory salmon, sea trout and eel populations (and perhaps otters). If undertaken, this will benefit brown trout as well as the juvenile sea trout and salmon that form the basis of the sport-fishing in Shetland.

A small number of rare plants species, primarily hawkweeds (in the genus Hieracium) also occur within the boundary of the Viking study area (in particular within the Burn of Lunklet SSSI). However, their location on steep slopes above watercourses means that they are not directly affected by the proposed development or proposed HMP actions. Nonetheless, through continued vigilance during ecological surveys, the ECoW's work, and through liaison with the Shetland Biological Records Centre, the occurrence of any species rarities that need to be taken account of will be kept under continuous review,

1.7 The Extent of the HMP Coverage

The candidate areas for HMP works have been determined using environmental, ecological and practical information and criteria. The main HMP activities will occur within blanket bog restoration sites, and whimbrel enhancement sites. In addition, it is proposed to carry out red-throated diver enhancement measures at up to 20 diver lochans (out of the larger number of candidate sites identified in the ES Addendum). In addition, five areas have been identified, based on historical nest locations and habitat condition, where moorland will be managed to support breeding merlin.

Two locations with existing artificial impediments to fish migration will be assessed, and these impediments will be removed, if considered ecologically beneficial, subject to landowner permission being secured.

The boundaries of the Off Site HMP Areas and the S36 Site are shown in Figure 1. The candidate sites for potential implementation of the HMP Management Actions are shown in Figures 2-4.

2. SITE DESCRIPTION

Comprehensive details of the site's physical environment, habitats and land use are given in the 2009 Environmental Statement and 2010 Addendum and its draft HMP. Additional data, for example on peat depth, will also become available through Viking Wind Farm's Site Investigation (SI) works, and the submissions for the enhanced Kergord Access Track's construction and Sandwater Road Up-grade planning applications. To avoid unnecessary repetition, the information is not repeated here, and reference is be made to the appropriate documents as required.

3. THE PRIORITY HABITATS AND SPECIES

3.1 HMP Priorities

Table 2 below, details the habitats and species of principal interest to the HMP (priority species and habitats are in bold).

TABLE 2 – PRIORITY HABITATS AND BIRDS: THEIR CONSERVATION LISTING, SIGNIFICANCE OF THEIR POPULATIONS WITHIN THE APPLICATION BOUNDARY AND HABITAT MANAGEMENT PLAN OBJECTIVES

Species	Conservation listings	Viking importance	Habitat	Habitat Management Plan objectives
Blanket bog	**Annex 1, Scottish Biodiversity List**	**National**	**N/A**	**Restore and enhance 260ha of blanket bog**
Whimbrel	**Schedule 1, Red list**	**National**	**Short sward moorland & blanket bog.**	**Enhance breeding habitat leading to improved breeding success and distribution.**
Red-throated diver	Annex 1, Schedule 1, Scottish Biodiversity List	National	Peatland lochans & lochs.	Safeguard, restore & enhance lochans by restoring surrounding blanket bog and appropriate shoreline works.
Merlin	Annex 1, Schedule 1, Red List, Scottish Biodiversity List, LBAP	Regional	Rank heather for nesting, passerine- rich moorland & croftland for hunting.	Restore tall heather at historic nesting sites.
Rivers and Streams	Scottish Biodiversity List, LBAP			
Atlantic salmon	UKBAP, Annex 2, Scottish Biodiversity List	Regional	Low altitude streams, rivers, lochs & the coast.	Remove impasses & improve riparian habitat.
Sea/brown trout	Scottish Biodiversity List	Regional	Low altitude streams, rivers, lochs & the coast.	Remove impasses & improve riparian habitat.
European eel	Scottish Biodiversity List	Regional	Low altitude streams, rivers, lochs & the coast.	Remove impasses & improve riparian habitat.

Notes:
Annex 1 indicates listing on Annex 1 of the EU Birds Directive. Annex 2 indicates listing on Annex 2 of the Habitats Directive. Schedule 1 indicates listing on Schedule 1 of the Nature Conservation (Scotland) Act. Scottish Biodiversity List = Species which are listed within the Scottish List of priority species with the UK- Post 2010 Biodiversity Framework.

In additional to those species listed within Table 2 as species of priority or principle interest to the HMP, a variety of high priority conservation bird species will similarly benefit from the Management Actions completed in fulfilling the requirements of the HMP. These include but are not limited to dunlin, golden plover, artic skua and curlew.

4. IMPLEMENTATION BACKGROUND TO HMP

4.1 Introduction

Section 4 explains how the HMP ties in with the pre-commencement surveys, along with the HMP's aims and actions with regards to each receptor.

4.2 Pre-commencement Surveys

As a condition of consent, pre-commencement surveys will be carried out for target bird species (Condition 29), otters (under Condition 22 – the Ecological (Habitats and Species) Protection Plan of the SEMP), fish and macroinvertebrates (under Condition 24). These are separate from the HMP (as detailed in Table 1), but the results will nonetheless provide up-dated baseline data against which the success of the actions of the HMP can be gauged.

The pre-commencement bird surveys (to be completed over 2016 and 2017) will also provide the opportunity to up-date the original baseline surveys undertaken between 2003 and 2009 (and supplement the additional interim surveys undertaken between 2010 to 2015 at selected breeding sites within the HMP Area). The resulting 2003 to 2017 data set will provide a comprehensive baseline again which the effects of the HMP on target bird species can be determined.

It is not intended to carry out additional pre-commencement site-wide baseline habitat surveys because habitat types are unlikely to have significantly altered since the original ES surveys were completed (Phase 1 in 2005 and 2008, National Vegetation Classification in 2008). High resolution colour digital aerial photography has, however, been obtained for the whole site since the ES, along with LIDAR data which can be used to provide detailed digital terrain and elevation models (DTMs and DEMs). These will be integrated using GIS with Phase 1 and NVC habitat distribution maps and other targeted survey data to provide additional context and insights into the extent of blanket bog and peatland erosion. This combined information, together with site visits, will be used to prioritise and plan the blanket bog restoration work.

4.3 HMP Deliverables

4.3.1 <u>Blanket Bog</u>

The work on blanket bog will comprise two integrated work streams to maximise improvements from the HMP and also to minimise impacts from wind farm construction. To achieve this integration, detailed consideration has been given to both planning the blanket bog restoration and to the management of peat during construction (reflected in Table 1). This has brought together VEWF's ecology staff, its ecological and ornithological consultants, VEWF's internal environmental management staff and the engineers responsible for constructing the development.

The information below therefore summarises the resulting approach to blanket bog restoration and mitigation.

The Peatland Restoration Work Streams

As highlighted, the HMP's blanket bog restoration will be divided into two work streams. The first comprises the restoration work independent of construction i.e. outside the wind farm footprint but within the S36 Site planning boundary and without receiving peat or blanket bog turf generated by construction. It will deliver the 260ha of the blanket bog mitigation, with the aim of delivering the majority of the mitigation within five years of the commissioning of the development. Early implementation of blanket bog restoration activities in the lifespan of the development and the HMP will allow the greatest timeframe in which restoration actions can be monitored and necessary management activities implemented.

The second peatland restoration work stream will operate as part of the construction process, and although not directly part of the HMP, it will be integrated to ensure all peatland related obligations are met. At this stage it is proposed that the works will be implemented under the project's Ecological (Habitats and Species) Protection Plan, and aim to minimise the excavation, movement and storage of peat. Construction will nonetheless generate blanket bog turfs and volumes of peat, a significant proportion of which have the potential to be used for additional peatland restoration at locations in proximity to wind farm and access track construction. This work stream will therefore contribute to the HMP's blanket bog objectives. The progression of this restoration work will be complex and will require significant forward planning to ensure the Ecological (Habitats and Species) Protection Plan's objectives are met, and that where relevant, peat management during construction also maximizes its contribution to the delivery of the wider blanket bog restoration. It is also important that information on peat volumes, peat storage and peat slide risk are also shared across the construction and restoration teams so that overall peat protection, blanket bog restoration, pollution prevention and health and safety requirements are met. To this end therefore, the wider environment team (ECoW and Geotechnical Clerk of Works in particular) will be aware of the HMP and its activities and objectives, so that 'on site' handling of blanket bog vegetation and peat during construction and reinstatement can be orchestrated to best overall use.

Having set out this implementation structure, the information below explains the variety of restoration approaches that will be drawn on to implement the blanket bog restoration, drawn on by both work streams.

Management Actions for Blanket Bog Restoration: Grazing Control

The grazing of blanket bog habitat by livestock and wild mammals (in Shetland, principally sheep, mountain hare and greylag geese respectively) at low to moderate levels (the precise rates are location-specific) can be beneficial and help maintain and enhance vegetation diversity and productivity across a number of habitat types. However, even moderate levels of grazing intensity can be damaging to blanket bog habitats, with grazing having led to severe vegetation degradation and extensive peat erosion in a number of areas of Shetland (SNH 2002). Consequently, managing appropriate grazing levels is a crucial element to achieving many blanket bog biodiversity goals. Due to the natural variability in the productivity and condition of the common grazings it is not possible to define a generic sustainable stocking density figure for all areas, as the figure needs to reflect the local condition of the vegetation and substrate. Given the potential negative impact sheep can have on vegetation recovery,gated fencing will be used to prevent trampling or grazing of newly restored blanket bog areas (and in tandem, other forms of stock control, such as electric fencing, if practical). No more that 10% of any common grazing will be under restoration at any one time, and if some form of stock exclusion is required, such as fencing, it would only encompass a small proportion of the common grazing during restoration works. Given that areas targeted for restoration will generally be degraded blanket bog that provides poor quality grazing for livestock, grazing control, if required, is expected to have a minimal effect on the quantity of land available for grazing, and if there were any potential effects, a mechanism for compensation payments is in place.

Management Actions for Blanket Bog Restoration: Damming Small Drainage Channels

Man-made drains installed to facilitate the flow of water from areas of bog are relatively uncommon in the vicinity of the Viking Wind Farm. They generally serve to drain an area of bog for the purpose of improving pasture and they tend to be small (typically less than 0.5m x 0.5m in cross-section) and simple in structure (typically forming a single, linear feature or a localised ‘herringbone’ pattern, rather than an extensive network). Much more frequent are small (<1m in width) erosion gullies, the treatment of which will aim to prevent erosion into a larger and more complex gully system that would prove more difficult and expensive to repair.

A range of established techniques[2] will be used to reduce and reverse the impacts of ditches and small erosion gullies. Where these involve installing a series of dams to retard flow and hold shallow water within the channel, the intention is to promote the development of pool vegetation in the open water areas between the dams which, over time, will accrue peat that itself reduces the flow of water and reverses the impact of the drainage channel in the medium to long term.

The placement of the dams will be determined by examination of various factors and data, including slope, surface hydrology, vegetation cover, erosion extent and peat slide risk, examined for example, from high resolution aerial photography, LIDAR and other topographic data, along with sites visits. This is in line with the process used by Shetland Amenity Trust in the planning and implementation of the SNH funded peatland restoration projects on the Shetland Mainland.

The aim of this small drainage channel and erosion gully blocking is to ensure that the water table is restored to as close to the vegetation surface as possible and that water flow is effectively reduced to prevent further erosion, and to promote the colonisation of plants that contribute to blanket bog restoration.

The dams will be constructed from a variety of materials depending upon the size of the drain, access, labour and availability. These materials will be discussed in turn below and they include:

- peat;
- composite dams of peat combined with other impervious materials such as plastic sheeting;
- plywood and plastic sheeting; and
- plastic piling.

Peat is the most widely available material in the vicinity of the drains and it is suitable for use on its own only over low gradients because of its propensity to erode when subjected to water flows and its inability to provide a reliable spillway. It is also suitable only where permanent waterlogging is expected because peat dams are not completely impervious to water (unless used in association with a membrane) and they disintegrate if they dry out.

The best result is obtained by completely filling relatively level ditches with re-located peat and surface turfs so that the original arrangement of peat and vegetation layers in the surroundings is reinstated. However, it will be necessary to strike a balance between potential benefit from using this technique and the disturbance that will be caused by transporting large quantities of material across the site to locations that are remote from construction areas.

Where less peat is available, dams will be built from well-humified cohesive peat (classified as H6–H8 on the von Post humification scale) as this is relatively impervious to water flow. This peat will be removed in large blocks and handled as little as possible in order to maintain its cohesiveness. At the site of the proposed dam, the sides of the drainage channel will be cut back into the peat body to ‘key in’ dams and to leave a clean face that will form a good seal with the peat blocks. Vegetated turfs will be placed on the top of the dam in order to protect it from erosion. Drains larger than ca. 1m x 1m will require the peat to be cut by machine and potentially, the use of additional strengthening

[2] For example, see http://www.snh.gov.uk/climate-change/taking-action/carbon-management/peatland-action/peatland-action-videos/

materials (as specified below) to form a composite dam. The completed peat dams will stand proud of the adjacent surface (by around 30cm) in order to compensate for slumping and shrinkage.

Where suitably cohesive peat is not available, erosion-resistant dams will be constructed from stacks of sand bags or long sausage shaped hessian bags filled with the non-cohesive peat available at the site. Where suitable access is possible, this method could also make modest use of some of the peat excavated during the construction of the wind farm, thereby reducing the need to locally remove intact peat. If large quantities of ópeatbagsô can be produced and transported, they may also be used, topped with turves, to completely fill ditches and/or the spaces between other types of dams.

Plywood and Plastic Sheeting

Sheeting made of suitable plastic or plywood (usually marine ply) can be used as a means of damming the smaller drains and gullies. Panels of these materials will block the width of the drainage channel allowing for additional width to anchor them into the adjacent peat at the sides and bottom of the drainage channel (ca. 20ï 50% of the channelõs width or depth). Sheets of the appropriate dimensions will be hammered into vertical slits cut into the base and the sides of the drainage channel until they are just proud (2ï 3cm) of the adjacent vegetation surface. A shallow spillway will be cut into the mid-point of the dam face with the lowest point just below the level of the vegetation surface. Some form of strengthening (horizontal struts or supporting wall of turfs) may be required if upstream water pressure causes sheets to bow.

Plastic Piling

Plastic piling is very strong, lightweight and long-lasting (up to 150 years). The piles are normally 30cm wide, come in lengths of up to 8m, and they join together using integral interlocking edges that are designed to be water-tight. Their installation will be undertaken in a manner similar to that described above for the sheeting dams but each pile is installed separately, from the centre of the gully, towards the edges. Plastic piling should not be strengthened by rigid cross braces as it must bend in order to maintain its strength and water-tightness.

For all dams, whether using peat or artificial materials, these should extend well into the edges of the ditches to further reduce the likelihood of dam failure. The required extent that dams will be keyed into the edges will be assess on a location by location basis, and will be dependent on depth, width and topography of the channel.

Management Actions for Blanket Bog Restoration: Large Erosion Gullies

In comparison to the approaches described above, which completely block the cross-section of the drainage channel, the methods adopted for the larger and/or unstable erosion gullies will predominately focus on slowing the rate of water flow within the gully, enabling deposition of sediment at a number of locations to encourage the recolonisation of vegetation. As revegetation and peat accumulation continue over the lifespan of the HMP (and the original dams gradually become buried) additional small dams would be added to facilitate further infilling and recolonisation.

Materials that have been used successfully to impede water flows and encourage the capture of sediment in large erosion gullies are given below. These have been used in a number of Peatland Action Fund[3] and Moors for the Future Partnership projects:

- stones;
- sand bags filled with peat;

[3] See http://www.snh.gov.uk/climate-change/taking-action/carbon-management/peatland-action/ for further details.

- ‘sausages’ of rolled coir matting or hessian tubing filled with peat sods, anchored with metal pins;
- netting;
- ‘hay bales’ that may be formed from rushes; and
- corrugated plastic piling.

The potential also exists to use other materials naturally present on the site or generated by the construction of the wind farm. These include:

- vegetated turfs; and
- locally excavated peat where its retention at the point of restoration can be assured.

Where appropriate, the creation of the dams with the aim of retarding and storing water within the confines of the gully will be considered. Such activities will help support and stabilise the associated water table in the adjacent remaining peat body. The height and extent to which water may be trapped is dependent upon a number of factors including:

- gradient of the gully / drainage channel;
- complexity of the surrounding topography;
- nature of the upslope catchment;
- hydrological interconnections;
- relative widths of gullies and peat body adjacent to these; and
- structure and complexity of the connecting gullies’, their topography and extent of the surrounding drainage network.

The desired height, location and number of dams will be determined by detailed on site investigations as work progresses. In the case of gently sloping gullies, the use of natural, readily accessible materials (such as peat, stones or dislodged turfs) to form low dams may be appropriate. Whereas, in the case of steeper gullies where potential forces are greater, it may be necessary to use stronger, erosion resistant structures such as the sheeting and plastic piling as described above. In many instances, fully restoring the water table in the larger gullies to the level of the surrounding vegetation surface may not be feasible or advisable, especially where this will involve impounding substantial depths of water between banks of degraded peat on sloping ground. In such cases, as detailed above, the intention will be to promote the natural recovery process, in which peat sediment is captured, retained and re-vegetated in the gullies so that their floors gradually rise towards the level of the surrounding peatland surface.

In all cases, capture of the water and sediment flow behind the dams and structures placed within gullies will create small pockets of stabilised peat which will act as nuclei for the gradual re-establishment of plants. Initial colonisers such as common cotton grass will spread and consolidate the deposited peat with their rhizomes and roots, stabilising the strata enabling other grasses to gain a foothold. This process will be facilitated by introducing individual plants or turfs of these species that have:

- become detached from the bank of the gully;
- been cut selectively from small, discontinuous areas of the neighbouring, undisturbed vegetation; or
- been specifically grown for the purpose within a nursery.

It is also possible to introduce suitable native species to bind the peat such as wavy hair-grass and bents. These grasses are introduced to the bare peat as turf or as seed and they rapidly grow to form a sward that helps resists erosion. Seed collection of the native grasses that are likely to persist can be undertaken locally and this will require the purchase and hire of machinery and the training and seasonal employment of suitable locally based staff.

Given the especially nutritious nature of these grasses, the success of this approach is significantly increased by the exclusion or reduction of grazing in the area. This is because sheep will concentrate their grazing on the consumption of these ógrasslandsô that are more palatable than the surrounding blanket bog vegetation. The potential effects of grazing by lagomorphs will also be considered on a site by site basis. Furthermore, consideration will be given to the required timescale of exclusion of livestock and lagomorphs from sown areas of restoration. This will ensure these areas do not become preferential grazing sites with restoration progress retarded in the medium to long term.

Where it is necessary to stabilise peat as rapidly as possible, biodegradable erosion and sediment control textiles (e.g. coir mesh) will be used to assist the process of revegetation. These will be rolled out over areas subject to erosion (i.e. where the dominant process is sediment removal rather than re-deposition), e.g. on level plateau areas and at the tops of eroding gully sections, and may be seeded or planted with appropriate species to help assist and speed up natural colonisation.

Management Actions for Blanket Bog Restoration: Large Expanses of Sheet Erosion

In areas of extreme erosion at hill top locations, large expanses of ground are devoid of blanket peat or the associated vegetation. These often include areas of bare rock and quartzite gravels that tend to be well draining, and that are initially recolonised by heath rush prior to grasses such as bents and hair-grasses taking hold. Scattered plinths of stand-alone peat whose banks are being undermined by livestock and wind erosion are generally the only remaining fragments of the blanket of peat which once covered these areas. The óunder-miningô of these plinths causes further collapse of the remnant peat which is subsequently washed from the area during heavy rainfall.

Whilst these areas are the most highly degraded in the wind farm area, work completed in the East Kames area of Central Mainland Shetland by Shetland Amenity Trustõs SNH funded peatland restoration programme, has shown that initial recolonisation of these areas can be achieved, holding water in the area and slowing the rate of release from these hill top locations. This in turn decreases the rate of erosion in gullies draining the hill top, and therefore aiding in the restoration of the wider area.

Methods successfully trialled to date for restoration of such expanses of sheet erosion include:

- reprofiling the faces of the remain plinths (peat hags) within the area to a shallow gradient and placing turves across these reprofiled faces to decrease erosion;
- the use of netting on reprofiled plinths where vegetation is unavailable to stabilise the bare peat and provide a substrate to plant locally harvested plugs of suitable vegetation;
- creation of small bunded pools across wider flat area using locally source peat and an excavator. The pools subsequently can be sown with fragments of sphagna to aid in the recolonisation process; and
- the use of long hessian ñsausagesò filled with peat across the area to slow water release and capture sediment, in turn providing a more suitable substrate for recolonisation.

The above techniques have all been proven to be successful across blanket bog restoration projects within the UK. A number of Shetland specific techniques have also been trialled during Shetland Amenity Trustô SNH funded peatland restoration works at Cunningsburgh and East Kames. These include the use of waste materials from the islandõs fisheries industry, recycling materials such as netting and plastic tubing which would otherwise be destined for landfill. These have proved to be cost effective as well as environmentally sound practices, and the lessons learnt from these peatland restoration works will be built upon through the lifespan of this HMP and the associated blanket bog restoration works.

It should be noted, that at all points during blanket bog restoration activities consideration will be given to weather conditions including rainfall and wind speed. Peat movement and handling for the purposes of restoration will be stopped in periods of wet weather when watertables are high. This will reduce the risk of pollution related incidents and maintain the condition of the peat used for restoration activities. At all times during restoration activities, consideration will also be given to the risk of peat slide at restoration locations, with suitable techniques selected to ensure that any risk is managed appropriately. Where the risk is unable to be minimised, alternative restoration areas will be selected.

4.3.2 Whimbrel

Shetland is the most important area in the UK for breeding whimbrel holding at least 95% of the UK population (Richardson 1990, Dore *et al*. 1996, Jackson 2009). The UK whimbrel population is believed to have declined by approximately 50% since the 1990s, and currently numbers around 300 pairs (Jackson 2009). The causes of the decline are unknown, but several possible causes have been speculated, including predation of adults and chicks by the expanding great skua population and changes in habitat suitability linked to land management. The Shetland-wide 2008-09 whimbrel survey conducted by NRP and RSPB (Jackson 2009), combined with data collected between 2003 and 2008 to inform the Viking Wind Farm ES studies and subsequent work since 2010 in Central and West Mainland to inform the HMP, provide high quality and up to date information on whimbrel numbers, distribution, breeding biology and habitat requirements. These data are particularly relevant for Central and West Mainland Shetland where HMP measures are planned.

Potential for impacts on whimbrel from the Viking Wind Farm were greatly reduced at the wind farm design stage through adopting design criteria that, as far as practically possibly, kept the proposed wind farm infrastructure away from areas regularly used by whimbrel. Despite this, using precautious assumptions with regard to the species vulnerability to collision and displacement, the ES Addendum concluded that without mitigation there was potential for small scale impacts on this species from the 127 turbine layout. The reduction to a 103 turbine layout reduces the potential impacts to whimbrel by approximately a quarter. The ES Addendum also concluded that the magnitude of residual effects was negligible and not significant after mitigation, under the terms of the EIA Regulations (ES Addendum para. A11.17.10). Furthermore, the desired outcome was that the HMP measures would result in a benefit to the whimbrel population on Mainland Shetland (para. A11.17.10).

In order to deliver this outcome, areas containing approximately 70 pairs of whimbrel (approx. one third of the population on Mainland Shetland) were identified for HMP management activity. Whimbrel HMP measures will focus on enhancing habitat condition and breeding success within these areas, and aim to generate sufficient additional young birds and accommodate additional breeding pairs to mitigate the wind farm's predicted impacts, and deliver this overall population benefit for Central and Western Mainland.

Following the studies undertaken to inform the HMP (Massey *et al*. 2016) the habitat requirements of whimbrel on Mainland Shetland are relatively well understood. Studies of whimbrel habitat use on the island of Unst in Shetland in the mid 1980s (Grant 1991; 1992; Grant *et al*. 1992a and b), and more recently on Central Mainland (Massey *et al*. 2016) provide a broad understanding of which habitat characteristics are negatively and which are positively correlated with breeding whimbrel presence. This information, together with ongoing studies on whimbrel ecology will inform the objectives and methods used for whimbrel management in the HMP.

Habitat Preferences for Whimbrel

- Whimbrel are widely distributed in Shetland and use a variety of moorland types. Nevertheless the best sites appear to share a number of common features and it is likely that providing these will be the key to successful habitat management.
- Extensive areas of relatively short and dry moorland vegetation but ideally interspersed with some with some wet areas (pools and wet hollows). ‘Good’ whimbrel habitat typically has a closed short sward (i.e. limited bare ground) comprising a mixture of sparse heather, cotton grass and deer grass, together with woolly hair moss and reindeer moss lichen and, in blanket bog situations, *Sphagnum* mosses also. Such communities can develop in a range of situations including, intact deep peat blanket bog, maritime heath (highly exposed to sea gales) and on free draining base-rich serpentine soils (as found on parts of Unst). The very extensive areas of medium-sward-length blanket bog moorland are not generally selected, The vegetation of such areas generally consists of the same species but heather or cotton grass typically dominate (or co-dominate) and woolly hair moss and reindeer moss lichen are uncommon. On the ground there exists a continuum from short to medium height sward moorland vegetation (and longer) and at any one location there is usually a degree of heterogeneity of sward lengths.
- Flat or gently sloping gradients particularly in the concave parts of the landscape, but not exclusively so. Relatively low altitudes appear to be preferred, especially areas below 100m.
- Whimbrel often breed in association with Arctic skua, black-headed gull and common gull probably because the mobbing behaviour of these species affords them some protection from aerial predators such as crows and large gull species.
- Whimbrel select nest sites on hummocks (80% of nests) and/or heather (75% of nests).
- Grazing by livestock can help create a low sward height (which whimbrel prefer), although if grazing is too intensive it can initiate or exacerbate existing peat erosion, particularly at higher elevations.
- Steep ground (more than ca. 5 degree gradient), deep rank vegetation, extensive peat erosion and the presence of nesting great skuas all appear to be features negatively associated with breeding whimbrel. Adult whimbrel appear to make little use of marine or freshwater littoral habitats on the breeding grounds.
- ‘Improved’ and ‘semi-improved’ pasture close to moorland is sometimes used by adults for feeding, especially in the early part of the breeding season.
- Breeding whimbrels require relatively large areas of suitable habitat; typical densities in areas of ‘good’ habitat on Mainland range from approximately 1 to 3 pairs per square kilometre. Colour-ringed chicks monitored on Unst (where high densities of birds may have restricted movements) remained within 1km of nest sites until fledging (most within 400m).

4.3.3 Red-throated Diver

The 2010 ES Addendum predicts that following mitigation delivered through the HMP and breeding bird protection measures the wind farm will likely have long-term adverse residual effects of negligible magnitude on red-throated diver, concluding that these effects would be not significant under the terms of the EIA Regulations. The level of predicted impact has reduced further since the 2010 ES Addendum because the windfarm has been reduced in size and extent, to 103 turbines. Furthermore, SNH has revised its recommended behavioural avoidance rate for assessing collision risk to this species from 98% to 99.5%, which has the effect of reducing the predicted collision rate by 75%. As a consequence, the number of red-throated diver collision deaths is now predicted to average less than one per year. A range of measures to benefit red-throated diver were proposed in the 2010 ES Addendum and these are nonetheless being carried forward in the HMP where practical, aiming to have a positive outcome for the species on Central Mainland.

Management Actions for Lochan Restoration

Through the ES studies carried out on this species to inform the assessment of ornithological effects of the original Viking Wind Farm, it became evident that peatland erosion had damaged, or threatened to damage, many of the lochans where these birds breed. As a result, a number of candidate lochans have been identified where restoration and/or stabilisation of surrounding blanket bog would counter this threat to these birdsô nesting habitat (shown in Figure A10.9.1 of the ES Addendum). A range of techniques will be targeted on selected sites that are (i) accessible, and (ii) at suitable locations away from turbine arrays, to safeguard breeding lochans from progressive erosion, or where they have already been damaged, to restore them (Figure 2a).

The probability of achieving long-term success with these interventions will depend on the hydrology of the surrounding peatland. A lochan that has developed in a summit position, and so has no upslope catchment, retains water because the surrounding blanket peat slows the rate at which water is lost by seepage to below the rate at which new water arrives as rain (minus evaporation and overflow). Lochans of this type on the Viking site are vulnerable to erosion in two ways. Firstly, when erosion gullies develop on the surrounding slopes, they begin to drain the peat layer around the lochan. The result on some summits is that the peat has disappeared (through a combination of shrinkage, vegetation loss, drying-out, decomposition and wind erosion) from around the shoulder of the hill, leaving the lochan in a separate, hydrologically unstable óupstandingô block of peat that continues to erode at its outer edges. Secondly, once formed on the slopes, gullies can cut back through the peat blanket, gradually deepening and extending up towards the summit, and eventually may breach the bank of the lochan itself. The lochan can then drain into the gully system. The water level in the lochan may only be lowered initially but once a gully has connected with it, there is a tendency for the connection to grow in width and depth through continued erosion until the lochan basin is empty. Once such a process has begun, observations indicate that there does not appear to be any natural mechanism to arrest it.

Accordingly, appropriate measures to safeguard a summit lochan or to reinstate a drained one will include techniques to reinforce weakened banks, and block-up bank breaches and nearby erosion gullies. However, the approach of a gully close to a lochan is a sign that the ability of the peat blanket to sustain the hydrological equilibrium of the lochan is becoming marginal, so that artificially restoring the water level may actually destabilise the system further. Therefore, simultaneous action will be taken to stabilise erosion, and re-establish peat-forming vegetation on the surrounding areas up to at least 25m from the banks (it is anticipate the total area of restoration would not exceed 1ha per lochan).This would involve working outwards from the lochan, applying appropriate measures to stabilise and re-vegetate with appropriate plant species any bare peat, mineral ground and/or gullies. Ideally, the area treated should extend to the next stream, reversal of slope or other line of hydrological discontinuity in the landscape. In some cases, however, the distance may be so large or the boundary so indistinct that a closer range for intensive remedial work might be set following a detailed assessment of the individual situation.

Lochans and lochs in valley locations receive water from upslope and discharge it via a distinct outlet. Here, the principal adverse effect of erosion is the delivery of peat sediment which in time can fill the basin.

Lochan Stabilisation and Repair Techniques

The measures described below are concerned with restoring, stabilising and safeguarding lochan banks; measures to treat peatland erosion in the wider surrounding area will be same as the measures described earlier for treating blanket bog erosion in general. The aim of the bank specific measures is to arrest the advance of erosion gullies towards vulnerable lochans and to rebuild and strengthen banks where gullies have already been penetrated; in both cases promoting the development of peat forming vegetation around the lochan where this has been lost. Depending upon the circumstances at a particular lochan, measures could range from large scale blocking up of gullies (which can be up to 2m deep and several metres wide) with a mix of hard (rock, timber, interlocking plastic piling) and soft defences (compacted peat) to small scale surface measures aimed at raising the water table and promoting colonisation by *Sphagnum* moss, e.g. infilling or damming small gullies. The depth of water to be retained is typically 0.5 to 1m so the potential pressure on the banks is not especially high. However it is essential that the repairs do not leak significantly more than the remainder of the bank, which is likely to consist of fairly well humified (i.e. low permeability) peat. Whereas the use of membrane liners (e.g. óbutileôrubber) would undoubtedly produce a watertight basin, their use is probably not necessary and would in any case be very expensive. Nevertheless, there may be merit in incorporating some form of membrane patch across severe bank breaches to simulate the function of the impervious, well-humified peat that forms the remainder of the bank, since peat that is formed from recently established vegetation will probably take a very long time to reach the same degree of humification. The upper edge of the patch should, however, be level with the base of any vegetation layer on the bank and new vegetation should be re-established above to complete the surrounding, more-permeable living surface layer that is important in regulating the water level of the lochan.

Where the restoration of former water levels is an objective, the works may need to be phased over several years so that vegetation can recolonise and reinforce banks as they are gradually built up and strengthened. Restoring óemptyô lochans that retain most of their original shorelines is an attractive option for creating new water bodies because there is a ready-made basin and so relatively little if any excavation is required. However, it remains to be seen if large sections of destroyed bank can be economically repaired to successfully impound water. These measures would also require complementary work to tackle erosion of the surrounding peatland, which is often particularly severe around empty lochans.

Other Red-Throated Diver Lochan Enhancement Measures

Through the detailed investigations of the lochan characteristics which make waterbodies suitable for breeding divers, and which contribute to breeding success, candidate lochans have also been identified where minor modifications could help increase the likelihood of successful occupation by this species. The nature of these modifications is (i) small extensions to lochan length (in the region of a few metres), to enable landing and/or take off (in still conditions a red-throated divers typically requires a run-way of around 20m to get airborne), (ii) creation of small islands for nesting and (iii) increasing lochan depth to at least 0.5m (particularly applicable to existing pools on recovering summits which have lost their deep peat). Such interventions will be considered, where practical and beneficial to do so, as they can potentially prove more cost-effective than the erosion prevention highlighted above.

The provision of small artificial (approximately 2m x 2m) islands (commonly known as diver rafts) for divers to nest on is also likely to be an effective way to increase occupancy and breeding success at some of the lochs in Central Mainland, e.g. the relatively large rock-basin water bodies in valleys. Diver rafts have been a very successful conservation tool on mainland Scotland, and reduce the risk of nest loss caused by disturbance, predation and water level fluctuation.

Fences that are very close (<20m) to breeding lochans also pose a collision risk to flying divers as they take off; a time when, because of their poor ability to gain height, they can be flying very close to ground level. In Central Mainland four breeding lochans are known where livestock fences intersect the shores and there are several others with fences passing less than 20m away. The risks posed by these sections of fences were proven to be real during baseline survey fieldwork in 2006 when an adult diver was found recently dead by a fence that passed along the shores of a breeding loch. The scope and practicality of removal or re-orientation of these fences will be investigated as part of the HMP, in liaison with land owners and managers, to determine whether any such modifications can be accommodated.

Therefore, should it prove feasible, practical and cost-effective, and where land owners and managers are supportive, there is further scope to increase the enhancement afforded to this species, by adoptions of these three measures as part of the HMP.

In addition to the above measures, during construction screening of sections of infrastructure which are in close proximity to breeding diver lochans, and as such have the potential to cause disturbance to breeding divers, will be completed using appropriately sized earth banks.

The final need for and design of any screening measures will be decided in consultation with SNH, taking account of the micro-siting of tracks and turbines to minimise their visibility from diver breeding lochs. Before decisions are taken site visits will be made to refine what is actually most sensible. The screening will take the form of a raised bank of earth close to the relevant length of track or turbine base. The use of earth-bank screening to hide human activity from breeding divers has been successfully used by RSPB at Burgar Hill, where an embankment of approximately 50m length and 2m height screens the approach of visitors to a diver observation hide. All screening banks will be profiled to blend in with the natural topography and designed with due sensitivity to the local hydrology and ecology. The banks will be vegetated with living turfs of moorland vegetation retained from track cutting.

Three lochans where screening is recommended are identified in the Confidential Birds Appendix of the ES Addendum.

4.3.4 Merlin

The 2010 ES Addendum predicts that following the mitigation delivered through the HMP and breeding bird protection measures the wind farm will likely have long-term adverse residual effects of negligible magnitude on merlin and it concludes that these effects would not be significant under the terms of the EIA Regulations.

Since 1987, the number of merlin pairs has apparently declined in Shetland and the breeding population is now considered to be 15-20 pairs (Etheridge et al, 2008). The loss of breeding merlin from several historical sites in Shetland has coincided with significant habitat degradation. Notably patches of deep heather required for nesting have been lost through reseeding for agricultural purposes, over-grazing by sheep and defoliation by insect larvae (Pennington et al 2004). Merlin typically nest on the ground in heather moorland, often in deep heather on a slope of a hill or on the side of a valley. Importantly, merlins show high site fidelity returning in successive years to nest in the same suitable area.

Following detailed consideration, five candidate areas have been selected for works to benefit this species, based on historical nesting distribution data and temporary habitat condition. The location of these candidate areas are shown in Figure 2b.

4.3.5 Rivers and Streams

A wide range of design and pollution prevention measures have been identified to ensure the Viking Wind Farm poses no significant threat to fish populations. As a result, no mitigation is required within the HMP. The ES Addendum and 2010 HMP did however highlight scope for local habitat enhancement for migratory fish. These were locations where potential modification or removal of artificial barriers would benefit passage up watercourses (Figure 2c). Two of these locations are relatively close to the Viking Wind Farm area:

- Burn of Weisdale HU 39578 53100;
- Stromfirth Burn (Burn of Sandwater) HU 40787 51046.

As part of the development of this current HMP, further preliminary investigations were carried out at these two locations, confirming the likelihood that some modification could be of benefit to salmon and brown/sea trout (albeit subject to additional technical appraisals of flood risk, geomorphological and stakeholder implications).

The HMP will therefore undertake further feasibility investigations and if found to deliver sufficient benefits for migratory fish and acceptable in all other aspects, removal or modification would be carried out under the HMP.

5. IDENTIFICATION OF HABITAT MANAGEMENT AREAS

5.1 Selection Criteria for Blanket Bog Management Areas

Blanket bog is widespread across the Viking Wind Farm, and much of it is degraded to varying degrees. The extent of potentially restorable habitat therefore greatly exceeds the area required to mitigate the predicted impacts on this habitat. To make best use of the resources available, it is therefore sensible to prioritise candidate areas for blanket bog restoration work. To guide this process, over-arching principles have been used, together with a more detailed mapping and evaluation process.

Overall, the recovery of large areas is the most biologically robust way forward in terms of enhancing Favourable Conservation Status (as per SNH 2006 guidance). In addition, during consultation the RSPB highlighted that larger, rounder areas (with less edge) are better habitats biologically.

The more specific considerations relevant to determining priorities and practicalities are consideration of whether areas are:

- able to support a self-sustaining section of blanket peatland;
- can benefit from any functional connections to adjacent sections;
- actively eroding (e.g. have extensive areas of bare peat and mineral ground and/or actively eroding gully systems), in which case they should be given priority over those sites which have begun to re-vegetate, and thus apparently to recover without intervention;
- subject to direct human disturbance such as ditches, grazing lines, ploughing, tracks etc., especially where impacts could be reversed by active intervention;
- support additional important peatland habitats and species;
- coincident with opportunities to enhance specific habitat features (e.g. increasing the number of lochans suitable for red-throated diver breeding); and
- where continued erosion would detract from the quality of the stream and loch habitats receiving water from them (e.g. the silting up of salmonid spawning gravels with fine-grained, organic sediment).

In addition, two practical constraints have to be taken into account in the selection of candidate blanket bog restoration areas, specifically:

- mitigation areas for blanket bog restoration take into account the wind farm and associated infrastructure: and
- habitat management work needs to be compatible with existing land use, especially in view of the complex pattern of land ownership and occupancy associated with the long-established crofting economy, combined with changes in agri-environment subsidy mechanisms. To this end, the approach has been to ensure blanket bog restoration interventions within the Wind Turbines Site do not occupy more than 10% of the total area of any single common grazing, at any point in time.

With all the above in mind, RPS has considered the existing ES data, taken account of the SNH Peatland Action projects on Mainland Shetland, and undertaken preliminary site visits. This has informed an initial assessment of candidate HMP areas for blanket bog restoration. Initial consultations have also been undertaken with SNH and SIC (in January 2016) and subsequently to seek feedback on the approach to finalising the HMP.

The ES blanket bog data were prepared in support of the 2009 planning application, based on information provided to create Figures A10.7 ï 11 of the ES. These data were collected by Highland Ecology and analysed using methods provided in ES Appendix 1 of A10.1 ï Phase 1 Habitat Survey.

5.1.1 Methodology for the Definition of Candidate Blanket Bog Restoration Areas

In support of the original application for section 36 consent, blanket bog activity across the application area was categorised into five classes or bands. This estimated the percentage of bare ground present, the vegetation coverage, and made comment on the condition of the remnant bog. Bands are shown in the Table 3 below:

TABLE 3 – BLANKET BOG ACTIVITY BANDS AND THEIR ASSOCIATED DESCRIPTIONS (TAKEN FROM HIGHLAND ECOLOGY PHASE 1 HABITAT SURVEY REPORT A10.1 OF THE 2009 ES)

Band	Description
1	More or less totally inactive, poor condition, 80-100% bare peat (or vegetated shallow peat)
2	Largely inactive, 50%-80 bare peat (or vegetated shallow peat)
3	Intermediate, widespread larger scale peat erosion, 20-50% bare peat (or vegetated shallow peat)
4	Areas of broadly intact bog with smaller scale but frequent bare peat erosion, 5-20% bare peat (or vegetated shallow peat)
5	More or less fully active, good, stable condition blanket bog, <5% bare peat Overall

Categories 1-3 contain upwards of 20% bare ground and therefore include areas that are appropriate for restoration. Table 4 below gives the total area each blanket bog band occupies within each common grazing and the area within the S36 Site which are not subject to crofting tenure. Total areas of each common grazing and the percentage of the common grazing which each band occupy are also given for context.

As shown in Table 4 below, there is the potential for approximately 1,500ha of restoration to be undertaken within the S36 Site, approximately 1,100ha of such suitable ground falls within the common grazings. All potential restoration areas within the S36 Site are shown in Figure 3a (of which the majority are in areas where HMP works can be carried out, as shown in Figure 1). These values are significantly beyond what is required to mitigate for the predicted impacts of the development and provided the proposed additional enhancement to the S36 Site (260ha).

This provides an initial starting point for proposing restoration areas to be used for the purposes of the HMP. Groundï truthing and local knowledge of the HMP team, coupled with landowner and crofter liaison will similarly guide the prioritisation of candidate areas. This approach will ensure a consistent and systematic evaluation of potential candidate areas for blanket bog restoration at the individual site level, as the HMP proceeds into its implementation phase.

TABLE 4 – COMMON GRAZING AND PRIVATE LAND OWNERSHIP AREAS AND THEIR TOTAL POTENTIAL AREAS AVAILABLE FOR RESTORATION

Common Grazing Area+	Blanket Bog Activity							
	1		2		3			
	Area (ha)	% of Total Grazing	Area (ha)	% of Total Grazing	Area (ha)	% of Total Grazing	Total Area Available for Restoration within S36 Site (ha)	% of Total Common Grazing Available for Potential Restoration
Aithsting District Common Grazings **(2584ha)**	-	-	-	-	57.5	2.2	57.5	2.2
Grunnafirth Park **(227ha)**	0.7	0.3	29.4	13.0	66.3	29.2	96.4	42.5
Heglabister and Sound Common Grazings **(518ha)**	0.4	0.1	24.5	4.7	29.9	5.8	54.9	10.6
South Olnafirth Common Grazings **(2220ha)**	29.0	1.3	35.8	1.6	241.3	10.9	306.1	13.8

TABLE 4 – COMMON GRAZING AND PRIVATE LAND OWNERSHIP AREAS AND THEIR TOTAL POTENTIAL AREAS AVAILABLE FOR RESTORATION								
Common Grazing Area⁺	**Blanket Bog Activity**							
	1		**2**		**3**			
	Area (ha)	**% of Total Grazing**	**Area (ha)**	**% of Total Grazing**	**Area (ha)**	**% of Total Grazing**	**Total Area Available for Restoration within S36 Site (ha)**	**% of Total Common Grazing Available for Potential Restoration**
West Hill (Sandwick, Sweening and Laxo) Common Grazings **(1364ha)**	-	-	19.9	1.5	132.5	9.7	152.4	11.2
West Nesting Common Grazings **(1488ha)**	68.8	4.6	52.1	3.5	311.5	20.9	432.3	29.0
Non-Crofted Ground ï Upper Kergord and Kergord Farm **(1652ha)**	30.4	1.8	65.0	3.9	342.1	20.7	437.6	20.7
Totals	129.4	-	226.6	-	1181.1	-	1537.1	-

Notes:
[+]Areas of common grazing refer to the entire common grazing whether within or outwith the S36 Site. Data is sourced from that provided by the Crofterõs Commission to SSE in 2011. The exception to this is Grunnafirth Park Common Grazing where data provided for the purpose of this report is for areas only within the S36 Site, as no additional data was available at this time.

5.2 Selection Criteria for Whimbrel Management Areas

The insights into whimbrel distribution from the long run of survey work for Viking, and the habitat preference criteria that have been identified (as described above in Section 4.3.2) have been used to identify candidate management areas for this species.

As there are insufficient areas within Central Mainland that meet whimbrel habitat preferences, sites in West Mainland have also been assessed and considered to ensure that a sufficiently large area can be beneficially managed to meet the HMP aims for this species.

The candidate sites identified meet the following criteria:

- existing regular presence of breeding whimbrel;
- landscape characteristics that are attractive to whimbrel (low gradients, low altitude, wet elements, away from human settlements);
- appropriate vegetation;
- extensive (at least $1km^2$) areas; and
- landowner consent.

This has led to the identification of candidate whimbrel HMP sites, all of which overlap a whimbrel ôhot spotö identified through survey work. The candidate management sites are shown in Figure 4. Surveys conducted on behalf of VEWF at these sites between 2010 and 2016 show that together they hold around 70 pairs, equivalent to approximately 25% of the total Shetland population.

5.3 Selection Criteria for Red-throated Diver Management Areas

The process to identify candidate habitat management locations for red-throated diver followed a two-stage selection process, firstly using information on diver breeding selection and site characteristics obtained during the comprehensive survey of the ca. 200 water bodies (lochs and lochans) in original wind farm search area (i.e. the majority of Central Mainland), and secondly using practical and ecological information to prioritise sites for habitat management. The aim of this process was to select sites that will maximise the conservation benefit from the management work that is implemented for this species.

The first stage considers each water body as a candidate for the various management objectives, namely safeguarding from erosion, restoration of erosion degraded sites, lochan enhancement and raft provision. Matrices were used to classify lochans as ‘very high’, ‘high’, ‘medium’ or ‘low’ priority for safeguarding and restoration. The prioritisation for restoration work to reverse the impacts of existing erosion is based on a combination of current and estimated pre-erosion suitability. The prioritisation scoring for work to enhance lochans for divers, irrespective of any erosion, was restricted to small lochans (less than ca. 25m long) and pools, i.e. those that are currently below or close to the minimum acceptable size.

The second stage takes the ‘very high’ and ‘high’ priority sites identified in stage one and examines them against potential constraints that would affect the practicality and desirability of management work at that site. The potential constraints that need to be considered are local hydrology, distance from vehicular access, predicted amount of work involved (equates to likely costs) and the proximity to proposed wind turbines. These factors were each scored on a nominal 0, 1, 2, 3, 4 scale and that the product of the scores is used as a single practicality score to consider alongside the priority ratings from stage one. The zero score would be reserved for what are considered to be absolute constraints. Thus, a site that scores zero for any constraint would also achieve an overall practicality score of zero, indicating that management work at that site was impractical. This scoring exercise resulted in 20 lochans out of 200 being prioritised for HMP work. Figure 2a shows the distribution of candidate lochs and lochans provisionally identified as most suitable for diver habitat management measures.

5.4 Selection Criteria for Merlin Sites

The merlin habitat enhancement sites were selected from a database of historic nesting sites held by RSPB, i.e. all known locations where merlin had previous regularly bred in Central Mainland. Potential sites were visited and basic surveys of vegetation composition and structure were undertaken (NRP 2015). The sites chosen for HMP measures met the following criteria:

- sites that have a history of merlin breeding use but that have had no or very low occupancy since 2005;
- sites where there is a lack of high quality deep heather vegetation but where heather is nevertheless extensively present in the vegetation. i.e. the management work will be aimed at improving the condition of existing heather rather than attempting to establish heather cover in place of some other vegetation type;
- sites where it is feasible to erect gated fenced enclosures, both practically and in terms of reaching agreement with landowners and grazing tenants;
- sites that are at least 500m away from any proposed turbine location.

Of the 19 different possible merlin locations considered, five priority sites met the criteria required (NRP 2015), and were considered candidate sites (shown in Figure 2b).

5.5 Selection Criteria for Rivers and Streams

The need for criteria to be developed in relation to riverine habitat is negated largely by the ready identification of two defined potential impediments to the passage of migratory fish species, highlighted above (Figure 2c).

6. HMP AIMS, ACTIONS AND TIMETABLE

Having provided the background on the HMP's habitat and species priorities, this section sets out the aims, actions and timetable for implementation of the HMP's prescriptions.

6.1 Blanket Bog

6.1.1 HMP Aim 1: Blanket Bog Restoration and Enhancement

The aim is to restore a minimum of 260ha of degraded blanket bog within the S36 Site. Across this area, management will aim to:

- reduce the extent of bare peat;
- improve the condition and peat forming ability of vegetated areas of poor quality blanket bog to prevent further degradation;
- replace erosion patterns with the typical surface patterning for healthy blanket bog in Shetland; and
- establish grazing at a level that is compatible with maintenance of these features of the peatland.

6.1.2 Planned Blanket Bog HMP Actions

With the progression of the Peatland Action projects on Shetland (as well as the wider increase in blanket bog restoration) an iterative approach to the planning and implementing restoration work has evolved, and will be used to fulfil the aim above.

Progressing from the review and understanding of existing habitat, topographic, peat depth and hydrological data presented in the ES and ES Addendum, combined with the team's local knowledge, and awareness of the selection criteria in 5.1.1., the restoration planning process comprises interpretation of high resolution colour digital aerial photography to assess vegetation cover, erosion features, evidence of grazing impacts, natural and artificial drainage features, and other artificial activities (fence lines, peat cutting, tracks etc.) at the site specific level. This is combined with examination of peat body hydrological units, slope, slope stability, and drainage from detailed topographic data, sources from the OS base mapping and LIDAR imagery.

An initial worked example from this desk based exercise using blanket bog activity and vegetation mapping (as detailed in Table 3, Section 5.1.1) has provided an example of the potential breakdown of restoration areas; details of this are provided in Table 5, below. The desk based exercise details that a restoration scheme can be appropriately undertaken with the common grazings, whilst ensuring that no more the 10% of each common grazing is used for the purpose of HMP activities at any one time.

TABLE 5 – WORKED EXAMPLE OF COMMON GRAZING AREAS AND THE PROPOSED AREAS OF RESTORATION								
Common Grazing Area	**Blanket Bog Category**							
	1		**2**		**3**		**Totals**	
	Area (ha)	**% of Total Grazing**	**Area (ha)**	**% of Total Grazing**	**Area (ha)**	**% of Total Grazing**	**Area Proposed for Potential Restoration (ha)**	**% of Total Grazing Proposed for Potential Restoration**
Grunnafirth Park **(227ha)**	0.8	0.35	2.6	1.15	-	-	3.4	1.50
South Olnafirth Common Grazings **(2220ha)**	15.4	0.69	31.2	1.41	41.8	1.88	88.4	3.98
West Hill (Sandwick, Sweening and Laxo) Common Grazings **(1364ha)**	-	-	9.5	0.70	28.0	2.05	37.5	2.75
West Nesting Common Grazings **(1488ha)**	47.1	3.17	38.2	2.57	46.2	3.10	131.5	8.84
Totals	**63.3**	**-**	**81.5**	**-**	**116.0**	**-**	**260.8**	**-**

Areas proposed within Table 5 will form the starting point for restoration activities and will be subjected to further desk based assessment and ground-truthing to ensure that they meet the requirements for targeted restoration.

Key information from desk studies for the above areas will be transferred and highlighted onto colour prints of aerial imagery and base maps, to take into the field for ground truthing and to support further assessment of conditions (vegetation composition, grazing impacts, erosion etc.). This site visit also provides the opportunity to confirm the practicalities of carrying out restoration works, taking into account access conditions, Health, Safety and Welfare requirements for the restoration squad/contractors, and the land management needs, notably in relation to any fencing and grazing. The outcome of these site visits will be the refined proposals for targeted restoration.

Where all practical and technical considerations are favourable, the site will be taken forward for implementation of restoration works, with the combined information used to highlight the restoration activities that will be undertaken by the restoration squad, drawing from the range of techniques and materials described in Section 4.3.1.

For each site, the location, type and date of works will all be recorded, to provide the baseline for on-going monitoring of restoration outcomes.

As part of the above process, and as highlighted previously, the blanket bog restoration work will take place in two workstreams, one to deliver the 260ha of mitigation and the other, as part of the construction of the wind farm site, by ensuring construction impacts are minimised and opportunities for beneficial use in blanket bog restoration are maximised as far as practical. The assessment and planning process will take account of both sets of opportunities, to ensure integration and ensure both contribute to overall restoration of this habitat.

6.1.3 Blanket Bog HMP Work Timetable

The intention for the blanket bog restoration work is to undertake the majority of restoration works within 5 years of commissioning of the development. This is to ensure that as rapid and early start is made to the mitigation process as possible.

6.2 Whimbrel

6.2.1 HMP Aim 2: Management to Protected and Enhance the Whimbrel Habitat

The aim of the HMP for this species is to protect and enhance whimbrel breeding habitat and therefore their populations at the Central and West Mainland Shetland management sites, leading to:

- improved whimbrel breeding success there;
- increased whimbrel breeding densities locally; and
- protection and recognition of the importance of these sites for whimbrel and thereby lessen the likelihood that inappropriate incidental management (e.g. through agricultural change) will be deleterious to whimbrel.

Of particular importance is the scale of the proposed HMP whimbrel actions. The intention is that the magnitude of management is not only sufficient to offset any adverse effects from the wind farm but to also make a significant improvement to the regional/national conservation status of the species, i.e. management will take place in areas where ca. 25% of existing Shetland whimbrel population occurs. Modelling work on whimbrel population dynamics suggests that a relatively small increase in breeding success could reverse the recent population decline (ES Chapter A11; Appendix A11.1).

6.2.2 Planned Whimbrel HMP Actions

The management techniques available to benefit whimbrel are:

- management of grazing intensity of extensive moorland areas;
- wetting up small areas; and
- sensitive management of important areas e.g. no fertiliser, new reseeding etc.

It is likely that the proposed targeted management over the extensive proposed whimbrel management areas will more than offset the potentially negative effects of the wind farm on whimbrel (Chapter A11). The amount of whimbrel mitigation far exceeds predicted impacts and is aimed at bringing a significant proportion of the Shetland (and hence UK) population under conservation management.

Predator Control

Control of crows has been identified as one further measure which can be used, if it becomes desirable to increase the HMP's intervention for whimbrel. This would be the case, for example, if impacts on the species were higher than anticipated, and the other management measures were not producing the anticipated benefits for breeding success and maintenance of distribution. This scenario is considered unlikely however, so control is not considered further. Should monitoring reveal that it may be necessary to implement, the HMP can be revised at that point, in liaison with stakeholders and SWEAG.

6.2.3 Whimbrel HMP Work Timetable

There has already been considerable preparatory work and baseline monitoring to inform the identification and implementation of management at whimbrel management areas. The current proposed timetable is therefore for pre-commencement breeding whimbrel surveys to be completed in 2016 and 2017, with practical management actions as agreed for each site to commence prior to commissioning of the development. Management activities would subsequently be reviewed during each winter, with management proposals agreed ahead of each breeding season.

6.3 Red-Throated Diver

6.3.1 HMP Aim 3: Measures to Support Red-Throated Divers Breeding Success

The aim of the HMP for this species is to protect and enhance the red-throated diver breeding sites on the Central Mainland Shetland, such that in the medium and long term there are sufficient good quality sites to support a breeding population no smaller than the number breeding prior to construction of the wind farm. Specific measures to support red-throated divers will be undertaken across the Off Site mitigation area. However, where practicable to do so, blanket bog restoration activities completed within the S36 Site will provide additional protection to breeding diver lochan as so provide additional benefit to the species, providing these do not lead to increased collision risk or barrier effect for the birds involved.

6.3.2 Planned Red-Throated Diver HMP Actions

Where practical to do so, HMP actions for this species will be directed at water bodies identified by the selection criteria and will comprise the following management work:

- the restoration of selected priority lochans damaged by peat erosion processes;
- the safeguarding of selected priority lochans whose future suitability for breeding divers is threatened by ongoing peat erosion processes;
- the enhancement of selected lochans as sites for breeding divers through bank modification, deepening and extension;
- provision of diver nest rafts at selected lochs;
- the realignment of stock fences in the immediate vicinity of breeding lochans that are considered to posed a collision risk to divers; and
- the erection of strategically positioned screening banks to reduce the potential for ground-based disturbance to divers on breeding lochans from wind farm activities.

6.3.3 Red-Throated Diver HMP Work Timetable

The HMP actions for red-throated diver will commence implementation once construction of the development is confirmed and prior to construction commencing.

6.4 Merlin

6.4.1 HMP Aim 4: Measures to Support Merlin Breeding Success

The aim for this species is to re-establish suitable nesting habitat at up to five formerly occupied traditional sites identified for HMP work, and thus allowing for a modest increase in the Central Mainland Shetland population.

6.4.2 Planned Merlin HMP Actions

The planned HMP work is relatively straightforward and simple: create conditions conducive to the restoration of deep heather at (former) traditional merlin nesting sites. In order to have a high probability of success of achieving this, the HMP works will take place in up to five traditional nesting sites in Central Mainland Shetland where there is evidence of a lack of suitable nesting cover. Candidate site selection has been confined to Central Mainland Shetland as this area has the best information on previous site use (from monitoring by VEWF and before then by RSPB). NRP (2015) provides further details of merlin HMP site selection, with the five candidate sites shown in Figure 2b.

Gated fencing will be erected around the selected sites and livestock excluded to allow heather regeneration to occur over sufficiently large areas (at least a few hectares at each territory) to be attractive to nesting merlin. Depending on the rate of heather recovery (determined through monitoring) subsequent grazing management within the fenced areas is likely to be required to keep heather at the optimal height and structure for nesting merlin.

6.4.3 **<u>Merlin HMP Work Timetable</u>**

The HMP actions for merlin will commence implementation once construction of the development is confirmed and prior to construction commencing, with subsequent vegetation and breeding merlin monitoring informing the level and timing of grazing that is appropriate to maintain suitable nesting habitat.

6.5 Rivers and Streams

6.5.1 **<u>HMP Aim 5: Measures to Enhance Fish Migration in Rivers and Streams</u>**

The aim is to ensure, as far as practical, that the two artificial structures identified in proximity to the Viking Wind Farm site do not impose a significant constraint to migratory fish, notably to salmon and brown/sea trout.

6.5.2 **<u>Planned River and Stream HMP Actions</u>**

Following the recent pre-feasibility assessment (Waterside Ecology 2016), the subsequent actions recommended are to carry out the full detailed site investigation and stakeholder liaison. This will enable the conclusion to be reached on the extent to which these provide an obstacle, the environmental risks against benefits of full or partial removal, and the acceptability (or otherwise) to stakeholders.

6.5.3 **<u>River and Stream HMP Timetable</u>**

The follow-up feasibility assessment will be undertaken during the start of the wind farm's construction period, and modifications implemented during the construction period, if found sufficiently cost-effective, environmentally beneficial and locally acceptable as required.

6.6 Other Species

Although not subject to any specific planning conditions, the wind farm is predicted to have small adverse effects (assessed as not significant) on several other breeding moorland bird species. These include species of high conservation value such as dunlin, golden plover, Arctic skua and curlew. Although no specific HMP management actions are included for these species, the management actions listed above for whimbrel and for blanket bog are expected to result in benefits for these species.

7. IMPLEMENTATION

7.1 Management Responsibility

Implementation of the HMP will be the responsibility of VEWF, aided and advised by relevant partners, internal staff and consultants as necessary. Appropriate resources will be provided for the life time of the development to ensure the HMP is appropriately managed, implemented and reported on in line with the timescales outlined within this document. Implementation of the HMP will be reported to SWEAG as required within the developmentõs planning conditions. SWEAG will provide a review and advisory role where relevant, to help achieve the implementation and any evolution of the HMP.

7.2 Partnership Working

VEWF will take full responsibility for delivering the HMP, and in doing so, will work closely with of a number of partners, listed in Table 6. It is envisaged that these partners would welcome involvement from the earliest stages in order to ensure the effective delivery of the plan.

TABLE 6 – POTENTIAL PARTNERS IDENTIFIED AS RELEVANT TO THE DELIVERY OF THE HMP.

Partner	Roles
Scottish Environment Protection Agency	• Advice, information, monitoring & technical input. Licensing.
Scottish Natural Heritage	• Advice, information, monitoring & technical input. Licensing.
Shetland Islands Council	• Advice, information & technical input. • Integration of management plan outputs with LBAP. • Planning Condition compliance
Royal Society for the Protection of Birds	• Advice, information & technical input on habitat restoration & species requirements.
Academic institutes and environmental consultancies.	• Research & monitoring of the HMP outcomes. • Independent peer review.

7.3 Funding

HMP implementation will be funded by VEWF, the funding commitment by VEWF will span the life of the project; a period of at least 25 years and may include:

- management costs;
- consultancy, survey, research and labour costs;
- materials, (fencing, matting, dam materials, etc.);
- the collection and propagation of plant species for blanket bog regeneration; and
- the hire or purchase and maintenance of necessary equipment and premises.

7.4 HMP Duration

The duration of the HMP will last, as a minimum, the length of the operational life of the wind farm, i.e. 25 years. Once the HMP is approved, works will commence prior to commissioning of the development, and will continue until 2046, as a minimum, and likely to also extend through the decommissioning period.

7.5 Monitoring and Review

Monitoring and review are key aspects of the HMP, enabling progress towards its objectives to be gauged, and results used to refine the targeting and nature of management activities. Therefore, monitoring will:

(i) systematically record the location, timing and extent of all HMP management works;
(ii) quantify the extent and condition of the resulting restored blanket bog within the S36 Site;

(iii) quantify changes in the abundance and distribution of whimbrel within Central and West Mainland Shetland HMP sites;
(iv) measure changes in habitat quality and breeding performance of whimbrel at Central and West Mainland Shetland HMP sites and control sites; and
(v) quantify breeding site occupancy and breeding success by red-throated diver and merlin at sites where habitat enhancements have been carried out for these species, as well as the changes in the habitat suitability at these locations.

Annual reports detailing the prescriptions completed and blanket bog and breeding bird monitoring results will be submitted each winter to SWEAG. Feedback from SWEAG members prior to March each year on these results will help inform and up-date on-going requirements for HMP works.

The prerequisite to enable the evaluation of the HMPõs effect is having an adequate baseline prior to management work, to enable comparison with emerging conditions. For the Viking Wind Farm, considerable baseline data already exists, with extensive habitat and bird surveys undertaken between 2010 and 2016. Additional ôprior to commencementô breeding bird surveys will be carried out in 2017. The full time span of habitat and species data will therefore be used as the baseline from which to determine the impact and effectiveness of the HMP in achieving its stated objectives.

As well as suitable non-technical summaries covering the main blanket bog and bird findings, it is anticipated there will be background technical reports setting out the survey methods, results, discussion, conclusions and any recommendations from the monitoring completed for each receptor. Any relevant contextual changes (such as changes in SNH guidance, national or regional bird population trends, findings from other blanket bog restoration projects etc.) will also be referred to, where they help put the Viking HMP results into context. There will also be inclusion of all relevant data resulting from the Operations Team standard monitoring procedures, notably including any bird fatalities identified or any site remediation works that may have a bearing on hydrology or blanket bog restoration.

7.5.1 Monitoring of the Blanket Bog Habitat

In order to monitor progress towards blanket bog restoration, repeat surveys at appropriate intervals (likely to be every five years) will be carried out of vegetation cover, composition, the spread of active bog forming species, and the halting of erosion features. If appropriate, the use of drones at a suitable time of year recording in both real colour and near infra-red might enable an increased scope in monitoring the success of vegetation recolonisation and the extent of water pooling within restoration areas. This coupled with ground monitoring of vegetation species and extent, could provide an enhanced method of monitoring the success of the proposed activities.

The response to peat restoration measures by most of the priority breeding bird species will be measured periodically (approximately every three years) using appropriate moorland bird survey methods. It is likely that this survey work will be instigated as part of the wider programme of ornithological monitoring across the wind farm site. However it will be important that it is integrated (through careful design) with the specific of monitoring the habitat restoration work. Stands of heather managed for nesting merlin will be monitored by measuring vegetation height and density at appropriate time intervals. These areas will also be incorporated into areas checked during routine annual breeding merlin surveys.

7.5.2 Monitoring of Whimbrel

The Moorland Bird Survey method will be used to monitor the number and distribution of breeding whimbrel at the HMP sites and control sites in Central and West Mainland Shetland. This monitoring will also cover other species of moorland bird species (e.g.

waders, skuas, gulls) breeding on these sites. Each site will be surveyed at least once every three years.

Changes to whimbrel habitat and breeding performance in response to management actions will also be studied at HMP sites as part of a research programme on this species aimed at improving the understanding of whimbrel habitat and conservation requirements. The whimbrel research programme will be developed in consultation with other organisations, notably SNH and RSPB. The research results will feed into Management Actions for this species, which in turn would be monitored when implemented.

7.5.3 Monitoring of Red-throated Diver

Monitoring of the occupancy and breeding success of red-throated diver will be carried out annually across Central Mainland (VEWF has monitored all suitable sites almost annually since 2005).

At water bodies where habitat restoration, safeguarding or enhancement measures have been carried out, shoreline habitat change (including response to peat erosion treatments) and overall site condition will be monitored every three years after works have been completed. At lochs provided with a floating nesting raft, the condition of the raft and its moorings will be inspected annually to determine if any maintenance work is required.

Banks created to visually screen diver sites from wind farm roads will be inspected every three years to check on their condition.

Any fence removal carried out for this species will also be mapped and reported.

7.5.4 Monitoring of Breeding Merlin

Monitoring of the occupancy and breeding success of merlin will be carried out annually across Central Mainland (VEWF has monitored all historic sites annually since 2005).

For the five merlin sites, fence condition and changes to vegetation will be monitored every three years after works have been completed to assess the quality of the vegetation for nesting merlins. The assessment will consider grazing levels and any other ongoing management requirements.

7.5.5 Monitoring of River and Stream Restoration

The reporting on rivers and streams is only envisaged for the first three years (as the works are localised, and on-off measures), and will also be integrated with the general water quality monitoring and reporting (arising from fulfilment of Condition 25). The monitoring will cover any modifications to the two weirs, the impact on up and downstream local geomorphology, and up-stream salmon, sea/brown trout and eel populations.

7.5.6 HMP Review Process

It is proposed to review and up-date the HMP at appropriate points over the operational and decommissioning stages of the Wind Farm. The schedule proposed is to carry out the first up-date in 2022 once commissioning is complete and the project is handed over from the construction to operations team at VEWF. After this, a review every five years is considered appropriate, as that is sufficient time to judge the outcomes of the preceding HMP management activities.

A simple process is proposed for the review, of presenting the results from implementation of HMP actions to 2022, then five-yearly an annual summary of works completed, together with a summary of HMP outcomes for blanket bog restoration, and for birds (whimbrel, red-throated diver and merlin). This will include recommendations for any modifications to the HMP, for SIC, SNH and SWEAG to consider. Based on the feedback to these recommendations, the HMP revised version will be drafted for comment, after which a final revised version will be submitted for SIC approval. This will provide all stakeholders with clear opportunities to consider the HMP results and any proposed changes to this HMP document.

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APPENDIX 1 – PLANNING CONDITIONS WITH IMPLICATIONS FOR, AND RELEVANCE TO THE HMP

This Appendix gives the planning conditions that relate to the HMP in some direct or inter-related way (notably because they influence the extraction, handling and restoration of peat during construction). By presenting these conditions in full, the aim is to make it more convenient for all stakeholders to cross-reference these aspects of the development.

Part 2

Conditions applying to deemed planning permission
Implementation and Decommissioning

1. The Development will be undertaken in accordance with the Application and Environmental Statement and Addendum approved by this consent, except in so far as amended by the terms of this consent and direction.

Reason: To ensure the development is carried out in accordance with the application documentation.

2. Prior to the Commencement of Development, detailed plans and method statements for reinstatement proposals concerning access tracks (including the reduction of double width tracks) borrow pits, construction compound areas and other construction areas at the end of the construction period, as part of the development hereby permitted, will be submitted to, and approved in writing by the Planning Authority in consultation with SEPA. The approved reinstatement method statements shall then be followed, and the approved plans will be implemented to the satisfaction of the Planning Authority within 6 months of commissioning of the development or when otherwise directed by the Planning Authority.

Reason: In order to define the terms of this permission, to minimise the level of visual intrusion, and to ensure the satisfactory reinstatement of the site.

3. Within 6 months of the Commencement of Development the details of all seed mixes to be used for reinstatement of vegetation will be submitted to, and approved in writing by, the Planning Authority in consultation with SNH. Wherever possible, reinstatement work should be achieved by the careful use of turfs removed prior to construction works.

Reason: To ensure the satisfactory reinstatement of the site.

5. Within 5 years prior to the expiry of the consent granted under section 36 of the Electricity Act 1989, a Decommissioning Method Statement shall be submitted for the approval of the Planning Authority outlining the programme of decommissioning of the Development. The Decommissioning Method Statement will include details of all site decommissioning, the work to remove the infrastructure from the site, and any subsequent aftercare following site restoration, management and timing of works, environmental management provisions and a traffic management plan to address any traffic impact issues during the decommissioning period. It will include provision for the appointment by the Partnership of an Ecological Clerk of Works (ECoW) acceptable to the Planning Authority (in consultation with SNH and the SEPA), whose role will be to oversee implementation of the plans so approved. These plans will include the method, frequency and duration of ecological monitoring, particularly of watercourses, over the decommissioning period of the Development. Six months prior to the expiry of the section 36 consent, and at any other subsequent point as appropriate, the Decommissioning Method Statement shall be reviewed by the Partnership and the Planning Authority, and any alterations deemed appropriate and mutually acceptable shall be made.

Reason: To ensure the satisfactory reinstatement of the site.

6. A detailed restoration method statement will be submitted by the Partnership to the Planning Authority for written approval, after consultation with SNH and such other parties as they consider appropriate, within three months of the date of a direction given by the Scottish Ministers to decommission and reinstate the site or at least 12 months prior to the scheduled commencement of the Decommissioning of the Development. The approved restoration method statement will subsequently be implemented, following the approved Decommissioning Method Statement, unless otherwise agreed in writing by the Planning Authority.

Reason: To ensure the satisfactory reinstatement of the site.

7. Within 36 months following the end of the period of the consent granted under section 36, all wind turbines, ancillary equipment and buildings will be dismantled and removed from the Site and the land will be reinstated in accordance with the approved Decommissioning Method Statement.

Reason: To ensure the timely satisfactory reinstatement of the site.

8. Within 6 months of the Final Commissioning of the Development, any remaining temporary laydown and construction compound areas not already reinstated in accordance with Deemed Planning Condition 2 will be removed from the site and these uses discontinued, unless otherwise agreed in writing with the Planning Authority. Any works required for the reinstatement of the land will be carried out following the approved reinstatement method statement referred to at condition 2 and in accordance with the reinstatement plans, within 6 months of commissioning of the last part of the development.

Reason: In order to define the terms of this permission, to minimise the level of visual intrusion, and to minimise any adverse impacts as a result of the construction phase of the development.

10. No construction work will commence until a site-specific Construction Method Statement (CMS) has been submitted to and approved by the Planning Authority following consultation with SNH and SEPA. Thereafter, the approved method statement will be implemented by the Partnership. The method statement will incorporate "good practice" methods from the Scottish/UK wind farm industry, including best practice methods associated with developments on peatland. The CMS will include the following: (*inter alia)*

CMS – Track Construction (*including)*

- Details on track design approach: Maps of tracks indicating approved locations for double and single tracks and position of passing places. Full extent of anticipated track 'footprint(s)' including extent of supporting geogrid below roadstone and cabling at edges of the track.
- Details on track construction including floating track construction over peat >1m deep and gradients of 1:10 or less.
- Methods to deal with failing roads, sinking/sunken roads, peat rotation at road edges etc. during the processes of constructing and decommissioning the wind farm.
- Timing, extent, design, treatment and reinstatement of embankments, track edges and other areas affected by track construction.

CMS – Peat General (*including)*

The Partnership will undertake on-going assessment of ground conditions as construction progresses. The results of this monitoring will be fed into a geotechnical risk register which will include peat stability risks. On-going analysis and call out services will be provided by suitably qualified geotechnical personnel (Geotechnical Clerk of Works, GCoW) whose appointment has been approved by the Planning Authority. If a risk of peat failure is identified, the Partnership will install and monitor ground conditions using suitable geotechnical instrumentation as recommended by the approved geotechnical personnel. This may take the form of a line of stakes, levelling points or more complex installations such as inclinometers. Any remediation considered necessary will be approved in writing by the Planning Authority prior to implementation.

The Partnership will develop and adopt a formalised reporting procedure which records Site workings, monitoring results and any observations that may be pertinent to the stability of the works, under which terms the records shall always be available at the offices of the site contractor carrying out workings in the area being reported on and which shall be made available to all persons with responsibility for the site management, and officers of the Planning Authority or its nominees.

CMS ï Borrow Pit(s) *including*

Details of the proposed opening, working and reinstatement of new borrow pit areas, including details on:

- Ground investigation findings, including information on groundwater levels;
- Drainage including measures to control ingress of surface water into the borrow pit and to prevent the drying out of surrounding peatland, and any dewatering and associated drainage facilities appropriate to the area to be stripped of overburden and worked;
- Overburden (peat, mineral soil and loose weathered rock) handling and storage according to type and quality and in accordance with the Management of Extractive Waste (Scotland) Regs 2010;
- Programme of implementation (phased approach) to reinstatement of the borrow pit; and
- Design and programme of reinstatement, restoration and aftercare, including type and volumes of restoration materials (and where this is to be placed in the restoration horizon).

Reason: In order to define the terms of this permission, to minimise the level of visual intrusion, and to minimise any adverse impacts as a result of the construction phase of the development.

Ecology & Pollution Prevention

22. A site-specific Environmental Management Plan (SEMP) shall be submitted to and approved in writing by Planning Authority following consultation with SNH and SEPA at least three months prior to Commencement of Construction Works. Thereafter the approved Site Environmental Management Plan (SEMP) will be implemented by the Partnership and shall throughout the construction period be maintained and updated with the Planning Authorityõs agreement. The SEMP will incorporate ñgood practiceò methods from the Scottish/UK wind farm industry and applicable SEPA guidance documents to ensure that environmental impacts are reduced.

The site-specific SEMP will define good practice as well as specific actions required to implement mitigation requirements as identified in the Environmental Statement (ES), the ES Addendum, the planning process and/or other licensing or consenting processes. Unless already covered in the CMS, the SEMP will include (but are not limited to):

- Information on how Scheme Amendments and variations will be recorded including micrositing (change control);
- An Environmental Communication Plan detailing roles and responsibilities as well as lines of communication (to include the Planning Authority);
- Information on environmental checks and audits to be undertaken during and post construction;
- Information on a Site Induction Schedule;
- Site Waste Management Plan, including information on expected waste streams and volumes, management of each waste stream (including excavated materials which may be classed as waste under the Management of Extractive Waste (Scotland) Regs 2010, waste contractors, storage locations, and waste documentation;
- Drainage Management Plan, including details on permanent and temporary drainage and silt pollution mitigation measures (as far as not covered within CMS or Pollution Prevention Plan);
- Excavated Materials and Reinstatement Plan, including a site plan indicating all the areas which will be subject to reinstatement and proposed reinstatement objectives in terms of final ground conditions, details on type and volumes of materials to be excavated and areas, volumes and methodology for reinstatement. Furthermore any areas that may be subject to further disturbance during the operation of the windfarm, within the terms of the defined description of the development for the Section 36 consent and deemed planning permission, should be detailed including the likely frequency of disturbance and rational for disturbance;

- Ecological (Habitats and Species) Protection Plan, including information on monitoring and mitigation measures in relation to species and habitat protection as identified in the ES and other relevant documents relating to this consent; and
- Environmental Incident and Emergency Response Plan.

For the avoidance of doubt, the SEMP will include details on the following:

- A minimum buffer between all infrastructure, to include access tracks (but excluding access tracks leading to watercourse crossings) to be set at 50m. Exceptions to this by agreement of the Planning Authority in consultation with SEPA, and other parties relevant to interests being considered.
- A scheme of site specific buffer distances which are determined by the sensitivity of the soil, terrain, vegetation and other site specific characteristics, applying a minimum buffer to at-risk watercourses of 50 m. A map showing the demarcation of identified hydrologically sensitive areas will be included, together with a rationale for the different buffer distances.
- Contingency planning measures for storm events or the risk of localised peat slide, which may increase the rate of sediment transport and cause damage to fish habitats and populations.
- The terms of appointment, roles, responsibilities and powers (including the stopping of construction and reinstatement/restoration activities) of the Ecological Clerk of Works (ECoW), Geotechnical Clerk of Works (GCoW) and other roles relating to the implementation and monitoring of this consent and compliance with the terms of its relating documents.
- Information on environmental auditing and monitoring during construction (in relation to e.g. environmental, ecological and geotechnical monitoring pre-, during and post-construction, independent monitoring and auditing), to include frequency, methodology and details of parties to be invited to participate, which shall include the Planning Authority.

Reason: in the interests of ensuring that the development is implemented in full accordance with submitted and approved details and to provide details in a single location for ease of update and interrogation.

23. Prior to the Commencement of Development, the Partnership will appoint an Ecological Clerks of Works (ECoW), at its own expense, for the period from the Commencement of Development until the final commissioning of the development and again from the commencement of the decommissioning of the wind farm until the completion of the restoration of those parts of the site to be restored in accordance with the approvals given under the terms of conditions of this consent. The Ecological Clerk of Works will be a member of the Institute of Ecology and Environmental Management or equivalent. He/she will be appointed by the Partnership, subject to the approval of the Planning Authority, following consultation with SNH and SEPA.

The scope of the work of the Ecological Clerk of Works will include:

- Monitoring compliance with the ecological, hydrological and other environmental mitigation works that have been approved in this consent;
- Advising the Partnership on adequate protection of nature conservation interests on the Site, and prevention of off-site adverse environmental impacts;
- Checking for new recordings of protected species with any additional mitigation required;
- Directing the micrositing and placement of turbines and tracks;
- Monitoring the compliance with mitigation, reinstatement and restoration measures approved by this consent.

24. Any crossing works to a watercourse and waterbody must not restrict migratory fish and must be designed and constructed to protect fish interests. Prior to commencement of construction works, an additional pre-construction survey will be undertaken by the Partnership in streams, details to be agreed with the Planning Authority in consultation with SEPA and SNH beforehand, in order to assess ñnaturalò annual variation in fish abundanceò and to support establishment of a baseline for post-construction monitoring. This survey will also include an assessment of artificial barriers to fish passage as identified within the ES, and proposals to remove or modify those structures which result in poor ecological status as part of a habitat management plan. There will be no commencement of

engineering works to any standing water within the site boundary unless fully agreed by the Planning Authority in consultation with SNH and SEPA.

Reason: In the interests of ensuring minimal disruption to habitats.

Habitat Management Plan

26. (1) The construction of the Development shall not commence until:

(a) a proposed Habitat Management Plan has been prepared in accordance with this condition and in consultation with SNH;
(b) that proposed Habitat Management Plan has been submitted to the planning authority for approval;
(c) the planning authority have, in consultation with SNH, approved the Habitat Management Plan in writing; and
(d) all Necessary Consents have been granted or have been obtained by the Partnership.

26. (2) The Habitat Management Plan (based on the Habitat Management Plan set out in the Viking ES Addendum Appendix 10.9) is to set out measures and works to mitigate the impacts of the Windfarm by enhancement, restoration and conservation of priority species (in particular whimbrel, red-throated diver and merlin) and priority habitats (especially blanket bog) over the life of the development, and in particular is to include:

(a) an implementation programme, including details of the baseline surveys, initial phase of works and monitoring for the first three years of implementation;
(b) provisions requiring annual summary progress reports to be submitted to the Planning Authority and the Shetland Wind Farm Environmental Advisory Group (SWEAG) [as defined in Condition 27];
(c) provisions requiring a review of the Habitat Management Plan which are to include provisions-
    (i) requiring periodic reviews of the operation and effectiveness of the Habitat Management Plan to be carried out and submitted to SWEAG; and
    (ii) requiring such reviews to be carried out at recurring intervals of no more than three years commencing from the date of initial approval of the Habitat Management Plan; and
    (iii) for implementation of works on a phased basis between reviews;
    (iv) requiring (in addition to the regular reviews) the monitoring of implementation works and how this will (including all monitoring outputs) be reported to SWEAG; and
    (v) for adaptation and modification (with the written approval of the planning authority in consultation with SNH and SWEAG) of the management techniques and monitoring within the approved Habitat Management Plan in the light of monitoring and reviews.

26. (3) Following a review of the operation and effectiveness of the Habitat Management Plan any proposed modifications to the Habitat Management Plan are to be submitted to the Planning Authority for approval in writing.

26. (4) The Habitat Management Plan prepared and approved in accordance with paragraph (1) (or such Plan as amended following any modifications approved under paragraph (3)) shall be implemented to the satisfaction of the Planning Authority in consultation with SNH and SWEAG.

26. (5) In this conditionï

(a) ñNecessary Consentsò meansï
    (i) any consent or permission required by an enactment to enable the approved Habitat Management Plan (or as the case may be, (or such Plan as amended following any modifications approved under paragraph (3)) to be implemented; and
    (ii) any right of ownership or right or permission to use or take access over land required by the applicant in order to implement the Habitat Management Plan (or amended Plan); and
(b) references to SWEAG are references to the bodies comprising the Shetland Wind Farm Environmental Advisory Group constituted by virtue of condition 27(1).

Reason: In the interests of ensuring minimal disruption to habitats.

27. (1) Prior to the commencement of construction, details of the constitution, terms of reference (including procedures for the review of the Habitat Management Plan) membership and working arrangements of the Shetland Wind Farm Environmental Advisory Group (SWEAG) shall be submitted to and approved in writing by the Planning Authority in consultation with SNH, and the first meeting of SWEAG held.

(2) The approved details must within 2 months of such approval be published in accordance with the publicity requirements set out under Planning Condition 13.

Reason: In the interests of ensuring minimal disruption to habitats.

Ornithology

29. Prior to the Commencement of Development, relevant preconstruction ornithological surveys shall have been completed, and the HMP and a Bird Protection Plan (as specified in A11-17 of the ES addendum) shall be submitted to and approved in writing by the Planning Authority in consultation with SNH. A revised Bird Protection Plan will be produced and submitted for approval to the Planning Authority for works beyond the anniversary of any current approved plan.

Reason: In the interest of protection of breeding birds.

APPENDIX 8.10: HABITAT MANAGEMENT PLAN FIGURES

The figures that accompanied the 2016 Habitat Management Plan were seen as relevant and thus were included in the 2018 EIA.

FIGURES

List of Figures:

BRITISH NATIONAL GRID / OSGB36

HABITAT MANAGEMENT PLAN AREA

FIGURE /1

© Crown copyright and database rights 2016
Ordnance Survey 0100049967

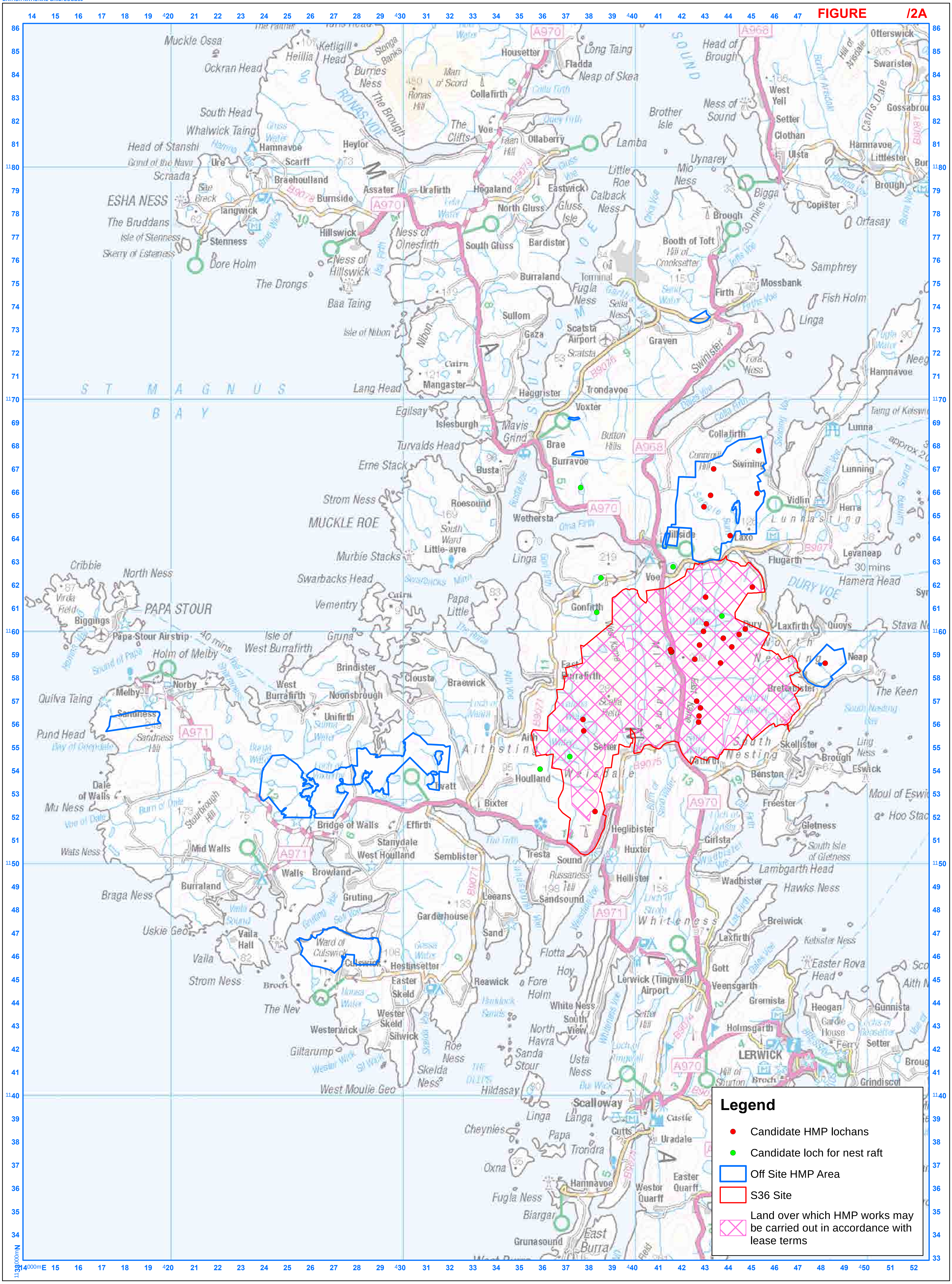
1:100,000 @ A2

Produced by J McDougall
Viking Energy Wind Farm LLP
Dated: 27 Jul 16
Task No:VIKING_v2_000_RPS #1

BRITISH NATIONAL GRID/OSGB36

HMP AREA WITH CANDIDATE ENHANCEMENT ACTIVITY LOCATIONS FOR RED-THROATED DIVER

FIGURE /2A



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Ordnance Survey 0100049967

1:100,000 @ A2

0 1 2 3 4 5 Kilometres

N

viking energy

Produced by J McDougall
Viking Energy Wind Farm LLP
Dated: 02 Aug 16
Task No:VIKING_v2_000_RPS #2a

sse

HMP AREA WITH CANDIDATE ENHANCEMENT ACTIVITY LOCATIONS FOR MERLIN

BRITISH NATIONAL GRID/OSGB36

FIGURE /2B

HMP MERLIN NEST ENCLOSURE		
ID	Easting	Northing
1	441321	1163906
2	437540	1167648
3	437322	1169153
4	443915	1156304
5	437184	1151295

Legend

- HMP Merlin Nest Enclosure
- Off Site HMP Area
- S36 Site

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1:100,000 @ A2

0 1 2 3 4 5 Kilometres

N

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Dated: 02 Aug 16
Task No:VIKING_v2_000_RPS #2b

sse

BRITISH NATIONAL GRID/OSGB36

HMP AREA WITH POSSIBLE ENHANCEMENT ACTIVITY LOCATIONS FOR FISH MIGRATION

FIGURE /2C

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1:100,000 @ A2

0 1 2 3 4 5 Kilometres

N

viking energy

Harnessing Shetland's natural resources

Produced by J McDougall
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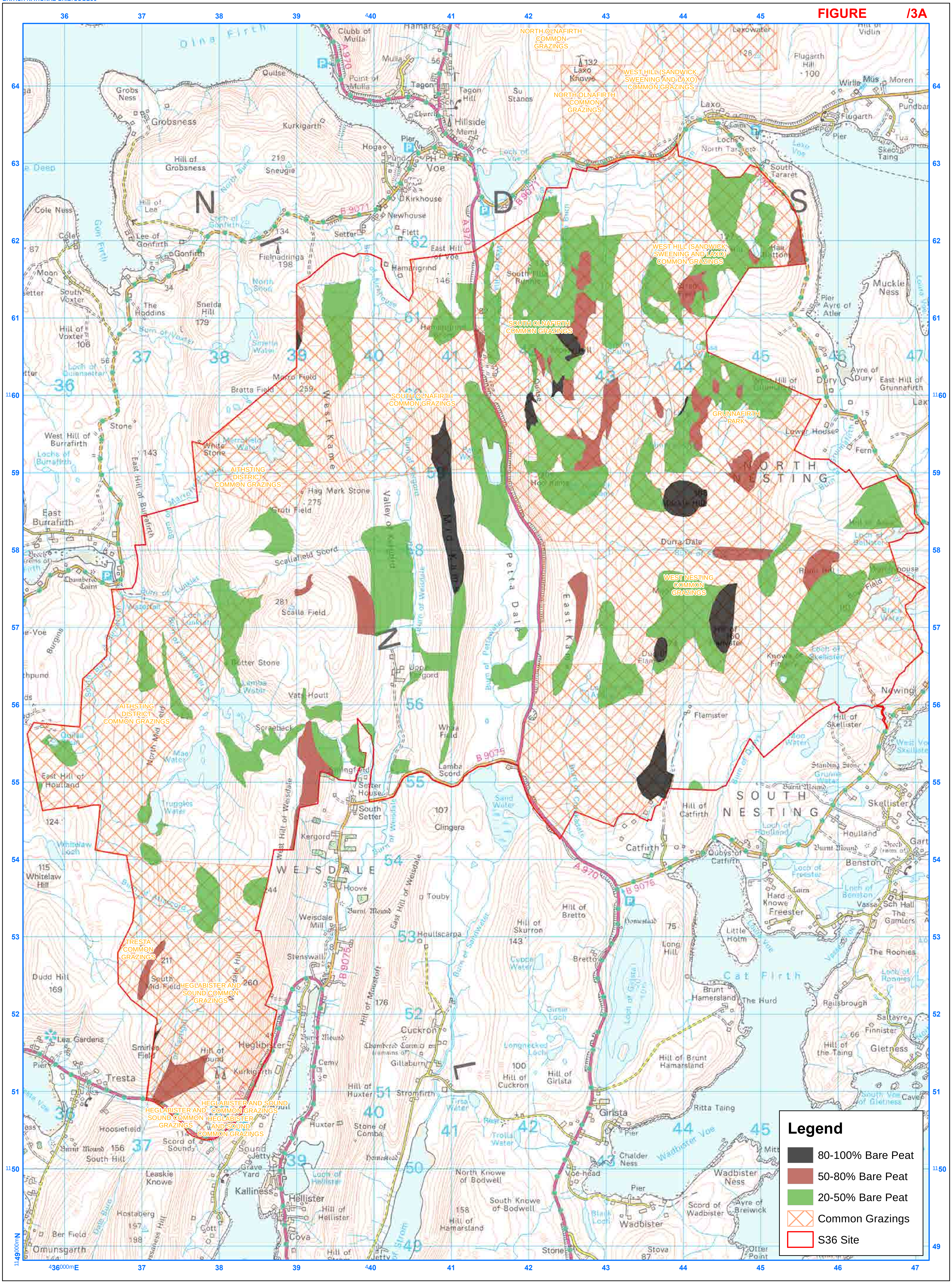
Dated: 27 Jul 16
Task No:VIKING_v2_000_RPS #2c

sse

BRITISH NATIONAL GRID/OSGB36

LOCATION OF HMP CANDIDATE BLANKET BOG RESTORATION AREAS



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1:30,000 @ A2

0 1 2 3 4 5 Kilometres

Produced by J McDougall
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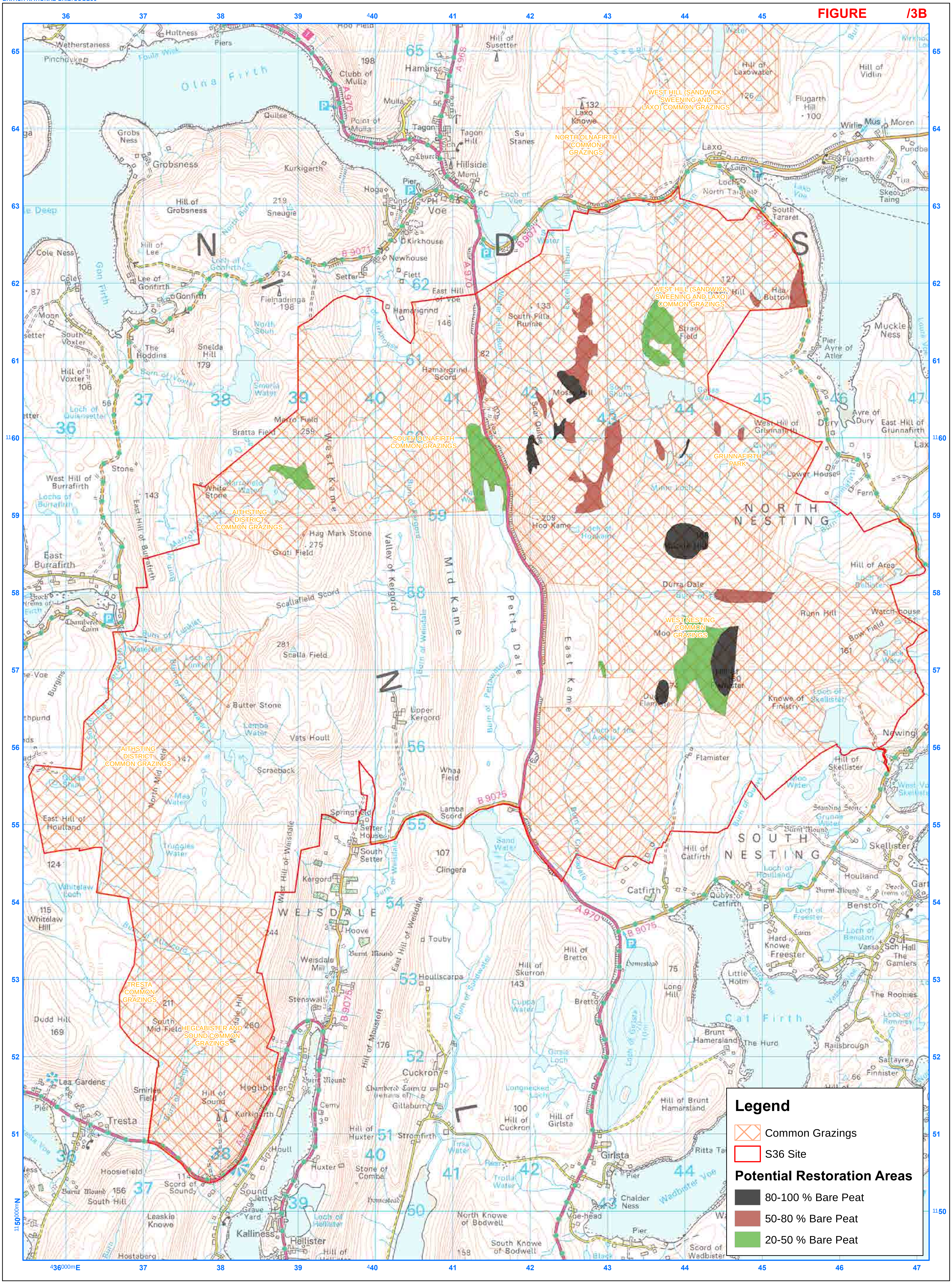
Dated: 05 Aug 16
Task No:VIKING_v2_000_RPS #3

viking energy

BRITISH NATIONAL GRID/OSGB36

HMP AREA WITH POTENTIAL BLANKET BOG RESTORATION AREAS

FIGURE /3B



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Ordnance Survey 0100049967

1:30,000 @ A2

0 1 2 3 4 5 Kilometres

N

viking energy
Harnessing Shetland's natural resources

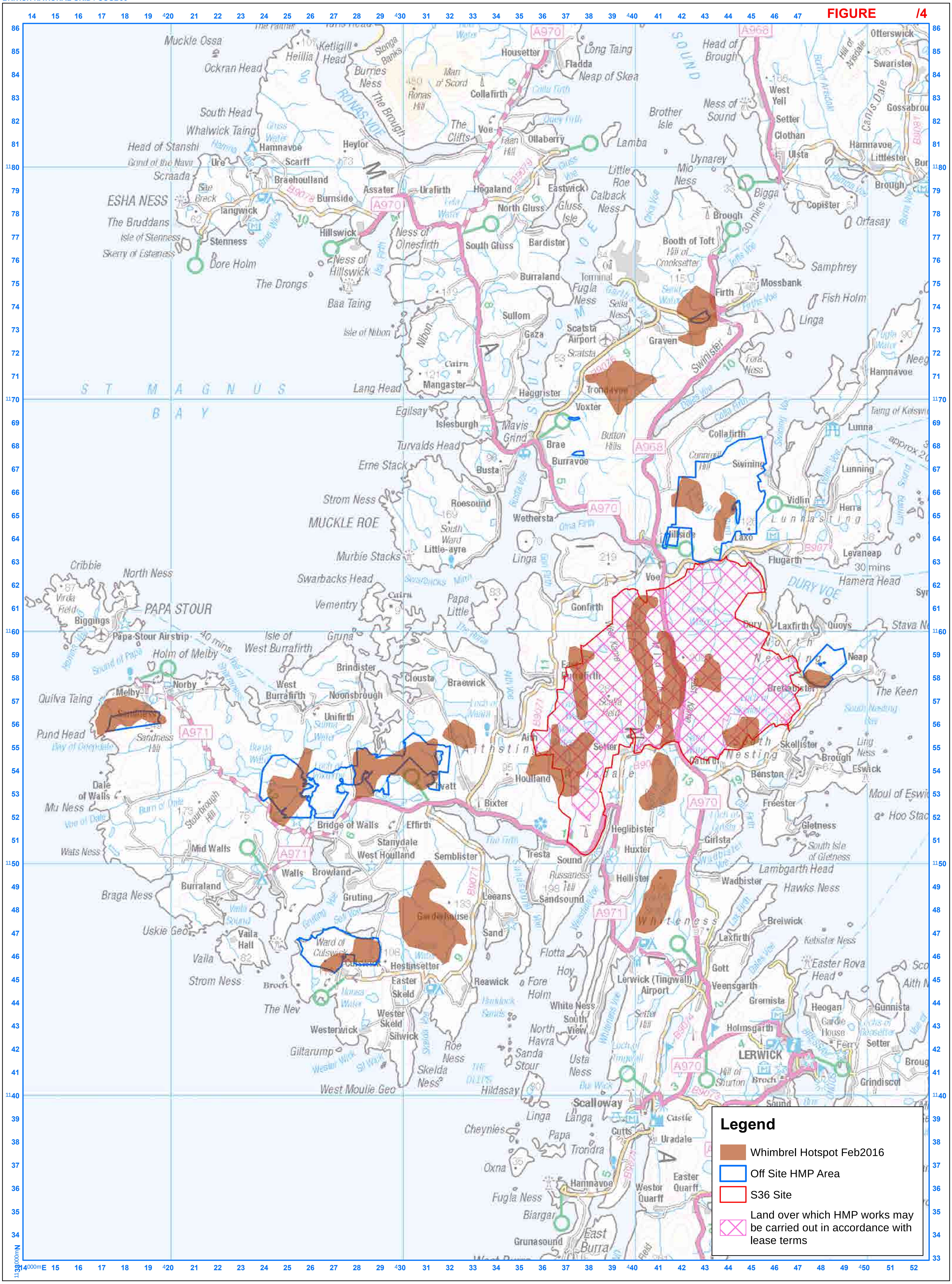
Produced by J McDougall
Viking Energy Wind Farm LLP
Dated: 08 Aug 16
Task No:VIKING_v2_000_RPS #3b

sse

BRITISH NATIONAL GRID / OSGB36

HMP AREA WITH POSSIBLE AREAS OF WHIMBREL ENHANCEMENT

FIGURE /4



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1:100,000 @ A2

0 1 2 3 4 5 Kilometres

N

viking energy

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sse