Technical Appendix 6.4

Watercourse Crossings Report

SCOTTISHPOWER RENEWABLES

Table of contents

1.1 Introduction 3

1.2 Route Selection 4
1.2.1 Access to the Development 4
1.2.2 Access Tracks 4

1.3 Crossing Descriptions 4
1.3.1 Assessment Method 4
1.3.2 Desk Study 4
1.3.3 Walkover Survey 4
1.3.4 Ecological Provision 5
1.3.5 Watercourse Crossing Assessment 5

1.4 Summary 5

1.5 References 6

1.6 Annex A – Watercourse Crossing Selection Guidelines 6
A.8.1. Small, Medium and Large Crossings 9
A.8.2. Bridges 9
A.8.3. Rectangular Culverts/Arches 9
A.8.4. Circular Culverts 9
A.8.5. Multiple Culverts (Circular) 10
A.8.6. Multiple Culverts (Rectangular) 10
A.8.7. Ecological Provision 10
A.8.8. Construction 10

1.7 Annex B - Description Sheets for CAR-Applicable Watercourse Crossings 17

1.8 Annex C – Minor Watercourse Crossings 27
1.8.1 Photographs 28

1 Watercourse Crossings Report

1.1 Introduction

1. This report provides additional information to **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** and should be read with reference to the chapter and associated figures presented in Volume 2. Hydrological features, including catchments, are shown in **EIA Report Figure 6.7**.

2. Consent for an eight turbine windfarm (Harestanes South Windfarm Extension) is sought by Scottish Power Renewables under Section 36 of the Electricity Act 1989. Harestanes South Windfarm Extension (Proposed Development), is located approximately 14km north of Dumfries.

3. The Site consists mainly of commercial conifer plantation, with clear-felled areas predominantly in the north east. Peat is notable in open areas, such as forestry rides, clearings and in the vicinity of surface water bodies.

4. Elevation of the Site undulates, reaching a peak at Pumro Fell, 393m AOD. Other hills include Kirkland Hill, 343m AOD, Whitefauld Hill, 351m AOD, Muir Hill, 333m AOD and Brownmoor Hill, 350m AOD.

5. The Site is located entirely within the Kinnel Water catchment, with a total catchment area of 229km^2 and spans the catchments of two of its tributaries, the Water of Ae (143.1km^2 catchment area) and Mollin Burn (6.9km^2 catchment area).

6. The northern extent of the Site is drained by the Deer Burn (5.0km^2 catchment area) which flows in a south-westerly direction to join the Water of Ae, 1.7km from the existing crossing where the burn is channelled beneath the existing forestry track, east of Muir Hill.

7. The central part of the Site is drained by the Glenkiln Burn (9.9km^2 catchment area), which flows in a south-westerly direction to join the Water of Ae, 7.8km from the existing crossing where the Ox Cleuch (Glenkiln Burn tributary) is channelled beneath the existing forestry track, north of Whitefauld Hill.

8. The eastern extent of the Site is drained mainly by the Garrel Water (2.4km^2 catchment area), which flows in a south-easterly direction to join the Kirkland Burn, 5.9km from where Garrel Water crosses the Site Boundary. The far eastern extent is drained by WhiteKnowe Head Burn (0.5km^2 catchment area), which flows in a south-easterly direction to join the Mollin Burn, 3.3km from where it crosses the Site Boundary.

9. The Kirkland Burn drains part of the southern extent of the Site and flows south adjacent to the existing Harestanes Windfarm access track, then flows in a south-easterly direction to join the Water of Ae, 7.0km from where Kirkland Burn crosses the Site Boundary.

10. The western extent of the Site is drained by the Clachanbirnie Burn (1.7km^2 catchment area) which flows in a south-easterly direction to join the Glenkiln Burn, 1.8km from where the burn crosses the existing forestry track north of Brownmoor Hill.

11. The narrow extension of the Site Boundary in the north incorporates a proposed cable route which would cross numerous watercourses, including Glenkiln Burn (9.9km2 catchment area), Auchendowal Sike (1.0km2 catchment area), Ox Cleuch (4.2km2 catchment area), Auchencaigroch Burn (0.9km2 catchment area), an unnamed tributary of Water of Ae (2.9km2 catchment area), Blenoch Burn (0.6km2 catchment area), Deer Burn (5.0km2 catchment area) and Water of Ae (u/s Goukstane Burn).

12. Compliance with The Water Framework Directive (WFD) (2000/60/EC) is required due to potential impacts of the Proposed Development on the water environment. The WFD has been transposed into Scottish legislation as the Water Environment and Water Services (Scotland) Act 2003 (WEWS) and has given Scottish Ministers powers to introduce regulatory controls over activities in order to protect and improve Scotland's water environment. The water environment includes wetlands, rivers, lochs, transitional waters (estuaries), coastal waters and groundwater. These regulatory controls, the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (known as CAR), specify that it is an offence to undertake the following activities without a CAR authorisation:

- Discharges to all wetlands, surface waters and groundwater (replacing the Control of Pollution Act 1974 (CoPA));
- Disposal to land (replacing the Groundwater Regulations 1998);
- Abstractions from all wetlands, surface waters and groundwaters;
- Impoundments (dams and weirs) of rivers, lochs, wetlands and transitional waters; and
- Engineering works in inland waters and wetlands.

13. Watercourse crossings (engineering works in inland waters and wetlands) comes under Section 6 of CAR. Three different types of authorisation under CAR allow for proportionate and risk-based regulation. The authorisation process operates at three levels which are:

- General Binding Rules;
- Registration; and
- Licence.

14. These levels cover activities with increasing potential impact upon the environment. Minor watercourses, which do not feature on the 1:50,000 scale Ordnance Survey mapping, are not within the remit of CAR regulations. However, these minor watercourse crossings have been considered within this report.

15. It would be the objective of SPR to ensure that all activities remain within the General Binding Rules (Engineering Activities) identified in The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide, Version 8.4, October 2019 (SEPA, 2019). Should activities be determined to be outwith the above GBR and Registration authorisations, it would be appropriate to consider a licence application (simple or complex). The SEPA Regulatory Method (WAT-RM-02) Regulation of Licence-level Engineering Activities (SEPA, 2019) lists conservation, environmental standards for morphology and good practice as tests for any licence application. During the determination, SEPA shall consider the specific location, type, size and existing water quality of the local water features.

16. The applicable Engineering Activities General Binding Rules (GBR) and Registrations that this application shall adhere to are as follows:

- General Binding Rule 6 – Minor bridges with no construction on bed or banks;
- General Binding Rule 8 – Controlling bank erosion by green bank reinforcement or re-profiling;
- General Binding Rule 9 – Operating any vehicle, plant or equipment (machinery) when undertaking other GBR activities (which includes GBR 6 and 8);

- Registration – Bridges with no construction on bed and <20m of total bank affected (open-based culverts would be anticipated to fall within this category);
- Registration – Where cables are not appropriately located to cross water channels via newly installed track infrastructure, it would be anticipated a Registration would be required, as cables would be anticipated being installed via isolated open-cut technique, due to small channel size; and
- Simple Licence – for all other bridges, fords and causeways, such as those with construction on bed and greater than 20m of total bank affected.

1.2 Route Selection

17. Before considering watercourse crossings in detail, SEPA will wish to satisfy themselves that 'good practice' has been followed, which in their terms means avoidance or minimisation of the number of crossings. The number of crossings is a function of the access route. In the case of most windfarms the purpose of the access roads is to link up the turbines, although occasionally there are ancillary purposes such as provision of haulage routes for timber extraction or borrow pit access.

18. The main factors that would be considered in determining a route include:

- Turbine and other infrastructure locations;
- Maximum track gradient suitable for the type of traffic and loads;
- Other track geometry factors such as bends and junction layouts;
- Stability and bearing capacity of the ground and adjacent slopes;
- The volumes of 'cut' and 'fill' to ensure a suitable track alignment;
- Land take (primarily determined by route length);
- The type and nature of bridging structures;
- Sensitivity (flora, fauna, soils, water, human, etc.); and
- Whole life costs (construction and maintenance).

19. Given this non-exhaustive list, optimum track geometry has been determined to link up the turbines and other development infrastructure. The development of access tracks is inevitably a compromise between several constraints: the desire to locate turbines on areas of stable and / or shallow peatland; environmental constraints; and routing access tracks away from difficult terrain, where practicable, means that the track geometry is constrained by ecological and topographical features to arrive at an optimum strategy.

20. There is not a direct link between that 'optimum' and 'good practice' in the WFD context, which is oriented towards the water environment; however, watercourse crossings should be avoided or minimised. In addition, the use of existing crossings, where feasible, would reduce the impact on the water environment.

1.2.1 Access to the Development

21. Access to the Site would be via an existing track linking the main windfarm area to the A701 in the south-east at a junction located approximately 14km north of Dumfries. The access route proposed is shown on **EIA Report Figure 6.7 Hydrology Overview**.

1.2.2 Access Tracks

22. The access track network within the Site would run from the south eastern entrance and connect all turbine locations, Turbines 1 to 8.

23. Potential upgrades to nine of the ten existing watercourse crossings present within the Site may be required as part of the Proposed Development and would be subject to CAR.

24. Approximately 3.1km of new access tracks would be constructed and 12.0km of existing track would be upgraded.

25. A key objective of the WFD is that water bodies achieve at least 'Good' status by 2027. SEPA classify surface water bodies using five classes: 'High', 'Good', 'Moderate', 'Poor' or 'Bad'. The classifications take into account pressures and their potential effects, compared to near natural conditions for the respective water body (SEPA, 2018b).

26. The WFD classification (2016) for SEPA water bodies (SEPA, 2018c) have been provided in **Tables 6.8** and **6.10** of **Chapter 6**, with the Glenkiln Burn, Kirkland Burn and Garrel Water (u/s Kirkland Burn) classified as Poor overall status.

1.3 Crossing Descriptions

1.3.1 Assessment Method

27. The catchment-based approach in this assessment follows that discussed in **Chapter 6**.

28. The project involved a desk study and walkover surveys. This work is underpinned by the watercourse crossings selection guidelines that have been developed by WSP in support of windfarm projects. These guidelines have evolved over a number of windfarm projects and have incorporated valuable input from SEPA and SNH. The guidelines, presented in Annex A, assist in selecting an appropriate type of watercourse crossing dependent on the physical and ecological characteristics of the watercourse.

1.3.2 Desk Study

29. The desk study consisted of a review of the information regarding the development, principally involving an examination of the proposed track layout and cable route, and the identification of watercourses marked on the OS 1:50,000 scale map which would require crossings, under the CAR Regulations. Crossings of minor watercourses were also identified at OS 1:10,000 scale mapping, where possible. This information informed the design to minimise crossing locations of all mapped watercourses.

1.3.3 Walkover Survey

30. Subsequent to the initial desk study, walkover surveys of the Site were conducted between March 2020 and September 2020, during which the identified crossings were visited to obtain specific information about each location. Photographs and detailed field notes were taken reporting channel dimensions, and valley, channel substrate, and type of either the existing or proposed crossing. A hand-held GPS unit was used to obtain locations with greater than 10m accuracy.

31. A number of unmarked watercourses were observed during the walkover surveys and details were recorded to give as complete a list of crossings as possible, to help inform the track construction process.

32. All watercourse crossings (both CAR and non-CAR crossings) are shown on **EIA Report Figure 6.7**. CAR crossings are labelled as WC, non-CAR crossings are labelled as WX.

1.3.4 Ecological Provision

33. For each crossing, there is provision to indicate the likelihood of the watercourse being used by mammals, principally otters and water vole, and fish.

34. Where mammal or migratory fish presence is confirmed or suspected, appropriate design features would be included within the crossing design. These may include incorporation of ledges or additional dry passages to allow passage at high water levels, in-channel baffles or low water channels to aid fish passage, and other design features appropriate for the crossing location. Track design has considered good practice guidance and recommendations in the Design Manual for Roads and Bridges (Highways England, 2020). A 50m hydrological buffer has been applied to all infrastructure except where watercourse crossings are required, with track construction minimised within this buffer.

35. The protected mammals surveys found evidence of the presence of otter within the site, with signs of activity on the Yellowtree Grain, Auchencaigroch Burn, and a small, unnamed tributary of Water of Ae. Evidence of water vole was recorded in the north east of the Site, on the Glenkiln Burn, and Auchencaigroch Burn. Areas considered to provide moderate habitat for both otters and water voles include tributaries of Glenkiln Burn, Clachanbirnie Burn, Cat Cleuch and Black Linn.

36. Fish surveys were undertaken to provide baseline information on the riparian habitat and fish populations of the major watercourses. The Glenkiln Burn, Rough Cleugh and associated tributaries were noted to be important spawning and rearing areas for trout (**Appendix 7.3: Aquatic Ecology Report**, River Annan Fisheries Board (2013)).

1.3.5 Watercourse Crossing Assessment

37. The watercourse crossing guidelines in Annex A provide a generic approach to crossing various types and sizes of watercourse.

1.3.5.1 CAR Watercourse Crossings

38. A total of 10 watercourse crossings where CAR apply have been identified from the final track layout, with reference to 1:50,000 OS mapping. These are required to accommodate construction and operation of the Proposed Development. Of these crossings, seven watercourse crossing locations are required for the proposed track upgrades; two cable route crossing using an extended culvert and one cable crossing utilising an existing bridge structure not requiring watercourse engineering works. These crossings are mapped on OS 1:50,000 scale map and therefore subject to CAR. It has been assumed that nine of these existing locations have a structure in place that requires upgrading. The upgrading will be required if the crossing falls within a track section that requires upgrading. This will be investigated further during detailed design stage.

39. Annex B contains information about each CAR watercourse crossing, providing location data and photographs of the watercourse and ecology data. An assessment of the catchment area upstream of the crossing is given so that the required conveyance capacity of the bridging culvert or bridge may be calculated or checked at the design stage to confirm appropriate sizing.

40. A summary of the CAR watercourse crossings is provided in **Table 6.5.1**, giving the classification by watercourse size, with the different types of crossings across the development. Watercourse sizes are defined in Annex A.

Infrastructure	Crossing Type	Watercourse Size			
		Large	Medium	Small	Total
Track Upgrades	Bridge	-	WC02	-	1
	Rectangular culvert / arch	-	-	-	-
	Open base arch structure	-	-	-	-
	Circular culvert	-	WC03, WC06, WC07	WC01, WC04, WC05	6
	Drainage layer	-	-	-	-
Cable crossings at existing track crossing locations	Extended culvert – circular pipe	-	-	WC10, WC08	2
	Suspended to bridge	-	WC09	-	1
Total		-	5	5	10

Table 6.5.1: Summary of Types and Sizes of CAR-Applicable Watercourse Crossings

1.3.5.2 Minor Watercourse Crossings

41. Minor watercourse crossings noted within the 1:25,000 OS map are summarised in Annex C and will help to inform the track construction process, as these and others similar, would be likely to be regularly encountered where new track is created. It should be noted that this list is not considered comprehensive.

1.4 Summary

42. The design of the infrastructure has attempted to minimise the number of new watercourse crossings, resulting in the proposal to use seven existing watercourse crossing structures to cross watercourses shown on the OS 1:50,000 mapping, subject to CAR. These locations would be required for access across the Site and would require structural upgrades to widen the access track at watercourse crossings, using the existing structure as support to minimise disruption to channel bed or banks, if possible.

43. Where access necessitates watercourse crossings, construction features have been limited in these buffers as far as possible, for example minimising tracks running parallel to streams and trying to avoid track junctions being constructed in these zones. This approach has resulted in seven watercourse

crossing locations for the proposed track upgrades; two cable route crossing using an extended culvert and one cable crossing utilising an existing bridge structure not requiring watercourse engineering works. These crossings are mapped on OS 1:50,000 scale map and therefore subject to CAR. Nine of these existing locations have a structure in place that requires upgrading.

44. There would also be a requirement for a number of non-CAR applicable crossings, anticipated as open-bottom arch (con/span) culverts or circular culverts, depending on the size of the watercourse. The location of minor crossing locations have been provided (Annex C), which represent typical stream characteristics that would require crossing structures on access tracks.

45. Prior to the construction of the Proposed Development, it is anticipated that additional data to that provided in this report would be required. This information would include more detailed measurements in relation to structure dimensions and further refinements for flow conveyance and any ecological provision at each crossing, forming the detailed design stage. A number of the existing crossings may not need upgrade, with this engineering decision to be determined pre-construction.

46. It is anticipated that 9 crossing structures, seven watercourse crossing locations for the proposed track upgrades and two cable route crossing using an extended culvert, would require CAR Registration (as no in-channel supports are anticipated). However, should bridge structures require work that affects 20m or more of total river bank, these would escalate to Simple Licence applications.

1.5 References

47. Highways England (2020). Design Manual for Roads & Bridges. Highways England. [online]. Available from: https://www.standardsforhighways.co.uk/dmrb/ [accessed August 2020].

48. River Annan Fisheries Board (2013). Fish Population Surveys in Relation to Construction of the Harestanes Windfarm Development.

49. SEPA (2019a). Regulatory Method (WAT-RM-02) Regulation of Licence-level Engineering Activities, Version 6.1, January 2019. Scottish Environment Protection Agency.

50. SEPA (2019b). Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended): A Practical Guide, Version 8.4, October 2019. [online]. Available from: https://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf [accessed August 2020]

51. SEPA (2018). Water Classification Hub. [online]. Available from: https://www.sepa.org.uk/data-visualisation/water-classification-hub/ [accessed August 2020]

52. WSP (2020). EIA Report Chapter 6: Hydrology, Hydrogeology, Geology and Soils for Harestanes South Windfarm Extension.

1.6 Annex A – Watercourse Crossing Selection Guidelines

A.1. Introduction

53. Windfarms have been proposed and constructed in a wide range of landscapes which have varying forms of topography, land use and habitat. In any new development there is the likelihood of new access roads being constructed which would require crossing watercourses, ditches and other features, such as peat haggs. In some instances, there may also be existing crossings that require a structural upgrade. Additionally, some of the features may only intermittently convey water.

54. In Scotland, many of the windfarms are on hilltops thus the majority of the crossings are over small headwater burns or minor watercourses. In engineering terms, the usual approach has been to place circular culverts into the stream bed and build the access track on an embankment above the culvert. This approach, and associated good practice, as given in The Forests and Water Guidelines (Forestry Commission, 2011), has been used for over 30 years in the construction of forestry access roads. Where a single circular culvert would be inadequate, twin or triple culverts have been used or, on wider watercourses, rectangular culverts or conventional abutment bridges may be installed.

55. Although windfarm developments may be located in areas of similar terrain to forestry plantations, higher standards for watercourse crossings are expected. In part, this is because some Proposed Developments are in forestry areas that would not have been considered in the past and there is a limited history of practical engineering solutions. The main driver for a change from past practice is the introduction of the Water Framework Directive (WFD) and its associated Regulations. Under these regulations, it is ecological status that has primacy over engineering and the conveyance of flows.

56. Most proposals which would involve engineering activity in the vicinity of water have to be submitted to Scottish Environment Protection Agency (SEPA) for appraisal and, depending on the scale of the work and sensitivity of the waters, may require registration or licensing.

57. The adoption of best practice guidelines is recommended in the design of watercourse crossings in order to remain compliant with CAR regulations. Such guidelines should include a procedure for watercourse characterisation and a list of appropriate options for spanning each watercourse type. This would provide a tool for evaluating the numbers, types and potential impacts of the crossings. It is intended that full acknowledgement should still be taken of the Forest and Water Guidelines as well as the CIRIA Culvert, screen and outfall manual (C786F) (CIRIA, 2019), which focuses mainly on engineering features.

A.2. Method

58. The morphological conditions of watercourses, namely planform, cross-sectional form, bank form and floodplain type and characteristics were defined. These were considered in conjunction with the range of potential engineering activities associated with watercourse crossings, such as fords, culverts (circular and rectangular), arches and abutment supported bridges. A set of guidelines were used to define appropriate watercourse crossing type based upon the watercourse (morphological) characteristics and required ecological considerations.

59. Ecological issues should consider not only the operational aspects of the proposed watercourse crossing structures, but also the risks and duration of construction impacts on ecological receptors. Key risks to ecology may include the requirement of stream-bed continuity (to avoid significant negative local effects on aquatic ecological and fishery receptors) or the passage of mammals,

A.3. Watercourses

60. Windfarm developments may potentially cross many types of water features. Thus, in the context of this document 'watercourse' needs to be seen in a broader sense than a burn or stream alone and needs to encompass the following:

- Natural burns and streams as normally perceived;
- Ditches and drains as encountered alongside roads, in moor gripping or forested areas;
- Incised channels in peat (also known as haggs or gullies);
- Peat pipes; and
- Flushes.

61. Of these features, it is the natural watercourses that typically display the greatest morphological diversity (such as size and cross-sectional profile). They may also be regarded as being the most ecologically sensitive as they typically tend to support the most valuable assemblages of aquatic flora and fauna with high individual nature conservation and fishery value. However, it must be recognised that this guideline is not intended to cover major river crossings where many other factors would come into play.

62. In cross-section, ditches and drains tend to be regular and trapezoidal and have a flow regime which may be transient. Nevertheless, they provide refuge, corridors for movement and offer damp habitats for certain species, such as frogs.

63. Haggs and peat pipes are natural features within areas of blanket bog. Gullies between haggs are formed where the force of water has eroded the peat; these could be up to 5m deep and frequently take the form of a narrow irregular 'V' or broad 'U' shape. They act as drainage channels following periods of prolonged rainfall. The formation of peat pipes is not well understood, but these often occur at the peat/mineral soil interface and could be 0.5m diameter but are usually significantly smaller.

64. Flushes usually occur at the headwaters of watercourses where flow is predominantly sub-surface interflow with perhaps some overland flow during wetter periods. Flushes are usually located within a concave part of the hillside; they have no defined channel and the width of the flush may vary considerably depending on the terrain.

65. Within watercourses, a large range of channel substrate and bank materials may be encountered including organic soils, clays, gravels, boulders and bedrock.

66. Some channels within the Site only convey intermittent flow. Furthermore, for aquatic ecology, fish are confined to burns and streams with amphibians having a more widespread habitat and may utilise the wet and damp conditions of ephemeral watercourses.

A.4. Structures

67. The envisaged structural components of the crossing may comprise circular or rectangular culverts, segmental arch sections or a bridge deck set upon abutments. Construction may use a variety of techniques and materials – steel, precast and in-situ concrete, plastics and timber.

68. Table A1 sets out the generally available sizes and materials in which these elements may be procured.

Type	Materials	Size Range (mm[1])		Comments
Circular Culvert	Precast concrete	200[1]	2400	High strength and durable
	Corrugated metal	300	6000	
	Plastic	100	600	
Rectangular Culvert	Precast concrete	1000 x 600	4800 x 3000	Large range of widths and heights
Open-Base / Segmental Arch	Pre-cast concrete	2000	10000	No interference with stream bed
	Corrugated metal			
Bridge Decking	Pre-cast concrete	4000	10000	Standard Beam with in-situ deck
	Steel & Concrete			Steel Beam with in-situ deck
	Timber	2000	4000	Limited life / load capacity
Abutments	In-situ concrete	-	-	Conventional construction
	Pre-cast sections	-	-	Reinforced earth techniques
	Masonry	-	-	May be in the form of gabions

Table A1: Sizes and materials for structural components

[1] Although pipes may be available in these smaller sizes the CIRIA minimum recommended diameter for any circular culvert is 450mm.

69. The suggested range of diameters or spans for which these different structures may be applied should be regarded as indicative. Particular manufacturers of pipes, box culverts and arch systems have a greater or lesser range and bespoke solutions such as bridges can be almost of any size.

A.5. Ecological Provisions

70. Ecological provision for fish and mammals need only be provided where there is reasonable evidence that these animals occupy or migrate through the locus of the proposed crossing. For example, fish may be entirely absent upstream of a natural barrier, such as a waterfall or a reach with a non-navigable

gradient and high flow velocities. Similarly, field surveys may have failed to establish the presence of any of the designated mammals and that habitats are such as to be unlikely to attract inward migration.

71. Conversely, if the need for ecological provision has been established then this should take an appropriate form, which would depend on the species and the physical nature of the crossing. In general, the provisions at burns and streams may encompass:

- Mammal ledges within the crossing and at top of bank elevation;
- Mammal tunnels adjacent to the watercourse and accessible from bank level;
- Continuity of stream bed comprising natural indigenous material;
- Absence of a step in the water levels in excess of 300mm;
- No reduction in overall width or natural fluctuation of depth; and
- Reinstatement of natural vegetation to provide 'cover'.

72. This guideline does not provide any methodology for assessing the ecology of the Site in general, or the specific location of the proposed watercourse crossing. This guidance only provides information on the requirement for ecological provision at the proposed watercourse crossings.

A.6. Hydraulic Sizing

73. The CIRIA Guidelines provide recommendations on calculation methods for the design flood to be passed through a culvert without risk of structural damage. In the absence of a historically significant period of actual flow records, the recommendation is to use the Flood Studies Report (Institute of Hydrology, 1993). Although valid at the time the guidelines were produced, the normal method would be to use the Flood Estimation Handbook Web Service (Centre for Ecology and Hydrology, 2020) and the associated digital model of channel networks.

74. The design standard in terms of flood severity is normally expressed as a return period. Windfarms are typically located in rural areas with access tracks generally conforming to forestry type roads where bridging culverts have been designed to a 1:50 year return period. Due to climate change it is suggested that a 0.5% annual exceedance probability (1:200 year) plus climate change allowance standard is now adopted. For information, on the basis of the Flood Studies Report the approximate growth factors on Qbar (about 2 a year return period) for Region 1 (Scotland) for various return periods is set out in **Table A2**.

Return Period	Growth Factor
15	1.7
25	1.9
50	2.2
100	2.5
200	2.8
300	3.0
400	3.1
500	3.2

Table A2: Return period growth factors

75. This shows that, between the 1:50 year to 1:200-year return period, there is a 27% increase in flood. This is considered to be an adequate uplift for bridges or culverts where a small amount of transient upstream ponding would be of no consequence.

76. Furthermore, in terms of sizing rectangular culverts where there is a need to re-establish a natural stream bed, it is proposed that an additional 450mm is added to the vertical dimension so that the structure may be a depressed invert culvert, installed below natural bed level.

77. Note, however, that the digitised channel network is based on the watercourses visible on a 1:25,000 scale Ordnance Survey (OS) map. It may be that many of the smaller crossings in a particular development do not feature at this scale, nor would other features such as drainage ditches or moor grips. Thus, a pragmatic approach along with hydrological judgement may be required where definitive calculations are not practical. Thus, the range of options may comprise:

- Comprehensive use of FEH featuring the actual stream to be crossed;
- Utilise surrogate watercourse to calculate unit flow rates per hectare and then pro-rata to the specific crossing;
- Consider watercourse morphology to estimate 1-2-year return period flow based on bank full condition and then scale to design return period;
- Consider channel morphology and 'match' conveyance capacity of existing channel so that crossing unlikely to form a restriction.

78. Although these may appear to be in decreasing order of sophistication it should be borne in mind that the regression equations for Mean Annual Flood (MAF) are not precise and may under or overestimate actual values. The error in the estimate does not improve when scaled up to the design return period. The channel morphology has been shaped by actual flow characteristics and recognising that may provide useful insight to past flood levels.

79. Where the crossing takes regard of migratory fish, the Scottish Government issued guidelines (Scottish Executive, 2012) which provide important design criteria such a minimum width and depth of water, maximum velocity of flow and provision of rest pools. These parameters are species and culvert length dependent.

A.7. Selection Process

80. The process of 'mapping' watercourse characteristics to a suitable form of crossing is conceptually simple. It is a case of matching several physical / ecological criteria to the most appropriate crossing type.

81. In practice, there are many permutations of watercourse, topography, bed materials etc. that can be considered. The number of categories of each attribute is set out in **Table A3**.

Type of Attribute	Options	Cases
Watercourse types	5	Stream, Ditch, Peat Hagg, Peat Pipe, Flush
Setting / Context	6	Incised, Broad, Road drain, Land drain, Buried, Surface
Size	3	Small, Medium, Large (predominantly as in width)
Ecological Provision	2	Yes, No

Table A3: Description of watercourse attributes

82. If every one of these attributes were permutated without regard to feasibility there would be 180 permutations; however, this reduces to 47 if anomalous physical combinations, such as buried streams or surface peat pipes, are discounted.

83. The number of options can be further reduced to 25 by considering only those that make environmental sense - thus fish migration within peat pipes is not a recognised phenomenon for which provision needs to be made. The reduction in numbers has been based on removing 22 hypothetical cases of Ecological Provision where it is believed that the case for mammal ledges / passes and natural bed reinstatement either do not make sense or cannot be justified. Of these, seven relate to road side ditches or small land drains, eight to peat haggs, four to peat pipes and four to flushes. In all of these cases, fish are neither present, nor mammals likely to be impeded.

84. The selection process can be reduced to a decision table, **Table A5**, whereby working from left to right across the columns a watercourse crossing type is determined. This table is also available as a spreadsheet and, with auto-filtering, allows a rapid check to be made of alternatives where a classification is marginal. A summary count of the options is given in **Table A4**.

Water feature	Number of options	Arch / Bridge	Culvert / Pipe	Comments
Streams	12	4	8	All large streams crossed by bridge / arch
Ditches	5	-	5	Only large ditches would justify bridges
Peat Haggs	4	-	4	None.
Peat Pipes	2	-	2	Pipes ensure continuity of subsurface flows
Flush	2	-	2	
Total:	**25**			

Table A4: Summary of crossing options

A.8. Decision Rationale

85. In drawing up the choice of crossing type and the form of ecological provision a number of assumptions have been made. In effect these are embedded in the table and the rationale for making certain choices is explained below.

A.8.1. Small, Medium and Large Crossings

86. Within the crossing type selection table, watercourse size is expressed in terms of small/medium/large but without actual dimensions being stated. In part this is because the table covers a range of features such as peat haggs, ditches and streams where “large” in one context may not be “large” in another. However, within the category of streams and for the following dimensions are proposed:

- Small - less than 1m;
- Medium - between 1m and 3m;
- Large - greater than 3m.

87. For other features, such as haggs, flushes etc., the size differentiation is not significant in determining crossing type; it merely governs the diameter or number of circular conduits to ensure drainage is unimpeded.

A.8.2. Bridges

88. Where the watercourse is of significant width or the stream is within a deeply incised valley, a conventional abutment bridge may offer the best practical engineering solution whether or not ecological provision has to be made. In some cases, the bridge may be multi-span with one of more supports required within the watercourse. Where technically possible the abutments would be set back by at least 1m from the banks of the watercourse, if these are well defined. However, over the passage of time erosion/deposition could change this marginal strip between the abutment and watercourse, unless “hard” engineering is employed, which may not be desirable.

A.8.3. Rectangular Culverts/Arches

89. Rectangular culverts and arches can be used where there are watercourses narrower than those appropriate for bridge construction but which have a requirement to provide mammal and / or fish passage and ensure sufficient hydraulic capacity during peak flow periods. Rectangular culverts may incorporate mammal ledges and can be buried below stream bed level to enable the formation of a natural channel bed.

90. Arches minimise disruption to stream banks and base and enable mammal passage.

A.8.4. Circular Culverts

91. In all cases where there are no ecological provisions to be made, it is assumed that neither natural bed material, water velocity nor depth are critical other than in the purely hydraulic sense. Thus, circular culverts provide an economic and viable solution.

A.8.5. Multiple Culverts (Circular)

92. None of the multiple culverts have ecological implications, so the rationale above for singular circular culverts applies. Multiple (usually twin) culverts have been considered a viable option where the crossing is wide and the use of a single circular culvert would require a disproportionately large diameter which would also raise the height of the crossing.

93. In the case of deeply incised streams, culvert height may not be a major factor as it may be accommodated without the need to raise the road level. In such cases, it is recommended that the Contractor decides on the most appropriate design solution, in consultation with SEPA. A single circular culvert is typically preferred by SEPA as multiple culverts may become blocked easily, thus creating a fish barrier and preventing sediment from being transported downstream (SEPA, 2010).

A.8.6. Multiple Culverts (Rectangular)

94. Multiple (usually twin) culverts have been considered a viable option where the crossing is wide. Although there is a reasonable range of width to depth ratios available for off-the-shelf precast units, there may be occasions where the topography and channel morphology would favour multiple culverts.

95. The decision table includes cases where ecological provision needs to be made and this can be designed into rectangular box culverts. The fact that there are multiple culverts means that there would be one or more piers within the watercourse, but the culvert sizing may be such as to ensure the original cross-sectional width is maintained. With twin culverts, it is also possible to set one at a lower elevation to act as a low flow channel.

96. 'Flashy' streams, particularly within incised channels, may lend themselves to rectangular culverts as a large height to width ratio can be employed to accommodate larger water level changes than would a circular culvert.

A.8.7. Ecological Provision

97. The determination of ecological provision requirement is provided in **Chapter 7: Ecology**. Where ecological provision is required for fish, the priority is that natural channel substrate is retained, which may be accomplished using depressed invert culverts. Where preservation of the bank is also deemed essential, the crossing type may be either a bridge or an arch to avoid impacts to the banks. Experience shows that in most cases the ground below a bridge or arch is unlikely to retain the former vegetation.

98. Where provision must be made for the passage of mammals, this may be accomplished by incorporating ledges at bank level within a rectangular culvert. Alternatively, a tunnel may be provided to one side of the watercourse.

99. The assumption has been made that wider crossings would be undertaken with a bridge resting on abutments which are clear of the stream edge. The smaller crossings may be constructed from segmental arches or similar – although small span bridges would be equally serviceable.

100. Inevitably, there would be some disturbance in the vicinity of the crossing during the construction period. The Environmental Management Plan/Pollution Prevention Plan (EMP/PPP) would address risk elimination and mitigation, particularly during the construction period. However, in addition to engineering, the reinstatement of vegetation must be integral to the design to provide 'rest / cover' areas.

A.8.8. Construction

101. As a rule, the more in situ construction, the more complex the task and the longer the duration of activity in the vicinity of a watercourse crossing, the greater is the risk of a hazardous or pollution incident arising. Thus, "constructability" is a relevant factor to consider when selecting the type of stream crossing solution.

102. For example, it may be possible to span a 3m stream using either a rectangular culvert or conventional abutment bridge. A bridge may take weeks to construct and involve in-situ concrete pours and require a temporary crossing to facilitate work at both sides. A bridging culvert could be put in place within days and, with bed reinstatement, it would appear no different from the bridge option. Thus, where there are competing options it would be prudent to evaluate all forms of risk during the construction and operational phase of the structure and not just the status of the structure when completed.

103. In addition to the cross-sectional geometry of the watercourse, geotechnical factors also have an influence on constructability. The practicalities of excavation for foundations or bed preparation would depend upon the surrounding material being 'hard' and 'soft'. If the bed or banks would require heavy percussion hammering, drilling, blasting etc. then the material is 'hard'. Where the bed can be excavated by hand or excavator then the material is 'soft', which may include rock that is weathered or weak. In either case it is assumed that the bed rock can be broken out to a depth sufficient to allow the normal 200mm of granular bedding on which to lay precast concrete units where this is the chosen option.

104. In the schedule of individual stream crossings an indication has been given as to what is considered to be the most appropriate crossing type. This is generally based on the selection matrix in Table A5; however, this is intended as guidance only. On occasions specific channel characteristics or local morphology may suggest some variation on the selection table is more appropriate. For example, the table may suggest a single circular culvert, but due to topographic considerations multiple circular culverts may be more appropriate.

105. A particular issue that may arise with small / ephemeral water courses is that the channel is ill-defined and on the day of the site inspection an optimum position for the culvert is unclear. These conditions are most likely to arise on small headwater streams that are unmarked on the OS 1:50,000 scale maps or in areas containing peat haggs. In these cases, it is anticipated that further observations would be made closer to the construction period. Also, some ditching or realignment immediately upstream may be necessary to convey flows towards the culvert to minimise ponding upstream of the crossing point.

106. A further issue to consider, in some instances, would be the provision of temporary crossings, perhaps to facilitate the construction of the permanent crossing or for some other purpose of limited duration. In these circumstances ecological provision to a lower standard may be inevitable although, as this would be temporary and perhaps seasonally phased, the actual impact may be negligible.

A.9 Diagrams

107. A selection of schematic diagrams has been produced to illustrate some of the watercourse crossings that may arise. These are shown in **Table A6** and although not every permutation has been drawn, the selection attempts to cover the most frequent situations and at the same time show a variety of key design features.

108. In the majority of cases, these diagrams only show cross-sections of the crossings, however the length of culverts and arches would depend on the depth of the embankment material above the soffit of the pipe or crown of the arch and the arrangement of any entrance and exit structures. A single longitudinal section is given as a general illustration.

109. For example, if the face of the embankment is at 45º and the road width (W), the fill material height above the soffit is F and the height of the opening is H then the length of the culvert would be; W + 2 x (F + H), approximately. This excludes possible entrance and exit wing walls or pools.

110. Thus, for a 6m wide road with 1.5m of fill on top of a 2m high rectangular culvert the length would be approximately 6 + 2 x (1.5 + 2); giving 13m.

111. The situation is somewhat different for bridges as there is no fill placed above the stream, only the bridge deck which would be marginally wider than the road. However, the base of the abutments would be wider than the banks of the watercourse. This would depend on the height of the road embankment and the side slope.

A.10 References

112. Centre for Ecology and Hydrology (2020). Flood Estimation Handbook Web Service.

113. CIRIA (2019). Culvert, screen and outfall manual (C786F), published by CIRIA.

114. Forestry Commission (2011). Forests and Water Guidelines, Fifth Edition, published by the Forestry Commission. [online]. Available from: https://www.confor.org.uk/media/246145/forest-and-water-guidelines.pdf [Accessed September 2020]

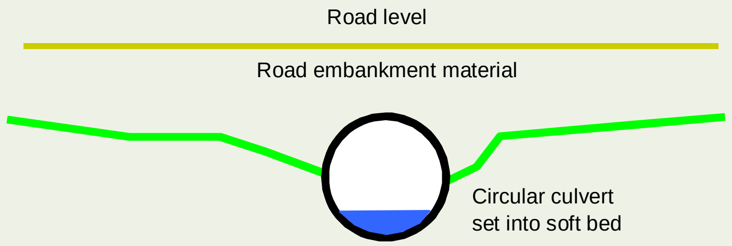
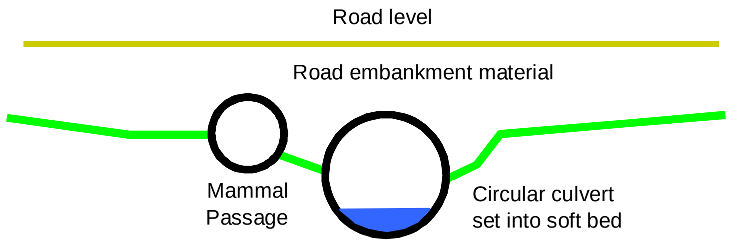
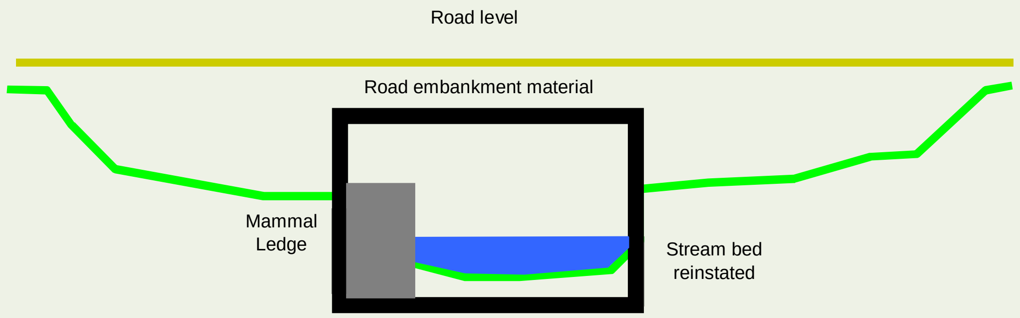
115. Institute of Hydrology (1993). Flood Studies Report.

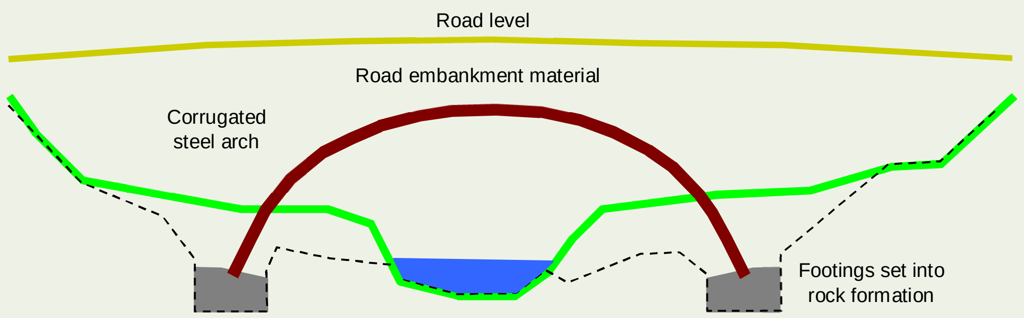
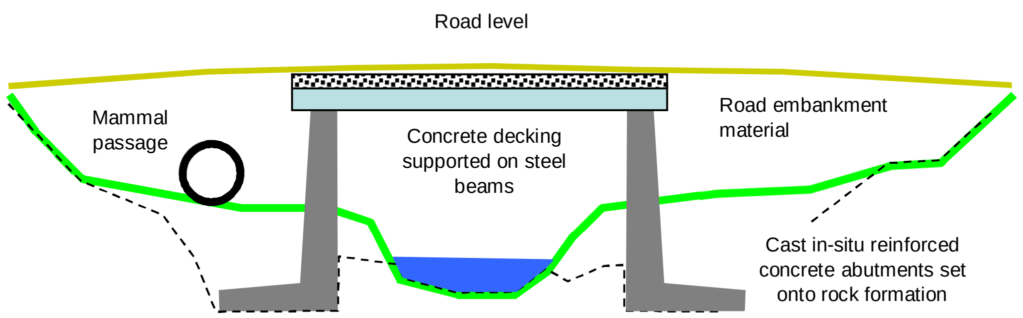
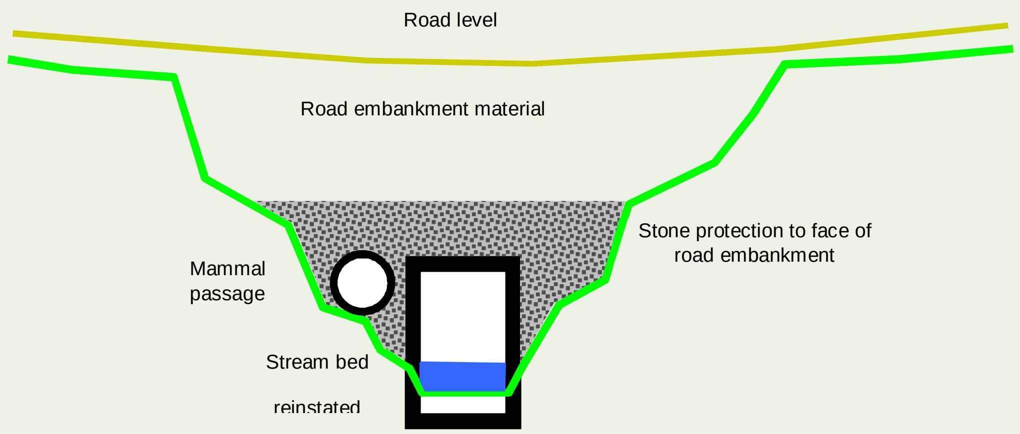
116. Scottish Executive (2012). River Crossings and Migratory Fish: Design Guidance, published by the Scottish Executive. [online]. Available from: https://www2.gov.scot/Topics/marine/science/Publications/publicationslatest/rivercrossings [Accessed September 2020]

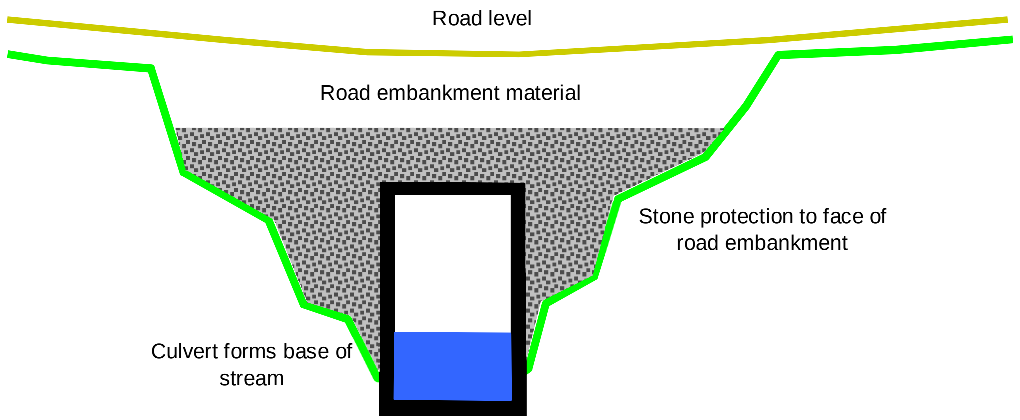
117. SEPA / Natural Scotland (2010). Engineering in the water environment: good practice guide. River Crossings. 2nd Edition. [online]. Available from: https://www.sepa.org.uk/media/151036/wat-sg-25.pdf [Accessed September 2020]

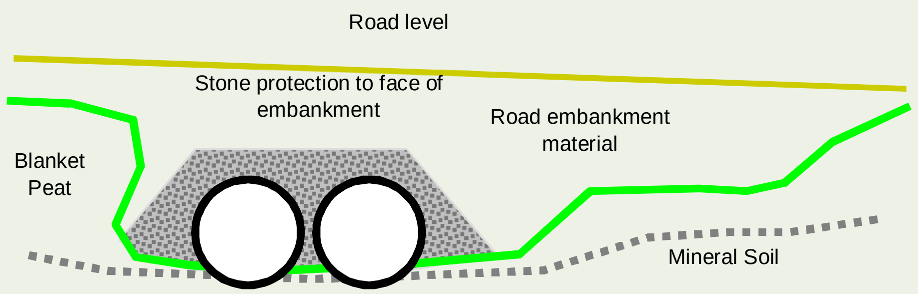
Code	Watercourse	CAR Applicable - Shown on OS 1:50,000 Mapping	Context	Size	Eco	Structure	Eco Provisions
WC01	Black Linn	Yes	Land drain	Small	Yes	Existing culvert to be upgraded to circular culvert.	The structure should permit the passing of mammals and fish.
WC02	Auchencaigroch Burn	Yes	Broad	Medium	Yes	Bridge.	The structure should permit the passing of mammals and fish.
WC03	Ox Cleuch	Yes	Land drain	Large	No	Existing culvert to be upgraded to circular culvert.	-
WC04	Auchendowal Sike	Yes	Land drain	Small	No	Existing culvert to be upgraded to circular culvert.	-
WC05	Rough Cleuch	Yes	Land drain	Small	No	Existing culvert to be upgraded to circular culvert.	-
WC06	Clachanbirnie Burn	Yes	Broad	Medium	Yes	Existing culvert to be upgraded to circular culvert.	The structure should permit the passing of mammals and fish.
WC07	Yellowtree Grain	Yes	Incised	Medium	Yes	Existing culvert to be upgraded to circular culvert.	The structure should permit the passing of mammals and fish.
WC08	Auchencaigroch Burn	Yes	Broad	Medium	No	Existing circular pipe to be upgraded, which will involve extending the pipe and run the cable in a trench adjacent to the road.	The structure should permit the passing of mammals and fish.
WC09	Deer Burn	Yes	Broad	Medium	Yes	Existing steel cable bridge to be upgraded with the inclusion of cable suspending to bridge.	The structure should permit the passing of mammals and fish.
WC10	Unnamed Tributary of the Water of Ae	Yes	Incised	small	Yes	Existing circular pipe to be upgraded which will involve extending the pipe and run the cable in a trench adjacent to the road.	The structure should permit the passing of mammals and fish.

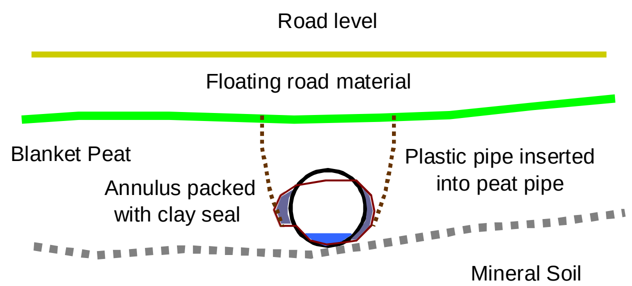
Table A5: Crossing type selection table

	Sketch of Channel Cross-Section / Longitudinal Section	Comments
1	**Stream: Broad valley, Small channel, No Eco provision** 	Typical of small headwater burns on rolling topography, perhaps before slopes become steeper and streams gather volume and energy and are more incised. Altitude or downstream topographic features exclude the possibility of fish being present. A circular precast concrete or plastic pipe would be placed on bedding material so that the invert is aligned with the original bed level. The pipe diameter would be sized by inspection of stream morphology because calculations alone may only provide the illusion of precision.
2	**Stream: Broad valley, Small channel, Eco provision** 	Typical of small burns on rolling topography, similar to (1) but where there is a requirement for mammals to pass along the watercourse. A circular precast concrete or plastic pipe can be placed on bedding material so that the invert is aligned with the original bed level. The mammal passage would need to be at top of bank level and comply with minimum diameter requirements.
3	**Stream: Broad valley, Medium channel, Eco provision** 	Typical of mid reach ‘Highland’ streams with granular and cobbled beds. The habitat is well suited to resident and migratory fish. Aquatic mammals are present. The rectangular box culvert structure would contain a reinstated natural bed and the width would allow for the provision of mammal ledges aligned with the banks. The freeboard would provide passage for the design flood flows.

	Sketch of Channel Cross-Section / Longitudinal Section	Comments
4	**Stream: Broad valley, Large channel, Eco provision (or not)**  	Typical of mid reach streams where superficial drift deposits are shallow. The stream has cut to the rock and the bed consists of boulders and intact rock. Placing rectangular box culvert(s) would require bedrock to be broken and excavated. An alternative to (5) using corrugated metal arch set into concrete footings which are clear of the stream banks. This would also allow passage for mammals. The height of the arch would pass the design flood without surcharging.
5	**Stream: Broad valley, Large channel, Eco provision (or not)**  	Typical of mid reach streams where superficial drift deposits are shallow. The stream has cut to the rock and the bed consists of boulders and intact rock. Placing rectangular box culvert(s) would require bedrock to be broken and excavated. An alternative to (4) using concrete abutments and steel / concrete composite decking. Passage for mammals where necessary. The height of the bridge soffit would pass the design flood without surcharging.
6	**Stream: Incised valley, Medium channel, Eco provision**  	Typically found on energetic streams which have cut into deep clay or glacial deposits. As flood flows cannot spread latterly depth fluctuations may be considerable. The rectangular box culvert structure would contain a reinstated natural bed. As an alternative to mammal ledges a higher level circular pipe would allow mammal passage. This would act as a high flow relief if required, but be above the majority of minor floods.

<table>
<tr><th></th><th>Sketch of Channel Cross-Section / Longitudinal Section</th><th>Comments</th></tr>
<tr><td>7</td><td>Stream: Incised valley, Large channel, No Eco provision
</td><td>Typically found on energetic streams which have cut through superficial deposits and into the rock formation. Depth fluctuations may be considerable, as flood flows cannot spread laterally.

The bedrock would be broken out to facilitate the placing of large rectangular box culvert which would pass the design flow without surcharging.</td></tr>
<tr><td>8</td><td>Peat Hagg: Broad, Large (deep) channel, No Eco provision
</td><td>Typically found in deep blanket peat where the gully has bottomed out at the mineral soil / rock interface. Normally flows are small arising from seepage out of the peat, with intermittent large storm flows which may carry blocky peat fragments.

The soil / bedrock would be excavated to allow for bedding and twin circular culverts set at a level which would avoid upstream ponding. The pipe diameter would be sized by inspection of the gully morphology because calculations alone may only provide the illusion of precision.</td></tr>
<tr><td>9</td><td>Peat Pipe: Buried, Large size
</td><td>These are encountered at random in blanket peat (and some may go un-noticed). Ensuring continuity of the bog hydrology is important.

The section of peat pipe which would be below the road would need to be excavated and a ‘best fit’ plastic pipe would be inserted into the irregular ends. The space between the drainage pipe and the peat pipe would require to be sealed with natural material such as clay. The trench would be refilled with the excavated peat.</td></tr>
</table>

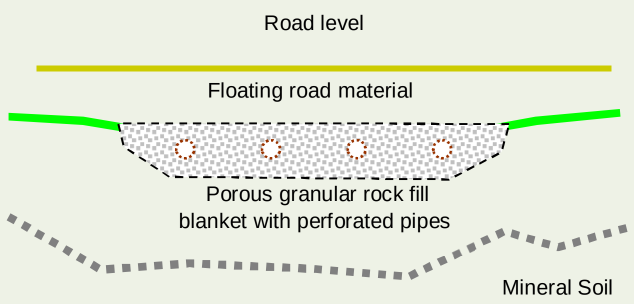
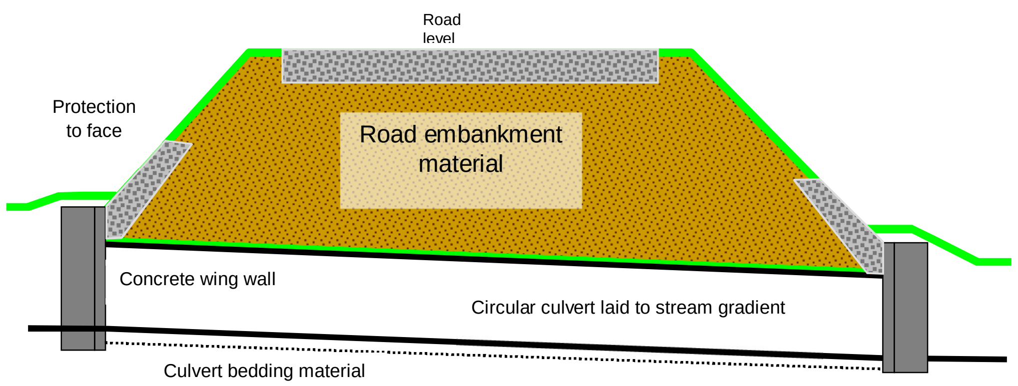
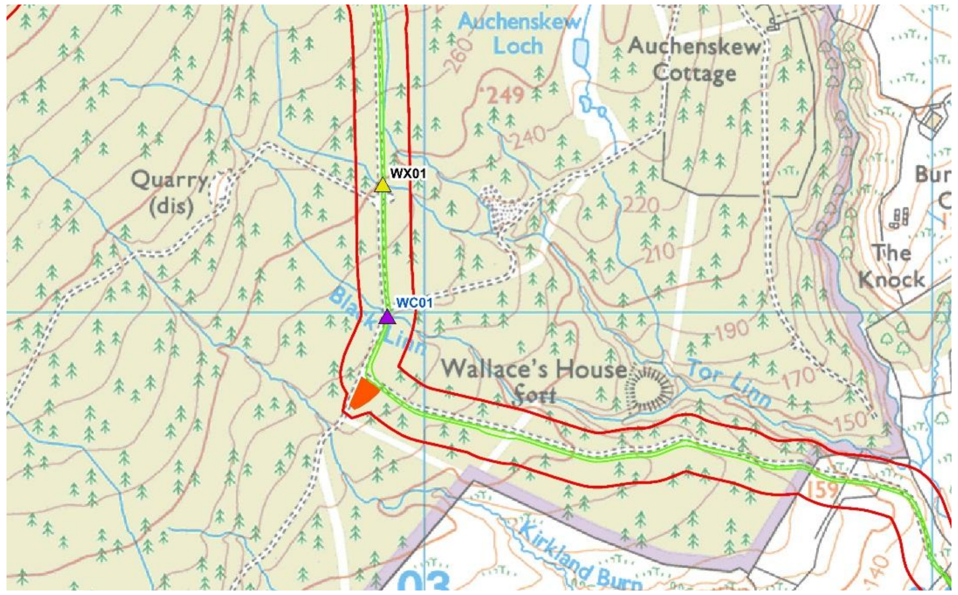
	Sketch of Channel Cross-Section / Longitudinal Section	Comments
10	**Flushes: Various widths**  	Within the area of the flush there is no clearly defined channel, other than perhaps a broad concave area. Flow is predominantly by sub-surface interflow and it is important to ensure this continuity and avoid compaction of the flush by the road. A drainage blanket wrapped in geotextile placed below the road construction would provide flow continuity without concentrating the discharges into a narrow channel.
11	**Longitudinal Section: Circular culvert, no Eco provision**  	In the case of crossings which have no need for particular ecological provision a circular culvert may be the preferred choice. This would generally be laid to the stream gradient on prepared bedding material. The entrance and exit to the culvert would require wing walls to locally stabilise the stream banks and the toe of the road embankment. Depending on the size of the opening various forms of wing wall construction may be used - concrete, gabions, stone. If there is a risk of surcharge then the embankment face may require protection.

Table A6: Illustration of watercourse crossings

1.7 Annex B - Description Sheets for CAR-Applicable Watercourse Crossings

Crossing ID:	WC01 **NGR:** NGR 302926, 590995
Route:	Crossing approximately 1.8km south of Turbine 5.
Watercourse:	Black Linn (Garrel Water tributary), Water of Ae Catchment.
Description:	Bed material consists of boulders, pebbles and cobbles. No bedrock visible at bed layer. Bank material is vegetation and soil. Small watercourse with rippled flow. The main channel is approximately 0.8m wide and 0.5m deep, with the valley 7.0m wide and 3.0m deep. The watercourse flows south east to the confluence with Garrel Water, approximately 1.2km downstream of this crossing.
Catchment Area:	Approximately $0.22km^2$
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	$Q_{mean} = 0.008m^3/s$
Flood Risk:	Identified on SEPA Flood Risk Map: Yes, surface water flooding upstream of the crossing.
Ecology:	Ecological surveys indicated that the burn has limited fish habitat suitability and was therefore scoped out for fish surveys. Signs of mammal protected species were noted along the Black Linn. However, the habitat suitability assessment considered that Black Linn provides moderate habitat for these species.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.

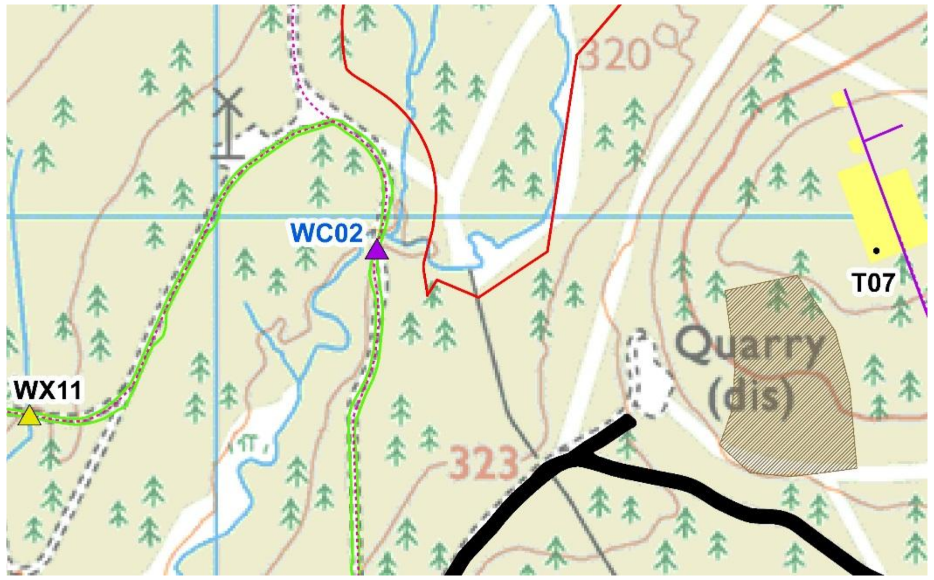



Looking upstream from NGR 302926, 590995


Looking downstream from NGR 302926, 590995


View across channel from NGR 302926, 590995

Crossing ID:	WC02 **NGR:** NGR 302162, 593969
Route:	Crossing approximately 0.5km west of Turbine 7.
Watercourse:	Glenkiln Burn tributary, Water of Ae Catchment.
Description:	Bed material consists of boulders, pebbles, cobbles and gravel. No bedrock visible at bed layer. Bank material is vegetation and soil. The main channel is approximately 2.0m wide and 1.0m deep, with the valley 15.0m wide and 5.0m deep. The watercourse flows south west to the confluence with Glenkiln Burn, approximately 1.8km downstream of this crossing.
Catchment Area:	Approximately 3.3km^2
Peak Flows (m^3/s):	Q_5 = 4.98, Q_{25year} = 7.87, $Q_{200year}$ = 12.92, $Q_{200year + cc}$ = 15.50
Mean Flow (m^3/s):	Q_{mean} = 0.12
Flood Risk:	Identified on SEPA Flood Risk Map: Yes, surface water flooding upstream of the crossing and river water flooding downstream of the crossing.
Ecology:	Ecological surveys indicated the burn has been identified with habitat suitability for both juvenile and adult salmonids. Surveys indicated good trout numbers present. Evidence of water vole was noted on the Glenkiln Burn upstream of the crossing. No signs of otters were noted.
Crossing Type:	Existing concrete clear span bridge to be replaced by a bridge crossing for this watercourse.
CAR Application:	This would be anticipated as requiring a Registration under CAR. Should bankside works extend to 20m or beyond, this would become a Simple Licence application.

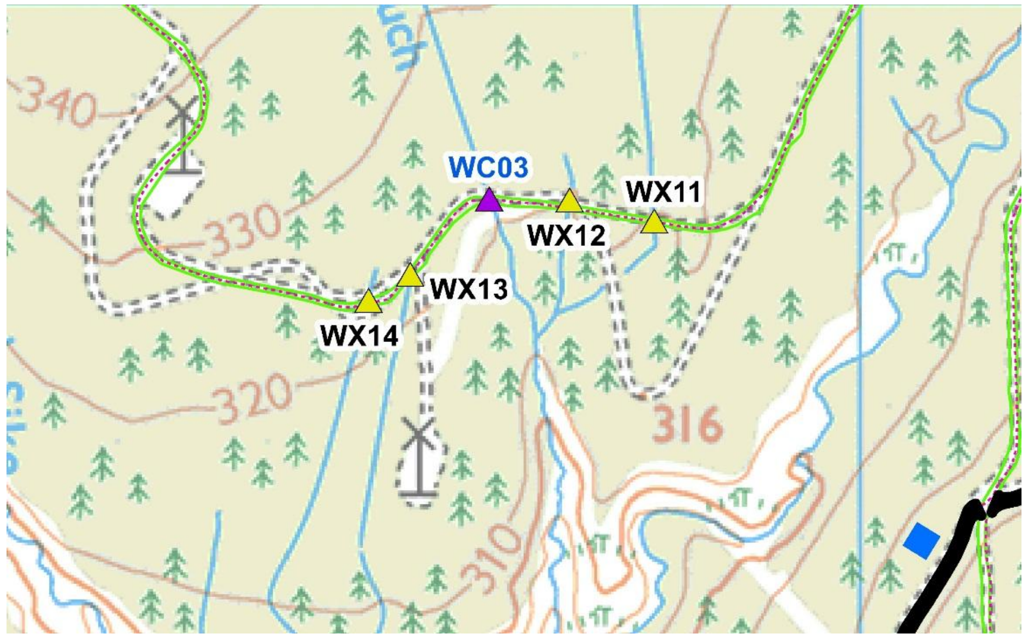



Looking upstream from NGR 302162, 593969


Looking downstream from NGR 302162, 593969


View across channel from NGR 302162, 593969

Crossing ID:	WC03 **NGR:** NGR 301660, 593821
Route:	Crossing approximately 0.6km north of Turbine 4.
Watercourse:	Ox Cleuch (Glenkiln Burn tributary), Water of Ae Catchment.
Description:	Bed material consists of cobbles, gravel and soil/clay. No bedrock visible at bed layer. Bank material is vegetation and soil. Small watercourse with rippled flow. The main channel is approximately 4.0m wide and 2.0m deep, with the valley 8.0m wide and 3.0m deep. The watercourse flows south to the confluence with Glenkiln Burn, approximately 1.3km downstream of this crossing. Downstream culvert is suspended above natural channel. The channel is incised with bank collapse evident downstream on the left bank. During the site visit, a deep pool below the culvert was noted.
Catchment Area:	Approximately 0.35km^2
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	Q_{mean} = 0.011m^3/s
Flood Risk:	Identified on SEPA Flood Risk Map: No.
Ecology:	No evidence of fish present within this burn; however, the ecological surveys indicated the Glenkiln Burn has been identified with habitat suitability for both juvenile and adult salmonids. Surveys indicated good trout numbers present. No evidence of water vole or otters were recorded during the surveys around the Ox Cleuch crossing.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules. However, due to the bank erosion noted during the site visit, a Simple Licence might be required.




Looking upstream from NGR 301660, 593821


Looking downstream from NGR 301660, 593821


View across channel from NGR 301660, 593821

Crossing ID:	WC04 **NGR:** NGR 301004, 594116
Route:	Crossing approximately 1.2km west of Turbine 7
Watercourse:	Auchendowal Sike (Glenkiln Burn tributary), Water of Ae Catchment
Description:	Bed material consists of cobbles and gravel. Bank material is boulders, vegetation and soil. The main channel is approximately 6.0m wide and 4.0m deep, with the valley 30m wide. The watercourse flows south to the confluence with Glenkiln Burn, approximately 1.5km downstream of this crossing.
Catchment Area:	Approximately 0.34km^2
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	$Q_{mean} = 0.011m^3/s$
Flood Risk:	Identified on SEPA Flood Risk Map: No.
Ecology:	Ecological surveys indicated that there is limited habitat suitability for fish and there is no evidence of fish present within the Auchendowal Sike. However, ecological surveys indicated the Glenkiln burn has been identified with habitat suitability for both juvenile and adult salmonids. No evidence of water vole or otters were recorded during the surveys around the Auchendowal Sike crossing.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to require a CAR Registration and constructed following the relevant General Binding Rules.


Looking upstream from NGR 301004, 594116


Looking downstream from NGR 301004, 594116


View across channel from NGR 301004, 594116

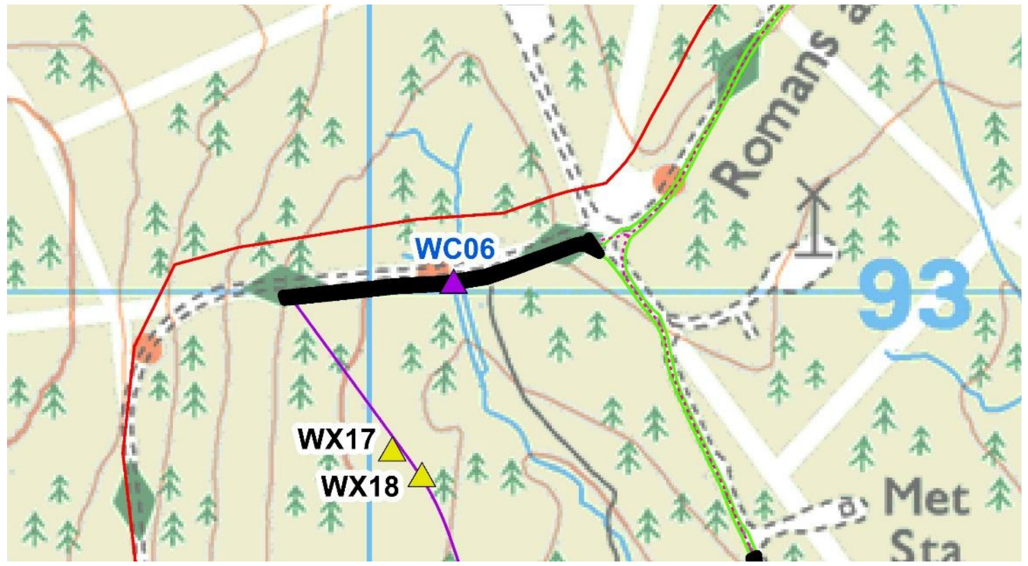
Crossing ID:	WC05 **NGR:** NGR 300481, 593384
Route:	Crossing approximately 0.9km north of Turbine 2
Watercourse:	Rough Cleuch (Glenkiln Burn tributary), Water of Ae Catchment.
Description:	This is a small drain with little visible flow at the time of the survey. Bank material is vegetation and peat. No bedrock visible at this layer. Bed material was not visible due to overgrown vegetation. The main channel is approximately 1.0m wide and 0.2m deep, with no apparent valley. The watercourse flows south east to the confluence with Glenkiln Burn, approximately 1.2km downstream of this crossing. The watercourse is currently culverted via a 0.5m pipe. Further downstream the watercourse drains into a ditch, which is then culverted via a second 0.5m pipe.
Catchment Area:	Approximately $0.08km^2$
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	$Q_{mean} = 0.003m^3/s$
Flood Risk:	Identified on SEPA Flood Risk Map: No.
Ecology:	Ecological surveys indicated that this watercourse offers suitable fish habitat. Further surveys indicated good trout numbers are present. No evidence of water vole or otters were recorded during the surveys around the Rough Cleuch crossing.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.


Looking upstream from NGR 300481, 593384


Looking downstream from NGR 300481, 593384


View downstream from the second culvert from NGR 300481, 593384

Crossing ID:	WC06 **NGR:** NGR 300076, 593011
Route:	Crossing approximately 0.5km north of Turbine 1
Watercourse:	Clachanbirnie Burn (Glenkiln Burn tributary), Water of Ae Catchment
Description:	Bed material consists of pebbles, cobbles, gravel and fine sediment. No bedrock visible at bed layer. Bank material is vegetation and peat. The watercourse had rippled flow at the time of the survey. The main channel is approximately 1.0m wide and 0.5m deep, with no apparent valley. The watercourse flows south, then east to the confluence with Glenkiln Burn, approximately 2.0km downstream of this crossing.
Catchment Area:	Approximately 0.17km^2
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	Q_{mean} = 0.006m^3/s
Flood Risk:	Identified on SEPA Flood Risk Map: No.
Ecology:	Ecological surveys indicated the burn offers suitable habitat for juvenile fish. No fish were recorded during surveys for Clachanbirnie Burn. No evidence of water vole or otters were recorded during the surveys around the Clachanbirnie Burn crossing. However, the watercourse was assessed as offering moderate habitat suitability.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.

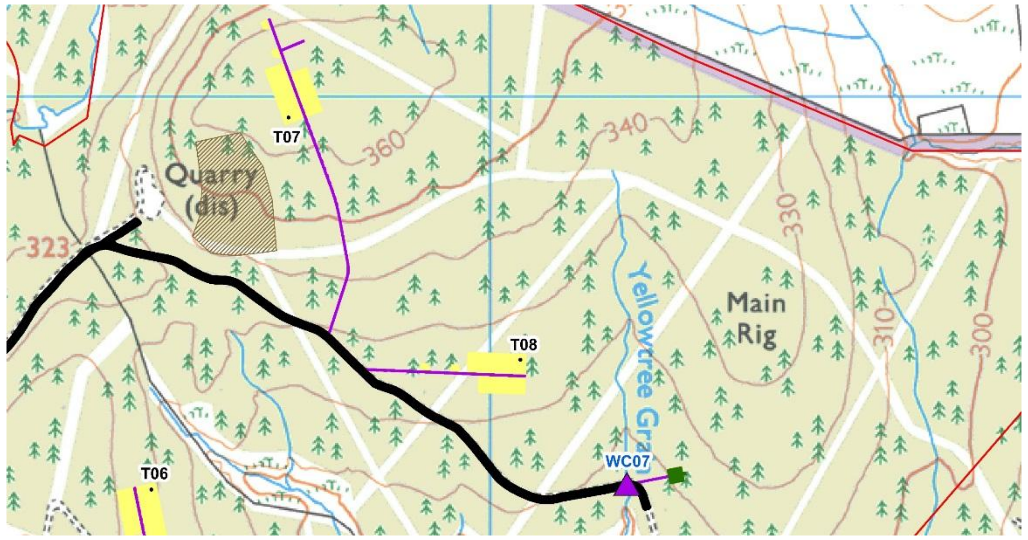



Looking upstream from NGR 300076, 593011


Looking downstream from NGR 300076, 593011


View across channel from NGR 300076, 593011

Crossing ID:	WC07 **NGR:** NGR 303225, 593362
Route:	Crossing approximately 70m west of Met Mast
Watercourse:	Yellowtree Grain (Garrel Water tributary), Water of Ae Catchment.
Description:	Bed material consists of pebbles, cobbles and gravel. Bank material is pebbles, cobbles, vegetation and peat. The watercourse had rippled flow at the time of the survey. The main channel is approximately 1.5m wide and 0.5m deep, with the valley 5.0m wide and 2.5m deep. The watercourse flows south to the confluence with Garrel Water, approximately 0.7km downstream of this crossing.
Catchment Area:	Approximately $0.27km^2$
Peak Flows (m^3/s):	Not available for this sub-catchment, WC08 values are considered representative.
Mean Flow (m^3/s):	$Q_{mean} = 0.009m^3/s$
Flood Risk:	Identified on SEPA Flood Risk Map: No.
Ecology:	Ecological surveys indicated the burn is considered suitable habitat for fish. Fish surveys undertaken on Yellowtree Grain indicate no presence of fish. Signs of otters were noted upstream of the crossing. No signs of water vole were noted.
Crossing Type:	Existing culvert to be replaced by oversized circular culvert for this crossing.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.

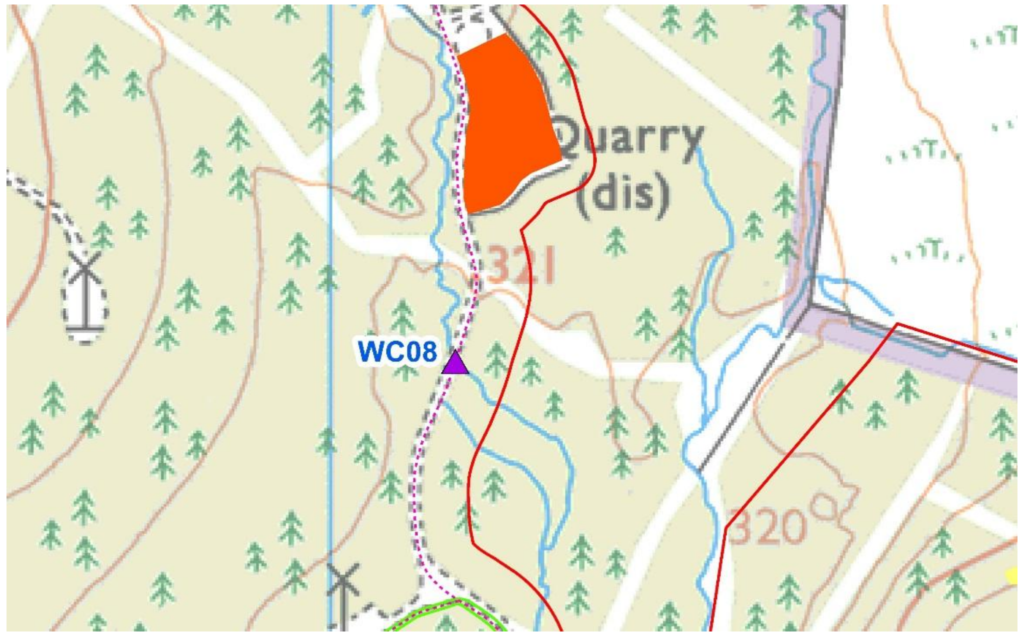



Looking upstream from NGR 303225, 593362


Looking downstream from NGR 303225, 593362


View across channel from NGR 303225, 593362

Crossing ID:	WC08 **NGR:** NGR 302114, 594318
Route:	Crossing approximately 0.7km north west of turbine 14.
Watercourse:	Auchencaigroch Burn, (Tributary of Glenkiln Burn) Water of Ae Catchment.
Description:	Bed material consists of pebbles, cobbles and gravel. Bank material is pebbles, cobbles, vegetation and peat. The watercourse had rippled flow at the time of the survey. The main channel is approximately 1.0m wide and 1.5m deep. The watercourse flows south to the confluence with Glenkiln Burn, approximately 1.5km downstream of this crossing. This watercourse is currently culverted.
Catchment Area:	Approximately 0.85km^2
Peak Flows (m^3/s):	$Q_5 = 1.55$, $Q_{25year} = 2.45$, $Q_{200year} = 4.09$, $Q_{200year + cc} = 4.90$
Mean Flow (m^3/s):	$Q_{mean} = 0.03$
Flood Risk:	Identified on SEPA Flood Risk Map: Yes, small areas of surface water flooding throughout the burn.
Ecology:	Ecological surveys indicated the burn is considered to have limited suitability for habitat for fish. The watercourse is considered to provide moderate habitat for otters. Evidence of water vole was noted on Auchencaigroch Burn.
Crossing Type:	Existing circular pipe to be upgraded, which will involve extending the pipe and run the cable in a trench adjacent to the road.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.

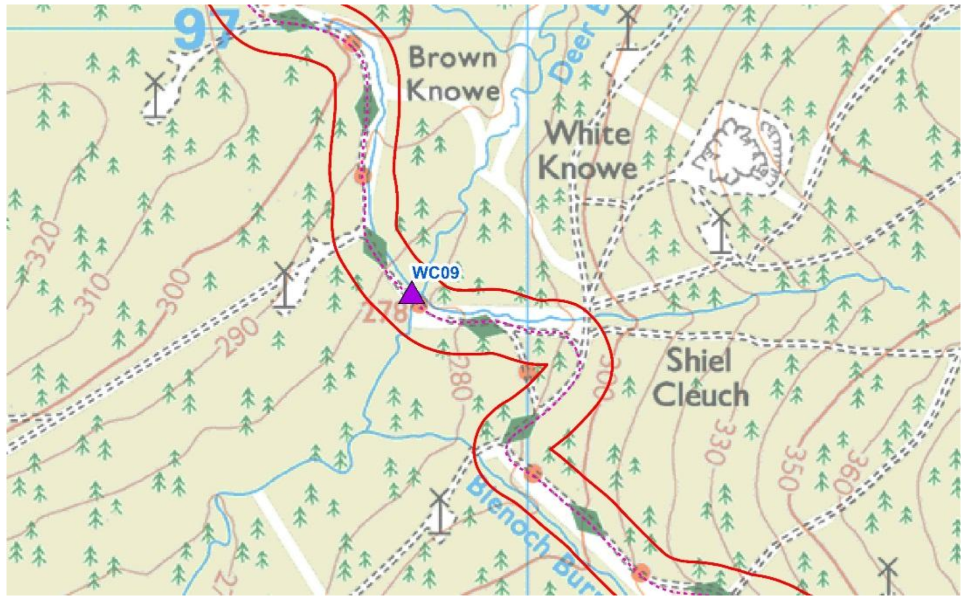



Looking upstream from NGR 302114, 594318


Looking downstream from NGR 302114, 594318


View across channel from NGR 302114, 594318

Crossing ID:	WC09 **NGR:** NGR 300825, 596580
Route:	Crossing approximately 1.07km south of the substation.
Watercourse:	Deer Burn, Tributary of the Water of Ae Catchment.
Description:	Bed material consists of pebbles, cobbles and gravel. Bank material is largely vegetation. The watercourse had rippled flow at the time of the survey. The main channel is approximately 1.8m wide and 1.0m deep, with the valley 3.0m wide and 1.5m deep. The watercourse flows south west to the confluence with Water of Ae, approximately 3.30km downstream of this crossing. This watercourse crossing currently consists of two clear span structures at crossing point (one housing cables, the other supporting forestry track.
Catchment Area:	Approximately 2.81km^2
Peak Flows (m^3/s):	$Q_5 = 4.75$, $Q_{25year} = 7.57$, $Q_{200year} = 12.45$, $Q_{200year + cc} = 14.94$
Mean Flow (m^3/s):	$Q_{mean} = 0.11$
Flood Risk:	Identified on SEPA Flood Risk Map: Yes, small areas of surface water flooding throughout the burn upstream and high river flood risk downstream.
Ecology:	Ecological surveys indicated the burn is considered to provide suitable habitat for fish. Further surveys confirmed the presence of trout. Potential otter couch habitat was recorded under the cable and track bridges. No signs of water vole were noted.
Crossing Type:	Existing steel cable bridge to be upgraded with the inclusion of cable suspending to bridge.
CAR Application:	This would be anticipated to be require a CAR Registration and constructed following the relevant General Binding Rules.

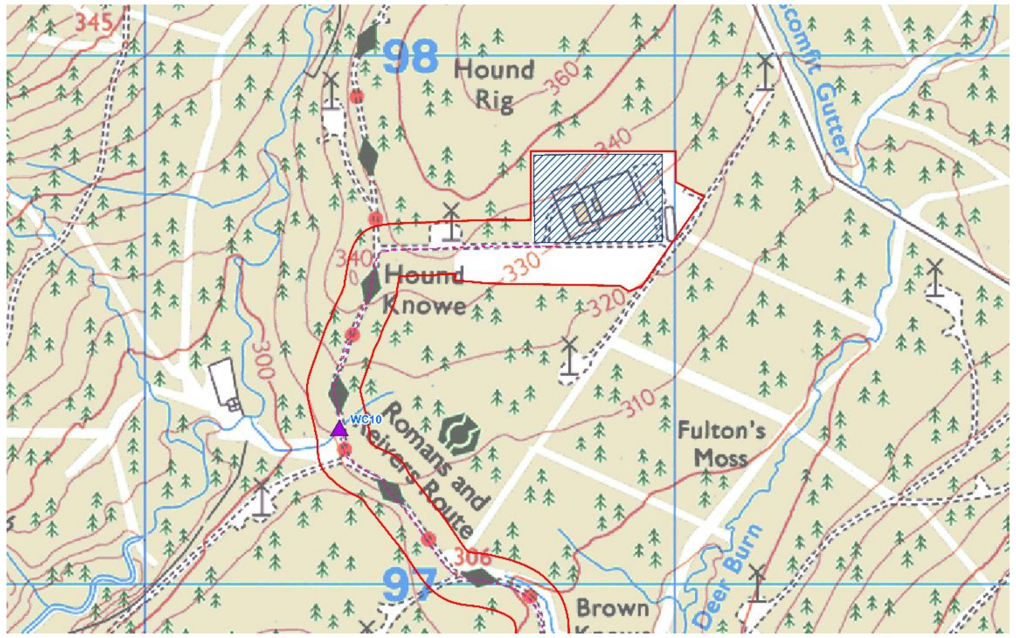


Looking upstream from NGR 300825, 596580

Looking downstream from NGR 300825, 596580

View across channel from NGR 300825, 596580

Crossing ID:	WC10 **NGR:** NGR 3003374, 597302
Route:	Crossing approximately 0.55km south west of the substation.
Watercourse:	Unnamed Tributary of the Water of Ae
Description:	Bed material consists of pebbles, cobbles and gravel. Bank material is pebbles, cobbles, vegetation and peat. The watercourse had rippled flow at the time of the survey. The main channel is approximately 0.25m wide and 0.50m deep, with the valley 8.0m wide and 4.0m deep. The watercourse flows south to the confluence with Water of Ae approximately 0.32km downstream of this crossing.
Catchment Area:	Approximately 2.86km^2
Peak Flows (m^3/s):	Not available for this sub-catchment, WC09 values are considered representative.
Mean Flow (m^3/s):	Q_{mean} = 0.003
Flood Risk:	Identified on SEPA Flood Risk Map: No. Areas of flood risk from rivers downstream of the tributary on the Water of Ae.
Ecology:	Ecological surveys indicated the watercourse is considered to have limited suitability for fish habitat. Otters were noted in the valleys of Water of Ae. No signs of water vole were noted.
Crossing Type:	Existing circular pipe to be upgraded, which will involve extending the pipe and run the cable in a trench adjacent to the road.
CAR Application:	This would be anticipated to require a CAR Registration and constructed following the relevant General Binding Rules.




Looking upstream from NGR 3003374, 597302


Looking downstream from NGR 3003374, 597302


Looking upstream from NGR 3003374, 597302

1.8 Annex C – Minor Watercourse Crossings

Crossing ID	Grid Reference	Watercourse Type	Crossing Type	Comment
WX01	NGR 302917, 591254	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX02	NGR 302565, 592267	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX03	NGR 302477, 592373	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX04	NGR 302411, 592936	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX05	NGR 301939, 593309	Small Land Drain	Circular culvert	New crossing
WX06	NGR 301857, 592983	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX07	NGR 301838, 592931	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX08	NGR 301746, 592867	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX09	NGR 301714, 592846	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX10	NGR 301671, 592812	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX11	NGR 301811, 593801	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX12	NGR 301733, 593820	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX13	NGR 301587, 593752	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX14	NGR 301549, 593728	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX15	NGR 300953, 594035	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX16	NGR 300760, 593672	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX17	NGR 300020, 592858	Small Land Drain	Circular culvert	New crossing
WX18	NGR 300047, 592834	Small Land Drain	Circular culvert	New crossing
WX19	NGR 300107, 592666	Small Land Drain	Circular culvert	New crossing
WX20	NGR 300126, 592521	Small Land Drain	Circular culvert	New crossing
WX21	NGR 300127, 592473	Minor tributary channel	Circular culvert	New crossing
WX22	NGR 302101, 594281	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track
WX23	NGR 301614, 595751	Minor tributary channel	Circular culvert	Existing crossing underneath the existing forestry track

Table A6: Minor Watercourse Crossings

1.8.1 Photographs

118. A selection of representative photographs of minor watercourse crossings is presented below.

Photograph A1: WX17, taken at NGR 300020, 592858, looking upstream.

Photograph A2: WX18, taken at NGR 300047, 592834, looking upstream.

Photograph A3: WX19, taken at NGR 300107, 592666, looking upstream.

Photograph A4: WX20, taken at NGR 300126, 592521, looking upstream.

Photograph A5: WX21, taken at NGR 300127, 592473, looking upstream.

Harestanes South Windfarm Extension Project Team

ScottishPower Renewables
9th Floor ScottishPower Headquarters
320 St Vincent Street
Glasgow
G2 5AD

HarestanesSouthWindfarm@scottishpower.com

www.scottishpowerrenewables.com

SCOTTISHPOWER
RENEWABLES