11 Geology, Hydrogeology & Hydrology

11.1 Introduction

11.1.1 This chapter of the Environmental Statement (ES) assesses the effects of the proposed Talladh-a-Bheithe Wind Farm (referred to hereafter as the proposed development) on the geological, hydrogeological and hydrological environment. The assessment was undertaken by the Natural Power Consultants (Natural Power) hydrology team.

11.1.2 This chapter details the existing baseline condition in terms of the geological, hydrogeological and hydrological conditions present within the site. The assessment covers the construction, operation and decommissioning phases of the proposed development and identifies aspects which have the potential to influence the existing baseline conditions.

11.1.3 Effects on hydrology, hydrogeology and geology may also result in secondary ecological effects on habitats (peat) or species. Effects on ecological receptors (non-avian) are considered in Chapter 8: Ecology of this ES with effects on peat described within Technical Appendices 11.1: Peat Stability Risk Assessment and 11.2: Peat Management Plan.

11.1.4 This chapter is supported by the following Technical Appendices:

- Technical Appendix 11.1: Peat Stability Risk Assessment;
- Technical Appendix 11.2: Peat Management Plan; and
- Technical Appendix 11.3: Watercourse Crossing Assessment.

11.1.5 Hydrological considerations have influenced the design of the proposed development and these are explained in Chapter 2: Design Evolution and Alternatives. An outline of the proposed development is described in Chapter 3: Description of Development.

11.2 Scope of Assessment

Project Interactions

11.2.1 The proposed development will introduce physical changes, which may alter the hydrological characteristics of the site. During the construction phase, and to a lesser extent during operation, potential sources of pollution will be present on site. Hydrological surveys have been undertaken to establish the existing baseline conditions at the site and associated areas downstream, to assess the potential effects of the proposed development, the significance of these effects and the potential for mitigation.

Study Area

11.2.2 The proposed development would be located on an upland site with significant elevations and would be situated approximately 42 km to the west of Pitlochry and 25 km south of Dalwhinnie in Perth & Kinross. The site lies to the east of Loch Ericht and north of Loch Rannoch on the Talladh-a-Bheithe Estate. A topographic high is located in the northern part of the proposed development at approximately 542 m Above Ordnance Datum (AOD), which forms the base slopes to the Glas Mheall Mor. Within the southern half of the proposed development, the terrain is formed by two plateau summits of Sron Bheag (516 mAOD) and Meall Ban (547 mAOD), which extend south towards Loch Rannoch.

Scoping and Consultation

11.2.3 The scoping responses relating to the water environment are summarised in Table 11.1.

Table 11.1: Consultation Responses

Organisation	Comment	Response
Scottish Environment Protection Agency (SEPA)	In their response (05/12/2011) to the scoping report SEPA raised the following: Details of how impacts upon wetlands including peatlands is minimised and mitigated should be provided.	Technical Appendix 11.1: Peat Slide Risk Assessment and Section 11.5.39
	Details of likely volumes of surplus peat that will be generated, including quantification of catotelmic and acrotelmic peat; and the principles of how the surplus peat will be reused or disposed.	Technical Appendix 11.2: Peat Management Plan
	Expect that within the ES, that there is a systematic identification of all aspects of site work which might impact upon the environment.	Section 11.7
	If engineering works are likely to result in increased flood risk then a flood risk assessment should be considered.	Section 11.5.23
	A site survey of existing water features and a map of the location of all proposed engineering activities in the water environment should be included in the ES. A systematic table detailing the justification and how any adverse impact will be mitigated should also be included. The table should be accompanied by a photograph of each affected waterbody along with its dimensions.	Technical Appendix 11.3: Watercourse Crossing Assessment
	Identify potential pollution risks associated with the proposals and identify the principles of preventative measures and mitigations.	Section 11.7
Scottish Natural Heritage (SNH)	In their response (12/12/2011) to the scoping report SNH raised the following: Clear mapping of peatland/peatland soils to avoid the impacts of deeper areas of peat onsite.	Technical Appendix 11.1 Peat Slide Risk Assessment and Section 11.5.39
Perth and Kinross Council (PKC)	Their response (06/02/2012) to the scoping report raised the following: Investigations of private water supplies within and around the area of the proposed development, including plans for protections and/or mitigation of	Section 11.5.36

	contamination of these supplies should be provided within the ES.	
Scottish Government		
	Mitigation measures to be addressed for all stages of the proposed development (i.e. construction, operation and decommissioning).	Section 11.7
	Measures to avoid pH impact on peatland from use of cement/concrete should be addressed within the ES.	Section 11.7
	The ES should demonstrate that infrastructure elements have been situated to avoid the deepest areas of peat.	Technical Appendix 11.1: Peat Slide Risk Assessment and Section 11.5.39
	The ES should identify location of and protective/mitigation measures in relation to all private water supplies impacted by the scheme.	Section 11.5.36
	The nature of the hydrological and hydrogeological environment should be presented within the ES. It should also contain statements on the potential effects at all stages on hydrology, water quality and flood risk.	Section 11.5
	Effects of high rainfall and subsequent runoff should be addressed within the ES.	Section 11.5
	Impacts on watercourses, lochs, groundwater, other water features and sensitive receptors, such as water supplies need to be assessed.	Section 11.5
	Measures to prevent erosion, sedimentation or discolouration are also required, along with monitoring proposals and contingency plans.	Section 11.7.5
Marine Scotland	The ES should fully address the impact on water quality in terms of sedimentation, pollution, altered hydrological pathways and impeding migratory fish passage.	Section 11.7
	Construction should avoid water bodies and peatland as far as possible.	Section 11.7 and Technical Appendix 11.1: Peat Stability Risk Assessment
	Watercourse crossings should be avoided where possible. Where river crossings are proposed, Scottish Government guidance 'River Crossings and Migratory Fish' should be consulted.	Technical Appendix 11.3: Watercourse Crossing Assessment

	Where local salmonid and eel populations are present, a water quality plan for standing and running waters likely to be affected by the proposed development should be implemented.	Section 11.7 and Chapter 8: Ecology

Effects to be Assessed

11.2.4 The greatest risk of the proposed development affecting the hydrological, hydrogeological and geological environment will occur during the construction phase, with effects reduced during the operational and decommissioning phases. Taking this into account the following issues will be addressed during all phases of the proposed development:

- Changes to existing drainage patterns;
- Effects on baseflow;
- Effects on run-off rates;
- Effects on erosion and sedimentation;
- Effects on groundwater and surface water quality;
- Effects on groundwater levels;
- Effects on water resources;
- Effects on impediments to flow;
- Flood risk;
- Pollution risk;
- Effects on local geology; and
- Effects on hydrological integrity of peat bodies. Effects on the stability of peat are assessed in Technical Appendix 11.1: Peat Stability Risk Assessment.

Effects Scoped Out of Assessment

11.2.5 Effects arising from the process of decommissioning have been scoped out since they involve similar, but smaller scale processes to those employed during construction. Despite this similarity, the results of decommissioning are taken into account in assessing ongoing and operational effects where appropriate.

11.3 Policy Context

11.3.1 The assessment takes into account the requirements of the Water Framework Directive (2000/60/EC) (WFD). The WFD aims to protect and enhance the quality of surface freshwater (including lakes, rivers and streams), groundwater, groundwater dependent ecosystems (GWDTEs), estuaries and coastal waters. Historically, a range of inconsistent European legislation covered different aspects of the water management. Therefore, the WFD aims to introduce a simpler approach which will result in greater protection to the hydrological environment.

11.3.2 The key objectives of the WFD relevant to this assessment are:

- To prevent deterioration and enhance aquatic ecosystems; and
- To establish a framework of protection of surface freshwater and groundwater.

11.3.3 The WFD resulted in the Water Environment and Water Services (Scotland) Act 2003, which gave Scottish Ministers powers to introduce regulatory controls over water activities in order to protect, improve and promote sustainable use of Scotland's water environment. These regulatory controls currently, in the form of the Water Environment (Controlled Activities) (Regulations) Scotland 2011 (as amended), commonly referred to as Controlled Activities Regulations (CAR), came into force on 31st March 2011. Taking into account the key objectives of the WFD, it is an offence to undertake the following activities without a CAR authorisation:

- Discharges to all wetlands, surface waters and groundwaters (replacing the Control of Pollution Act 1974);
- 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.

11.3.4 Effects arising from the process of decommissioning have been scoped out since they involve similar, but smaller scale processes to those employed during construction. Despite this similarity, the results of decommissioning are taken into account in assessing ongoing and operational effects where appropriate.

11.3.5 Table 11.2 lists other legislation and key guidance which has been considered for this assessment.

Table 11.2: Policies, guidance and best practice

Topic	Sources of Information
Statutory Instruments	Water Environment and Water Services (Scotland) Act 2003 Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) Flood Risk Management (Scotland) Act 2009 The Water Supply (Water Quality) (Scotland) Regulations 2001 Private Water Supplies (Scotland) Act 2006 Part 11a of the Environment Protection Act 1990 Waste Management Licensing Regulations 1994 Pollution Prevention and Control Regulations (Scotland) 2000 Electricity Work (Environmental Impact Assessment) (Scotland) Regulations 2000
Scottish Planning Policy	Scottish Planning Policy (2010)
SEPA Policies	No. 19 Groundwater Protection for Scotland No. 22 Flood Risk Assessment Strategy No. 41 Development at Risk of Flooding: Advice and Consultation No. 54 Land Protection Policy No. 61 Control of Priority & Dangerous Substances & Specific Pollutants in the Water Environment
Scottish Government Planning Advice Notes (PAN's)	PAN 1/2013 Environmental Impact Assessment

	PAN 51 Planning, Environmental Protection and Regulation PAN 61 Planning and Sustainable Drainage Systems PAN 79 Water and Drainage
SEPA Pollution Prevention Guidelines (PPG's)	PPG1 General Guide to the Prevention of Water Pollution PPG2 Above Ground Oil Storage Tanks PPG4 The Disposal of Sewerage where no Mains Drainage is Available PPG5 Works in, Near and Liable to Affect Watercourses PPG6 Working at Construction and Demolition Sites PPG8 Safe Storage and Disposal of Used Oil PPG21 Polluting Incident Response Planning
SEPA Position Statements	WAT-PS-06-02 Culverting of Watercourses WAT-PS-07-02 Bank Protection WAT-PS-06-03 Sediment Management
Construction Industry Research and Information Association (CIRIA)	CIRIA C502 Environmental Good Practice on Site CIRIA C521 Sustainable Drainage Systems Design Manual for Scotland and England CIRIA C532 Control of Water Pollution from Construction Sites CIRIA C648 Control of Water Pollution from Linear Construction Projects CIRIA C650 Environmental Good Practice on Site (Expansion of C502) CIRIA C689 Culvert Design and Operation Guides
Other Guidelines	Scottish Renewables Joint Publication (2013), Good Practice During Wind Farm Construction Forestry Civil Engineering (FCE), SNH (2010), Floating Roads on Peat Scottish Renewables Joint Publication (2012), Developments on Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimisation of Waste SEPA, The Water Environment (Controlled Activities) Regulations 2011 (as amended), A Practical Guide, Version 7.1, March 2014 The Scottish Executive (2000), River Crossings and Migratory Fish: Design Guidance, A Consultation Paper WAT-SG-23: SEPA (2008), Engineering in the Water Environment, Good Practice Guide – Bank Protection Rivers and Lochs, Version 1 WAT-SG-25: SEPA (2010), Engineering in the Water Environment, Good Practice Guide – Construction of River Crossings, Version 2 WAT-SG-26: SEPA (2010), Engineering in the Water Environment, Good Practice Guide – Sediment Management, Version 1 WAT-SG-31: SEPA (2006), Special Requirements for Civil Engineering Contracts for the Prevention of Pollution, Version 2

	SEPA, Land Use Planning Service (LUPS) Guidance Note 4 (2012), Planning Guidance on Windfarm Developments

11.4 Methodology

Overview

11.4.1 The assessment has involved the following:

- Consultation with relevant statutory and non-statutory bodies as part of the Scoping exercise;
- Detailed desk studies and site visits to establish conditions of the proposed development area;
- Evaluation of the potential effects of the proposed development and the effect that these could have on the current site conditions;
- Evaluation of the significance of these effects by consideration of the sensitivity of the baseline features of the site, the potential magnitude of these effects and the probability of these effects occurring;
- Identification of possible measures to avoid and mitigate against any identified adverse effects resulting from the proposed development; and
- The residual significance of the potential effects following mitigation.

Desktop Study

11.4.2 A desktop survey to establish the baseline was undertaken in order to:

- Describe surface water hydrology, including watercourses, springs and ponds;
- Identify existing catchment pressures (e.g. point source and diffuse pollution issues);
- Identify all private drinking water abstractions and public water supplies within 5 km of the site;
- Identify all flooding risks;
- Describe the hydromorphological conditions of watercourses;
- Collect information relating to recreational and fisheries resources;
- Collate historic hydrological flow and flooding data for the immediate area and downstream watercourses;
- Collect soil, geological and hydrogeological information;
- Confirm surface water catchment areas and watersheds; and
- Confirm the extent and nature of peat deposits across the site (Technical Appendix 11.1).

11.4.3 Published information consulted for the baseline is outlined in Table 11.3.

Table 11.3: Baseline Information Sources

Topic	Source of Information
Topography	5m Contour data derived from Digital Terrain Model (DTM) data 1:10,000 Ordnance Survey (OS) Raster Data
Designated Nature and Conservation Sites	SNHi SiteLink website (http://www.snh.org.uk/snhi/)
Solid and Superficial Geology	BGS Digital Data provided at www.emapsite.com

Soils and Peat	James Hutton Institute (formerly the Macaulay Institute), Soil Survey of Scotland, Sheet 42, Loch Rannoch
Climate	SEPA, Loch Rannoch rain gauge site UK Met Office, Dalwhinnie rain gauge site Flood Estimation Handbook (FEH) CD-ROM, version 3
Surface Water Hydrology	1:10,000 and 1:50,000 Ordnance Survey Raster Data Flood Estimation Handbook (FEH) CD-ROM, version 3 LowFlows2 CD-ROM ISIS Hydrological Software Package
Flooding	SEPA, Indicative River and Coastal Flood Map, www.sepa.org.uk
Water Quality	SEPA, River Basin Management Plans, Web Mapping Application, http://gis.sepa.org.uk/rbmp/ SEPA, The RBMP for the Scotland Basin District 2009 – 2015
Water Resources	Private water supply information provided by Perth & Kinross Council
Hydrogeology	British Geological Survey (BGS), Hydrogeological Map of Scotland (1988), 1:655,000 mapping SNIFFER, Groundwater Vulnerability Map of Scotland (2004) BGS, Bedrock Aquifer Map (2004) BGS, Base Permeability data, 1:50,000 mapping BGS, Groundwater Flooding data, 1:50,000 mapping SEPA, River Basin Management Plans, Web Mapping Application, http://gis.sepa.org/rbmp/

Field Survey Techniques

11.4.4 The initial field survey was undertaken in early May 2013 to establish an initial first phase pass of the peat depths across the site on a 100 m by 100 m grid. During the survey, weather conditions were mixed with periods of dry sunny conditions and light showers. A hydrological survey was also carried out to help determine the hydrological characteristics of the proposed development. The purpose of the field survey was to visually assess the surface water features, land use, hydrological regime and gain an understanding of the topography, soils, distribution of peat and geography of the site. Further detailed peat investigation work across the infrastructure was carried out during June 2013 as part of the peat stability assessment, provided in Technical Appendix 11.1.

11.4.5 Additional site visits were undertaken on the 12th and 18th March 2014 to carry out surveys of the areas specific to infrastructure and water course crossings. The weather conditions during the site visits were dry with good visibility across the site. Details of the proposed watercourse crossings associated with the proposed development are provided in Technical Appendix 11.3.

Effects Evaluation

11.4.6 The significance of potential impacts of the proposed development have been defined by taking into account two main factors; the sensitivity of the receiving environment and the potential magnitude should that effect occur.

This approach is based on guidance outlined in Scottish Natural Heritage (SNH) guidance document[1]. This SNH Guidance has been adapted by Natural Power based on experience of carrying out impact assessments for a range of proposed onshore wind developments.

Receptor Sensitivity

11.4.7 The sensitivity of the receiving environment i.e. its ability to absorb the effect without perceptible change is defined in Table 11.4.

Table 11.4: Definition of Sensitivity of the Receiving Environment

Sensitivity	Definition
Very High	High Quality and rarity, regional or national scale and limited potential for substitution/replacement.
High	Receptor with a high quality and rarity, local scale and limited potential for substitution/replacement or receptor with a medium quality and rarity, regional or national scale and limited potential for substitution/replacement.
Medium	Receptor with a medium quality and rarity, local scale and limited potential for substitution/replacement or receptor with a low quality and rarity, regional or national scale and limited potential for substitution/replacement.
Low	Receptor with a low quality and rarity, local scale. Environmental equilibrium is stable and is resilient to changes that are greater than natural fluctuations, without detriment to its present character.

Impact Magnitude

11.4.8 The magnitude of effect includes the timing, scale, size and duration of the potential effect. For the purposes of this assessment the magnitude criteria are defined in Table 11.5.

Table 11.5: Magnitude of Effects

Magnitude	Criteria	Definition
Major	Results in loss of attribute	Fundamental (long term or permanent) changes to geology, hydrology, water quality and hydrogeology.
Moderate	Results in effect on integrity of attribute or loss of part of attribute	Material but non-fundamental and short to medium term changes to the geology, hydrology, water quality and hydrogeology.
Minor	Results in minor effect on attribute	Detectable but non-material and transitory changes to the geology, hydrology, water quality and hydrogeology.
Negligible	Results in an effect on attribute but of insufficient magnitude to affect the use/integrity	No perceptible changes to the geology, hydrology, water quality and hydrogeology.

Effects Significance

11.4.9 Assuming the successful implementation of best practice and design mitigation measures, the sensitivity of the receiving environment together with the magnitude of the effect, defines the significance of the effect as outlined in Table 11.6.

[1] Scottish Natural Heritage (2009) A Handbook on Environmental Impact Assessment, Guidance for Competent Authorities, Consultees and others involved in the Environment Impact Assessment Process in Scotland, 3rd Edition

Table 11.6: Significance Criteria

	Sensitivity			
Magnitude	Very High	High	Medium	Low
Major	Major	Major	Moderate	Minor
Moderate	Moderate	Moderate	Moderate	Minor
Minor	Minor	Minor	Minor	Not Significant
Negligible	Not Significant	Not Significant	Not Significant	Not Significant

11.4.10 Potential effects are therefore concluded to be of major, moderate, minor or no significance. Effects considered being Major or Moderate are considered significant in terms of the Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000.

Limitations of Assessment

11.4.11 The fieldwork carried out was a standard reconnaissance level walkover survey covering all main hydrological features. Due to the geographical extent of the proposed development and associated study area it was not practical to traverse the whole site. However, various representative locations and features such as peat bodies, watercourses and geological information were assessed and this information was interpreted for areas not visited.

11.4.12 Due to its complexity, the mapping of the site hydrology was based on the interpretation of aerial photography and results from the site visit. This interpretation is based on Natural Power experience at carrying out assessments for a number of developments in similar environments.

11.4.13 Private water supply information has been provided by Perth and Kinross Council (PKC). Private water supply sources on site are considered unlikely due to the remoteness of the proposed development. However, additional supplies could exist such as those that serve abandoned buildings and properties. It is also possible that there are non-potable supplies, such as for livestock, which have not been identified by the local authority and therefore omitted from the assessment.

11.4.14 The assessment of effects has been made on the basis of the current layout, with the assumption that the detailed design will not result in movement of infrastructure into areas of higher sensitivity as presented within the buffers provided in Figures 11.2.

11.4.15 The information presented in this assessment is based on desk studies and site investigations. There is the potential that further constraints may be identified during the pre-construction detailed design stage. Should further constraints be identified, these will be assessed and appropriately mitigated prior to construction.

11.5 Baseline Conditions

11.5.1 This section presents the information gathered on the existing topographical, geological, hydrological and hydrogeological (including peat) conditions across the site, including the results of the desktop studies and field surveys.

Climate

11.5.2 Rainfall data for a local rain gauge was obtained from SEPA at Loch Rannoch, National Grid Reference (NGR) (NN 59050 56360), located approximately 11 km south-east of the proposed development. Based on the data collected for Loch Rannoch (1972 – 2013), the average yearly rainfall is 1,288 mm. To put this into context, rainfall in Scotland varies from under 800 mm a year on mainland eastern Scotland in areas such as Fife, to over 3,000 mm on the mainland western Highlands.

11.5.3 Annual average rainfall information was also obtained from the UK Met Office gauge situated at Dalwhinnie (NN 64215 84632), approximately 24 km north-east of the proposed development with an average annual rainfall of 1,304 mm. The data provided covers the climate period 1981 – 2010 and is presented in terms of monthly averages in Chart 11.1, and has been used to validate the information from the SEPA gauge. It is noted that the monthly rainfall pattern is largely similar and suggests that the proposed development is subject to variable rainfall with the largest volumes of rainfall occurring in the winter months.

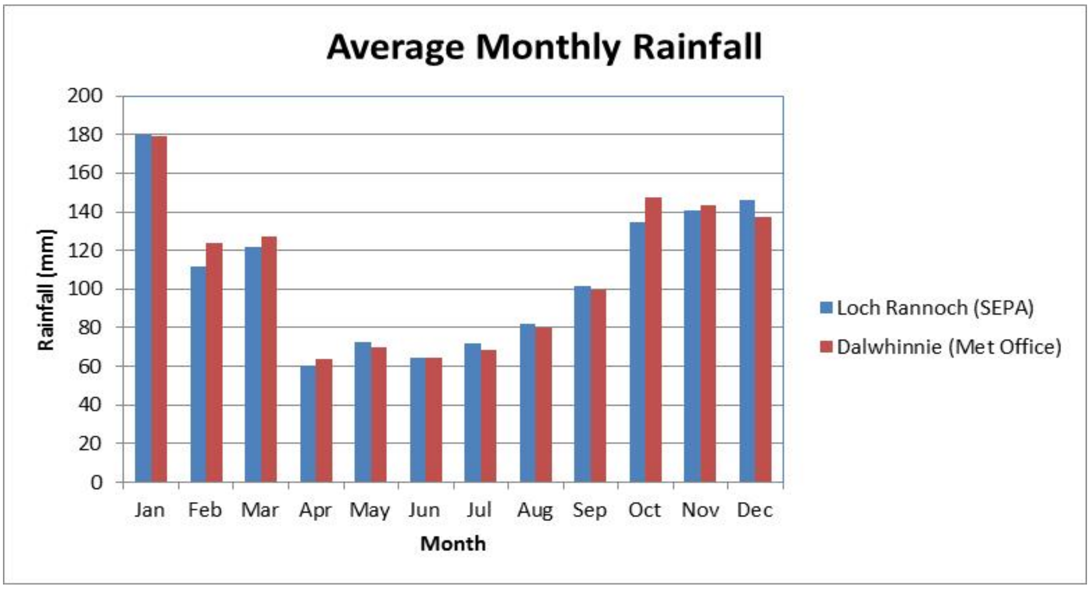

Chart 11.1: Average Monthly Rainfall Data

11.5.4 The standard annual average rainfall (SAAR) for the proposed development has been derived from the Flood Estimation Handbook (FEH) CD-ROM[2] as ranging from 1,421 mm to 1,787 mm. The differences in the average rainfall totals from the FEH CD-ROM and the rainfall datasets is partially due to differences in the reporting periods along with differences in geographic location. The SAAR value from the FEH CD-ROM is derived from a 1961 – 1990 climatic rainfall dataset based on nearby available station data, whereas the Met Office station data is determined from the 1981 – 2010 climatic average. The SEPA rainfall information covers a different monitoring period from 1972 – 2013. Despite these variances in how the average rainfall value is determined, the data gives a good indication of the rainfall patterns that can be expected in the area of the proposed development.

[2] Centre for Ecology and Hydrology (2009), Flood Estimation Handbook CD-ROM (Version 3).

Designated Sites

11.5.5 The following paragraphs highlight the designated sites of relevance to hydrology that are in the immediate vicinity of the proposed development. Information specific to each has been obtained from the SNHi, Site Link website[3]. The website provides information on designated sites across Scotland.

11.5.6 There is one designated area, approximately 3.9 km south of the nearest turbine that is of relevance to hydrology. The River Tay Special Area of Conservation (SAC) is designated for river and brook lamprey, otter and Atlantic salmon. A number of the watercourses within the site drain into Loch Rannoch via the River Ericht, but are not directly within the SAC.

Surface Water Hydrology

11.5.7 Hydrologically, the proposed development is located within the catchment of the River Ericht. This catchment and relevant sub-catchments to the River Ericht are discussed in detail in the following paragraphs, and accompanied by the following figures:

- Figure 11.1: Hydrology Overview;
- Figure 11.2: Hydrology Characteristics;
- Figure 11.3: Flow Accumulation and direction; and
- Figure 11.4: Topographic Wetness Index.

11.5.8 The hydromorphology has been qualitatively assessed in line with Annex V of the WFD for river continuity, morphological conditions and structure of the riparian zone.

Catchments

Allt Ghlas

11.5.9 The Allt Ghlas watercourse rises at NGR (NN 55410 69068) and flows south-west, forming a tributary of the River Ericht. The watercourse runs parallel to the existing estate access track before discharging into the River Ericht. The upper reaches and tributary headwaters of the Allt Ghlas meander over open moorland between the knoll features of Carn Dearg and Meallanan Odhar. The terrain of the upper reaches of the Allt Ghlas is demonstrated in Photograph 11.1.

[3] SNHi Site Link, (http://www.snh.org.uk/snhi/), accessed 18/07/2013.

Photograph 11.1: Overview of upper reaches of the Allt Ghlas watercourse

11.5.10 The lower reaches of the Allt Ghlas meander across a gently sloping stretch which features a tree plantation to the north of the watercourse before entering the River Ericht immediately below the Scottish and Southern Energy (SSE) Ericht Dam. It was observed during the site visit that there was an intake and weir structure within the Allt Ghlas watercourse, presumably associated with the SSE Hydropower scheme, situated at NGR (NN 51378 62887).

Allt a' Choire Odhair Bhig

11.5.11 The Allt a' Choire Odhair Bhig watercourse, a tributary of the Allt Ghlas, rises at NGR (NN 55111 65129) and flows south before heading west to enter the Allt Ghlas at NGR (NN 52031 63590). As shown in Photograph 11.2, the upper reaches of the watercourse consist of a steep meandering approach, featuring stepped pools and riffles. The channel widths of the upper reaches varied between 0.50m and 1.50m and bank heights of 0.30m to 0.40m were observed. During the site visit it was noted that there was good flow within the channel. The upper reaches of this catchment drain areas of open moorland, and there are also a number of artificial channels that drain the forestry plantation that is present in the northern reaches of the catchment, as shown in Photograph 11.2.

Photograph 11.2: View upstream of the Allt a' Choire Odhair Bhig upper reaches

11.5.12 The lower reaches of the Allt a' Choire Odhair Bhig are incised with large meanders, creating a channel width of approximately 12m with large boulders present within the channel. The base of the channel is predominately exposed bedrock. This region of the catchment drains areas of flat, with occasional hummocks, open moorland and there are areas of saturated boggy land along with hagged peat, as shown in Photograph 11.3.

Allt Caochan an t-Seilich

Photograph 11.3: View north-east of hagged peat areas, which were noted to show low surface flow which becomes subsurface flow.

11.5.13 The Allt Caochan an t-Seilich watercourse rises at NGR (NN 54819 64127) from the summit of Meall Garbh and initially flows south then south-east before draining into the Killichonan Burn, outwith the site boundary. The catchment consists of open moorland which is steep in the upper reaches of the catchment but opens out across the lower flatter areas where there are a number of saturated areas. The upper catchment tributaries were noted to have moderate to high flow at moderate speed during the site visit and ranged in width from 0.8 m to 1.4 m and 0.1 m to 0.3 m in depth, as shown in Photograph 11.4.

11.5.14 The channel of the main watercourse is meandering and incised, running through a wide u-shaped valley, approximately 10 m to 13 m in width. The channel is approximately 2.0 m to 3.0m wide and 0.4 m to 0.7 m deep with moderate flow at moderate speed noted during the site visit. The bed material is coarse and angular with bedrock exposed in places.

Photograph 11.4: View of the upper reaches of the Allt Caochan an t-Seilich watercourse

Hydrological Regime

11.5.15 Peak flows have been estimated for the key catchments described above using the FEH Rainfall-Runoff Method for a range of return periods, with results presented in Table 11.7. Catchment descriptors derived from the FEH CD-ROM[2] and FEH Handbook[4], are subsequently inserted into the ISIS hydrological modelling software package[5] to estimate the peak flows for the specified return period.

11.5.16 The table also presents low flows (Q_{95}) for the site catchments. The Q_{95} is the flow which is exceeded 95% of the year and is a measure of annual low flow for that catchment. The Q_{95} values are generated from the LowFlows software package[6]. The Q_{95} values presented in the table below do not take into consideration the presence of any lochs within the catchments.

[4] Institute of Hydrology (1999) Flood Estimation Handbook (five volumes).
[5] Halcrow/HR Wallingford (2004) ISIS Hydrological Software Package.
[6] Wallingford HydroSolutions (2007) LowFlows – UK Best Practice Low Flow Estimation CD-ROM.

Table 11.7: Estimated Low Flow (Q_{95}) and Peak Runoff Rates for Site Catchments

Catchment	Area (km^2)	Q_{95} (m^3/s)	Estimated Peak Runoff (m^3/s) for site catchments						
			2	5	10	25	50	100	200
Allt Ghlas	21.48	0.074	21.171	30.077	36.389	45.321	53.089	60.581	69.651
Allt Caochan an t-Seilich	5.01	0.019	5.657	7.926	9.607	11.945	13.964	15.905	18.245
Allt Coire a' Mhor-fhir	0.89	0.003	0.797	1.110	1.352	1.691	1.983	2.266	2.607
Loch Mheugaidh	3.13	0.013	3.310	4.624	5.577	6.931	8.098	9.217	10.565

11.5.17 The important characteristics used to define the response of the catchments to rainfall include the Base Flow Index (BFI) and Standard Percentage Runoff (SPR) parameters. The BFI is a measure of the proportion of a catchment's long-term runoff that is derived from stored sources, with the BFI ranging from 0.1 in relatively impermeable clay catchments to 0.99 in highly permeable catchments. The SPR values represent the percentage of rainfall that is likely to contribute to runoff.

11.5.18 The characteristics of the catchments which drain within the site boundary are outlined below in Table 11.8.

Table 11.8: Catchment characteristics

Catchment	Standard Annual Average Rainfall (SAAR) (mm)	Base Flow Index (BFI)	Standard Percentage Runoff (SPR) (%)
Allt Ghlas	1,787	0.342	55.35
Allt Caochan an t-Seilich	1,545	0.333	55.00
Allt Coire a' Mhor-fhir	1,493	0.516	41.41
Loch Mheugaidh	1,421	0.331	52.82

11.5.19 The BFI for the site catchments range from 0.331 to 0.516 indicating that between a third and a half of the catchments long-term runoff is derived from stored sources. The SPR for the site catchments range from 41.41% to 55.92%, which suggests that approximately half of the rainfall during an event contributes to runoff. The BFI and SPR values show that the site is located on slowly permeable catchments which are likely to have a moderate response to rainfall events.

11.5.20 Figure 11.3 provides information on the flow direction of the surface runoff within the study area. Flow accumulation is calculated in the Geographical Information System (GIS) package ArcGIS and is based on the 5 m resolution DTM of the area occupied by the proposed development. The flow accumulation represents the volume of water that would flow into each 5 m cell of the DTM, assuming that all water becomes runoff and there was no interception, evapotranspiration or infiltration. The volume of accumulation is represented in greyscale with higher flow accumulations being darker in shade to areas of lower accumulation. The figure clearly illustrates the influence of topography on the accumulation and direction of surface water runoff across the proposed development.

11.5.21 Figure 11.4 provides information on how the topography influences the saturation of the peat across the proposed development. From the analysis of the DTM a topographic wetness index (TWI) is derived. The TWI is a dimensionless index, defined by the equation: $\ln(a/\tan(\beta))$, where a = area draining through a point from an upslope contributing area and $\tan(\beta)$ is the local slope angle. The index provides the results on the hydrological similarity of peat. All points with the same value of index are assumed to respond in a similar hydrological manner. High index values will tend to saturate first and will therefore indicate potential subsurface or high surface runoff areas.

11.5.22 As shown in Figure 11.4, the TWI for the proposed development has identified those areas where water will accumulate on site and result in saturation of the surrounding peat. The highest values (20 plus) in the TWI form linear channels or where there is a tendency for the ground to saturate and are shown in blue. Drier areas where there may be less of a tendency for the ground to become saturated are shown in orange and red. The dark blue linear channels are considered to show achievable flow rates that are likely to occur throughout the year or during extreme rainfall events. The lighter blue areas are likely to represent areas of the site where the topography allows the accumulation and saturation of peat from subsurface or surface means during prolonged and/or intense rainfall events.

Flood Risk

11.5.23 The flood risk assessment has been carried out in accordance with Scottish Planning Policy (SPP)[7]. The document states that:

> "*Planning authorities must take the probability of flooding from all sources – (coastal, fluvial (watercourse), pluvial (surface water), groundwater, sewers and blocked culverts) and the risks involved into account when preparing development plans and determining planning applications".*

11.5.24 The Flood Risk Management (Scotland) Act 2009[8] sets in place a statutory framework for delivering a sustainable and risk-based approach to managing flooding. The main elements of flood risk management relevant to this assessment are assessing flood risk as well as undertaking structural and non-structural flood management measures.

11.5.25 A review of SEPA's Indicative River and Coastal Flood Map[9] indicates that there are a number of watercourses (Allt a' Choire Odhair Bhig, Allt Ghlas, and Allt Caochan an t-Seilich) which are within the site boundary and are at risk from the flood inundation envelope (0.5% (1:200) or greater probability of flooding in any given year). There are also a number of areas identified which are at risk from surface water flooding.

11.5.26 As highlighted above, all potential sources of flooding must be considered for any development. A summary of the potential sources of flooding is presented below.

Fluvial Flooding Sources

11.5.27 Flood information provided by the SEPA Indicative River and Coastal Flood Map indicates that there are three watercourses within the proposed development boundary that are at risk from flooding (greater than 0.5% (1 in 200) chance of flooding each year).

11.5.28 Due to the construction of new access tracks, turbines and hardstanding areas it is possible that there could be an increase in the potential flooding as the area of impermeable surfaces will increase during the construction and operational phases. The increase in impermeable areas, as well as the construction and/or upgrade of watercourse crossings can encourage greater surface runoff and reduced time to peak responses during intense

[7] Scottish Government (2010) Scottish Planning Policy.
[8] Scottish Government (2009) Flood Risk Management (Scotland) Act 2009.
[9] Scottish Environment Protection Agency (2011) Interactive Flood Map (http://go.mappoint.net/sepa), accessed 18/07/2013.

rainfall events. Any change to the hydrological regime could increase the risk of on-site and downstream flooding.

Tidal Flooding Sources

11.5.29 The site is located approximately 60 km to the nearest coast; and due to this distance along with topographical position, the proposed development will not be affected by tidal flooding.

Groundwater Flooding Sources

11.5.30 Flooding can also result from high groundwater levels if the water table rises above the surface level. Groundwater flooding is difficult to predict as it rarely follows a consistent pattern. The response time between rainfall and groundwater flooding is also relatively long.

11.5.31 Due to the topography, hydrology, slowly permeable peat and peaty soils, it is possible that areas of the proposed development situated on gentle slopes and topographic hollows could be affected by localised groundwater flooding. Figure 11.5 indicates that the areas along the watercourses and the low lying areas show the greatest potential for groundwater flooding.

Flooding From Artificial Drainage Systems

11.5.32 As shown in Figure 11.2, there is evidence of artificial drainage across a number of the catchments within the proposed development. There is the potential that these could cause some localised flooding by increasing runoff rates to the main watercourses within the catchments. However, at the time of the site visit in March 2014 there was negligible to no flow present within the drainage channels assessed, therefore it is expected that these will have negligible impact to flooding potential.

Other Sources of Flooding

11.5.33 Due to the moderately and steep sloped topography there is the potential for overland flow to occur, exacerbated by the dominance of slowly permeable peat and/or peaty soils underlying the proposed development. Peat deposits tend to have a ‘flashy’ flow regime which is characterised by storm responses and large differences between low and high flows. These resulting characteristics are due to the majority of the peat layer being permanently saturated with only a thin upper layer available to provide surface water storage. During heavy rainfall events, the limited volume of available storage is quickly exhausted with the ground becoming fully saturated and therefore, the rainfall is rapidly transmitted to the surface watercourses predominantly via overland flow. During dry conditions, the peat is able to sustain a low baseflow to the surface watercourses; however, these flows are generally low owing to the limited volumes of available storage and the low permeability of the peat. As such, drainage measures must be constructed to take this negligible storage capacity into account and protect vulnerable infrastructure.

Water Quality

11.5.34 Two watercourses within the vicinity of the proposed development have been classified under SEPA’s River Basin Management Plans (RBMP) (SEPA, 2011). The RBMP is one of the requirements of the WFD and are the plans designed for protecting and improving the water environment. The details of the watercourses within the vicinity of the proposed development that are classified under the RBMP classification scheme are provided in Table 11.9. The current ecological status of the watercourses is also provided in Figure 11.1.

Table 11.9: RBMP classifications

River	Current Ecological Status	Targeted Ecological Status (in line with first, second and third RBMP cycles)		
		2015	2021	2027
River Ghlas	Bad	Bad	Bad	Good
River Ericht	Poor Ecological Potential	Poor	Poor	Good

Water Resources

11.5.35 As indicated in Section 11.5.10, there is a hydropower intake weir on the Allt Ghlas watercourse. It is not expected that there will be any impact to the quantity or frequency of flows delivered to the abstraction point on this watercourse due to the proposed development. Therefore based on the information available, impacts on the hydroscheme are not considered further in this assessment.

11.5.36 Perth and Kinross Council (PKC) were contacted regarding the presence of private water supplies both within the site and within a 5 km search area. The local authority confirmed that there are a number of registered private water supplies within the search area, and on inspection none of these supplies are within the catchments identified that contain infrastructure associated with the proposed development. Based on the information available, impacts on private water supplies are not considered further in this assessment. The locations of the nearest identified sources, demonstrating no hydrological connectivity to the site, are shown in Figure 11.1.

Soils and Peat

11.5.37 The distribution of soils across the site is dependent upon land use, geology, topography and the drainage regime of the area. Information on site soils has been provided by Sheet 42, Loch Rannoch of the James Hutton (formerly the Macaulay Institute) Soil Survey of Scotland.

11.5.38 Table 11.10 provides a summary of the soils present within the site. The table also lists the infrastructure present within each soil component type.

Table 11.10: Summary of Soil Types

Soil Association	Parent Material	Component Soils	Infrastructure Present
Organic Soils	Organic Deposits	(4D) Blanket peat, deep	Turbines and associated hardstandings and new access tracks
		(4DE) Blanket peat, deep	Turbines and associated hardstandings and new access tracks
Aberlour	Drifts derived from schists, gneisses, granulites and quartzites principally of the Moine Series	(23) Peat, peaty gleys, peaty podzols	Turbines and associated hardstandings, borrow pit and new access tracks
		(26) Peat, peaty gleys, peaty podzols	Turbines and associated hardstandings, and new access tracks

		(33) Subalpine soils: some peat, rankers and alpine soils	Turbines and associated hardstandings, and new access tracks
Priestlaw	Drifts derived from granites and granitic rocks	(123) Peaty podzols, peat, peaty gleys	New access tracks

11.5.39 The above soils information indicates that peat and peaty soils dominate the area occupied by the proposed development. Peat is a soft to very soft, highly compressible, highly porous organic material that can consist of up to 90 – 95% water, with 5 -10% solid material[10]. Unmodified peat consists of two layers; a surface arcotelm which is usually 10 – 30 cm thick, highly permeable and receptive to rainfall. Decomposition of organic material within the acrotelm occurs aerobically and rapidly. The acrotelm generally has a high proportion of fibrous material and often forms a crust in dry conditions.

11.5.40 A second layer, or catolem, lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catolem usually remains saturated with little groundwater flow. Peat is thixotropic, meaning that the viscosity of the material decreases when stress is applied. The thixotropic nature of peat may be considered less important where the peat has been modified through artificial drainage or natural erosion and is drier, but will be significant when the peat body is saturated.

11.5.41 Due to the distribution of blanket peat and peaty soils across the site a peat depth and peat slide risk assessment has been carried out (Technical Appendix 11.1). There are a number of drainage and geotechnical issues to constructing and operating on such environments. Haggs have formed as a result of erosion and can act as conduits to water, therefore facilitating in the rapid removal of water from the slopes.

11.5.42 Technical Appendix 11.1: Peat Stability Risk Assessment provides the details on the methodologies adopted to complete the peat slide risk assessment, with the Table 11.11 below providing a summary of the peat depths recorded during the field surveys.

Table 11.11 Summary of Recorded Peat Depths

Peat Depth Range (m)	Results	% of Points
<0.50	1,259	48.3
0.51 – 1.00	726	27.9
1.01 – 1.50	325	12.5
1.51 – 2.00	153	5.9
2.01 – 2.50	75	2.9
2.51 – 4.00	66	2.5
TOTAL	2,604	100

11.5.43 The information presented in the table indicates a total of 2,604 peat depths were recorded as part of the site investigation survey work carried out across the proposed development by Natural Power during May and June 2013. The results would suggest that 48.3% (1,259 points) of the these depths were less than 0.50m with only 2.5% (66 points) of the total recorded depths greater than 2.51m. In total, 76.2% (1,985 points) of the total recorded depths were reported to be less than 1.00m.

[10] J. Warburton, J. Holden and A.J. Mills (2004), Hydrological controls of superficial mass movements in peat, Earth Science Reviews, 67, 139 – 156.

11.5.44 Technical Appendix 11.1: Peat Stability Risk Assessment provides the details on the methodologies adopted to complete the peat slide risk assessment, with the following information providing a summary of the peat depths recorded during the field surveys. In addition to this, a Peat Management Plan (PMP) has been prepared, and is outlined in Technical Appendix 11.2, which outlines the estimated volumes of peat that may be excavated during construction and details the processes and techniques that can be utilised to reinstate infrastructure elements. Details of proposals for restoring areas of blanket bog within the proposed development, using peat to block many of the artificial drainage channels are provided in Technical Appendix 9.2: Habitat Management Plan.

Geology

11.5.45 The following geological information has been obtained from digital information provided by the British Geology Survey (BGS)[11]. The proposed development is underlain by the bedrock from the Grampian-Group Psammite. This is a metamorphic bedrock sequence described by the BGS as locally arkosic, quartzofeldspathic psammite in units 100 – 1000m thick. The rock mass may contain subsidiary semi-pelite to pelite units (mudrock derived meta-sediments). Quartzite units occur locally towards the top of succession. There are also rare and linear outcrops of the Etive Dyke Swarm which is a Siluro-Devonian age igneous intrusive rock of porhyritic micro-diorite. Further small scale intrusions of the North Britain Siluro Devonian Dyke Suite also rarely predicted to sub-crop beneath the site. These are described as calc-alkaline lamprophyres (ultra-mafic rock). These amphibolites and calc-silicate rocks are described by the BGS as rare.

11.5.46 Peat forms a blanket deposit across the proposed development. The blanket peat has formed deep deposits in expansive lower valleys and across the site often in topographic depressions and in close proximity to watercourses. In areas of the proposed development with high topographic relief; the main control on peat depth is postulated to be the slope angle. Further details of the peat composition can be found within Technical Appendix 11.1: Peat Stability Risk Assessment.

11.5.47 The following geological information has been obtained from digital information provided by the British Geology Survey (BGS)[12]. The proposed development is underlain by the bedrock from the Grampian-Group Psammite. This is a metamorphic bedrock sequence described by the BGS as locally arkosic, quartzofeldspathic psammite in units 100 – 1000m thick. The rock mass may contain subsidiary semi-pelite to pelite units (mudrock derived meta-sediments). Quartzite units occur locally towards the top of succession. There are also rare and linear outcrops of the Etive Dyke Swarm which is a Siluro-Devonian age igneous intrusive rock of porhyritic micro-diorite. Further small scale intrusions of the North Britain Siluro Devonian Dyke Suite also rarely predicted to sub-crop beneath the site. These are described as calc-alkaline lamprophyres (ultra-mafic rock). These amphibolites and calc-silicate rocks are described by the BGS as rare.

11.5.48 Details of the on-site borrow pits and associated geology for the proposed development is described in Technical Appendix 4.1: Borrow Pit Search Report.

Hydrogeology

11.5.49 The groundwater regime beneath the proposed development is likely to be separated between superficial deposits and the underlying solid geology. Groundwater flow within the overlying peat is predicted to primarily influence the surface hydrological system. Sub-surface groundwater flow within the peat is likely to be controlled by the peat morphology including its composition, humification and permeability. The peat coverage is likely to form an aquifer, within which the groundwater is generally perched on the less permeable basement they overlie. The peat aquifer, in conjunction with the weathered bedrock zone, provides the base flow to the local surrounding

[11] British Geological Survey (BGS), Onshore GeoIndex Portal, http://www.bgs.ac.uk/geoindex
[12] British Geological Survey (BGS), Onshore GeoIndex Portal, http://www.bgs.ac.uk/geoindex

watercourses. In lower lying areas of lesser relief the water table generally occurs at or just below the surface. This is demonstrated by the presence of areas of saturated ground across the site. The hydrological system is likely to be driven by the low infiltration rates across the site and by the capacity of the peat deposits to hold and transmit ground and surface waters.

11.5.50 The Hydrogeological Map of Scotland indicates that the proposed development is underlain by impermeable Precambrian rocks, generally without groundwater except at shallow depth. The crystalline bedrock mass may offer little potential for groundwater storage and transport other than in cracks and joints which may be associated with tectonic features or near surface weathering. Under such conditions where groundwater flow is through fractures and other discontinuities, there may be potential for low productivity aquifers suitable for supporting private water supplies.

11.5.51 The Groundwater Vulnerability Map of Scotland indicates that the proposed development is underlain by weakly permeable strata of low primary permeability. These do not widely contain ground water in exploitable quantities, however, small amounts of groundwater may exist near the surface in weathered zones and in secondary fractures within the rock mass.

11.5.52 In lower lying layers of lesser relief the water table generally occurs at or just below the surface. This is demonstrated by the presence of areas of saturated ground in a number of areas across the site.

11.5.53 Groundwater Dependent Terrestrial Ecosystems (GWDTE), which are types of wetland, are specifically protected under the WFD, and are dependent upon good groundwater flows and/or quality. The WFD requires terrestrial ecosystems that are dependent on groundwater to be identified and assessed whether any anthropogenic pressures will impact these ecosystems. SEPA have developed a planning guidance note for wind farm developments[13], which outlines the standard approach for the assessment of potential disruption to GWDTEs. The assessment is required to detail the likelihood of disruption to GWDTEs in the proximity of site infrastructure: 100 m of roads and tracks; or 250 m of borrow pits and turbine foundations. By the utilisation of the results of topographic analysis, and BGS permeability and groundwater flooding datasets, the following information presents how the hydrological and hydrogeological conditions present on site may or may not be conducive to supporting groundwater dependent habitats.

11.5.54 The BGS has prepared permeability information based on the 1:50,000 Digital Geological Map of Great Britain for both bedrock and superficial geology layers. The permeability indices are based on the following geological considerations:

- The predominant flow mechanism, either intergranular flow, and mixture of intergranular and fracture flow;
- A maximum permeability index; and
- A minimum permeability index.

11.5.55 The maximum and minimum permeability indices are divided into five classes: very high, high, moderate, low and very low.

11.5.56 The data, as shown in Figure 11.6, shows that the bedrock geology is dominated by Fracture Flow with low maximum permeability and low minimum permeability. This confirms that the site is underlain by a weakly permeable strata of low permeability. Groundwater flow within the superficial geology, as presented in Figure

[13] SEPA (2012), Land Use Planning System – Guidance Note 4: Planning Guidance on Windfarm Developments.

11.6 is variable due to the varying permeability of the mapped superficial deposits underlying the site. Figure 11.6 confirms that groundwater flow within the superficial deposits varies with areas of intergranular flow with high maximum permeability and very Low minimum permeability located within proximity of the watercourses associated with Alluvium deposits.

11.5.57 The Groundwater Vulnerability Map of Scotland indicates that the proposed development is underlain by weakly permeable strata of low primary permeability. These do not widely contain ground water in exploitable quantities, however, small amounts of groundwater may exist near the surface in weathered zones and in secondary fractures within the rock mass.

11.5.58 As part of the surveys carried out in Chapter 8: Ecology, a habitat and vegetation survey was carried out to provide an ecological baseline of the ground conditions. As part of the assessment, heath and blanket bog communities were identified and contained a mosaic of upland 'wetland communities' typical of the local environment and regionally widespread, occurring both within the proposed development area and immediate surrounding area.

11.5.59 To enable an appropriate assessment of the potential for GWDTEs, the habitat data was mapped to show the contours, overlain with the proposed development infrastructure and appropriate buffer zones as per SEPA guidance. A hydro-geological approach to the identification of GWDTEs has been employed, utilising published information on the superficial and bedrock geology underlying the proposed development. As outlined above, the superficial and bedrock aquifers underlying the proposed development are likely to be dominated by fracture flow with low productivity. Therefore, flow is dominantly in fissures and fractures and the aquifers are likely not to be extensive across the proposed development.

11.5.60 Areas identified as supporting wet heath, mire and blanket mire were determined across a number of the areas proposed development, particularly mid-slope of topographies which have moderate gradient and are underlain by shallow to moderate peat depths. These communities form a mosaic of habitats, and not solely M15 (a moderately groundwater dependent habitat), as outlined in the guidance. Due to their location, and with the habitats being largely dependent on rainfall, these habitats are not GWDTEs and can therefore be ascertained that relevant schedules of the WFD and WEWS do not apply. These communities are typical of the wider environment, therefore is unlikely to be a moderately dependent groundwater habitat as assigned by SEPA.

11.5.61 In the south-east locale of the proposed development, the habitat has been determined as a wet heath. This habitat is located on a gently sloping area with occasional watercourses flowing east to west towards the existing track. Habitats in this area require wet conditions but have resilience to water table fluctuations and periods of drying over shallower and free draining areas of peat. Therefore, due to these conditions it is not expected that this area is heavily dependent on groundwater to support this habitat.

11.5.62 Where present, localised areas of marshy grassland were located in close proximity to watercourses, therefore it is considered likely that the presence of these habitats is connected to surface water features reliant on rainfall, rather than a strong dependence on groundwater flows. Where areas of wet heath have been recorded in close proximity to blocks of plantation, therefore, these habitats are likely to be related to the local topography, modified drainage systems and environment conditions connected with the adjacent forestry, and are not likely to be dependent upon groundwater flows.

11.5.63 Due to the local conditions and topography, it is considered likely that the 'potential GDTWEs' identified during the assessment of the baseline data are predominantly ombrogenous in nature and therefore are not heavily groundwater dependent. Within flush zones and the riparian corridors it is expected that there will be a high potential for groundwater flooding to occur as demonstrated by the information presented in Figure 11.5.

Modifying Influences

11.5.64 Information regarding climate change was obtained from the UK Climate Projections (UKCP09) website (UKCP09, 2011). The UKCP09 is a climate analysis tool which features comprehensive projections for different regions of the UK. Based on a high emissions scenario, climate information for the East Scotland UKCP09 predicts that the winter mean temperature will increase by 1.1ºC, with summer temperatures increasing by 1.4ºC by the 2020's. It also predicted that annual mean precipitation is to remain unchanged with winter mean precipitation increasing by 3% and summer mean precipitation reducing by 4% by the 2020's.

11.5.65 Thus, in winter months there could be an increase in rainfall and reduction in snowfall, due to warmer temperatures. If climate change leads to drier summers there is the potential for increased pressures on habitats supporting sensitive species as well as increased demand on downstream water users. There is also a suggestion that summer storms are likely to be more intense and frequent and this may lead to more extreme flow values during and immediately following such events, with consequential flooding and water quality issues. This is of key importance for the hydrological environment during summer construction periods.

11.5.66 It is anticipated that increased temperatures in the summer could also increase evapotranspiration and potentially cause desiccation of peat. The desiccation could result in the peat becoming more susceptible to erosion due to increased intensity in summer storms and increased rainfall during winter months.

11.5.67 As peat and peat dominant soils are composed of vegetation remains and are almost entirely organic they contain a high proportion of carbon compared to other soils. Thus, the process that forms peat effectively locks away atmospheric carbon. It is believed that the loss of peatlands could lead to the release of carbon into the atmosphere contributing to greenhouse gas concentrations which are believed to be one of the main drivers of climate change

11.6 Project Design

11.6.1 A summary of the hydrological influences on the project layout are given below with full details of the project design provided in Chapter 2: Design Evolution and Alternatives. Due to the nature of the environment occupied by the proposed development it is imperative that the design of the infrastructure does not result in significant implications to the hydrological environment with secondary effects on peat stability and ecology.

11.6.2 The design, where practicable, has been sited outside the areas of deepest peat, and through mitigation measures outlined in Technical Appendix 11.1: Peat Stability Risk Assessment, the risk from potential peat slides can be reduced to a residual level.

11.6.3 The hydrological desktop study and site visits have identified a complex hydrological environment, with a significant number of hydrological pathways and features associated with the upland, moorland environment. A series of buffer distances have been adopted to help reduce the effects of the proposed development on the hydrological environment. A 50m buffer was implemented for all watercourses considered to have continuous flow throughout the year, as well as areas of standing water or shallow groundwater.

11.6.4 Table 11.12 confirms that all turbines associated with the proposed development are located outside this buffer limit. Distances were calculated using functionalities provided within ArcGIS package. Features considered to be main channels, are where flow was encountered during the site visits.

Table 11.12: Distance of Turbines from Identified Hydrological Features.

Turbine ID	Turbine Distance from Identified Hydrological Features (50m Main Drainage Buffer)
1	153
2	201
3	79
4	73
5	181
6	257
7	104
8	271
9	342
10	418
11	212
12	193
13	102
14	18
15	185
16	286
17	177
18	91
19	122
20	138
21	54
23	113
24	89
25	131

Note: T22 was dropped through the design development process, however numbering remains throughout.

11.6.5 The design of infrastructure has also meant the associated tracks are located 50 m from hydrological features wherever possible. However, where access necessitates essential watercourse crossing, construction features have been limited in these buffers as far as possible, for example, minimising tracks parallel to streams and trying to avoid track junctions being constructed in these zones. The exceptions to this are where access tracks have to cross watercourses or when other constraints have resulted in the track having to infringe upon the buffer.

11.6.6 Proposed watercourse crossings associated with the creation of 16.4 km of new access track, required as part of the construction of the proposed development will be minimised to seven in total.

11.7 Effects Evaluation

Development Characteristics

11.7.1 The proposed development will comprise of 24 wind turbines with mass concrete foundations. The associated infrastructure will consist of transformers, on-site cabling, a control building, crane pads, four borrow pits, a construction compound and 16.4 km of access track, 12.8 km of which is new track to be constructed with the remaining 3.6 km consisting of the upgrading of existing estate tracks.

11.7.2 Typically, the construction phase will involve a period of earthworks, track construction and excavations for borrow pit workings and forming turbine bases. Following this, turbine bases and infrastructure will be installed and finally the turbines will be transported to site and erected.

11.7.3 The landtake during the construction phase of the proposed development, including borrow pits, will be approximately 47.8 ha (0.48 km^2), with approximately 15.3 ha (0.15 km^2) of temporary landtake (i.e. borrow pits and construction compound) that will be reinstated following construction.

Assumed Design, Management and Mitigation Measures

11.7.4 A number of planning, design and construction proposals have been identified during the assessment. Full details of the assumed best practice construction management and mitigation measures will be provided in a Construction Environmental Management Plan (CEMP), or similar, which it is anticipated would be required and prepared post consent in response to a condition attached to any future consent. A summary of the measures to be included in the CEMP are described below and have been assumed to be part of the proposals when the assessment of effects and their significance are reported. Any further mitigation or enhancement measures, specific to the proposed development, but all considered best practice are also provided in further detail in the following paragraphs. A number of mitigation measures described in the following paragraphs can be adopted during the construction and operational phases of the proposed development. To avoid the duplication of text, the reference to the specific stage the measures can be adopted is provided in the following paragraphs.

General Site Pollution Control

11.7.5 A site specific CEMP will ensure that best practice measures are put in place and activities carried out in such a manner as to prevent or minimise effects on the surface and groundwater environment during construction. The CEMP will be prepared prior to commencement of construction and will include the information as follows:

- Drainage – all runoff derived from construction activities and site infrastructure will not be allowed to directly enter the existing and natural drainage network. All runoff will be adequately treated via a suitably designed drainage scheme with appropriate sediment and pollution management measures. The proposed development is situated in an upland, moorland hydrological environment and it is imperative that the drainage infrastructure is designed to accommodate storm flows in a 1 in 200 year plus climate change scale to help maintain the existing hydrological regime.
- Storage – all oil/peat stockpiles as well as equipment, materials and chemicals will be stored well away from any watercourses. Chemical, fuel and oil stores will be sited on impervious bases with a secured bund.
- Vehicles and Refuelling – standing machinery will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable, refuelling of vehicles and machinery will be carried out in designated areas, on an impermeable surface, and well away from any watercourse.

- Maintenance – only emergency maintenance to construction plant will be carried out on site, in designated areas, on an impermeable surface well away from any watercourse or drainage, unless vehicles have broken down necessitating maintenance at the point of breakdown, where special precautions will be taken.
- Welfare Facilities – on-site welfare facilities will be adequately designed and maintained to ensure all sewerage is disposed of appropriately. This may take the form of an on-site septic tank with soakaway, or tankering and off-site disposal depending on the suitability of the site for a soakaway and prior to agreement with SEPA.
- Cement and Concrete – fresh concrete and cement are very alkaline and corrosive and can be lethal to aquatic life. The use of wet concrete in and around watercourses will be avoided and carefully controlled.
- Monitoring Plans – all activities undertaken as part of the proposed development will be monitored throughout the construction phase. Such monitoring will be to ensure environmental compliance. Water quality monitoring will also occur throughout each phase of the proposed development and will help to maximise the effectiveness of mitigation measures whilst monitoring the effects on the hydrological environment.
- Contingency Plans – plans will ensure that emergency equipment is available on-site i.e. spill kits and absorbent materials, advice on action to be taken and who should be informed in the event of a pollution incident.
- Training – all relevant staff personnel will be trained in both normal operating and emergency procedures, and be made aware of highly sensitive areas on-site.

11.7.6 Further details regarding the pollution prevention and mitigation measures that will be adapted during construction and operation of the proposed development are detailed in the following paragraphs.

Runoff and Sediment Management

11.7.7 The following measures will be adopted to appropriately attenuate and treat runoff during construction and operation of the proposed development.

11.7.8 The site drainage system will convey water away from construction activities as well as the infrastructure associated with the proposed development. However, due to the nature of the works on-site and the negligible infiltration and storage capacity of the underlying peat and bedrock there is significant potential for sediment and other pollutants to become entrained in the surface runoff.

11.7.9 To reduce this potential it will be ensured that prior to the commencement of work and during construction that figures showing site drainage and hydrologically sensitive areas are regularly checked to review potential runoff and ponding of water across the site to ensure that runoff patterns are well known.

11.7.10 The drainage systems installed on-site will also have sediment management measures incorporated into their design to help reduce or wholly mitigate effects on the hydrological environment. The type of sediment management will depend on the volume of construction activities occurring in particular areas across the site. For all of the suggested control measures, regular inspection and maintenance is necessary, particularly after prolonged heavy rainfall.

11.7.11 Straw bales and/or silt traps will be installed within the site drainage system. Silt traps could take the form of terram fences or clean stone. However, the ability of the silt traps to successfully treat runoff will be dependent upon the permeability of the terram geotextile material and the size and source of the clean stone and the frequency of monitoring and maintenance of these measures.

11.7.12 The ability of the straw bales and silt traps to effectively treat runoff will depend upon the volume of runoff within the drainage channel, the type of material used and the frequency of monitoring and replacement of the measures.

Pumping and Dewatering of Excavations

11.7.13 All pumping operations e.g. removal of water from turbine base excavations, will be carried out in line with best practice and where necessary in line with the requirements of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) prior to the works being undertaken. Suitable measures to minimise the impact of the pumped water on the hydrological environment shall be taken. These measures shall include, but are not limited to, the following techniques.

11.7.14 Due to the expected permeability of the peat and peaty soils it is expected that the potential for groundwater ingress would be low. The ingress of surface water into the excavations will be minimised throughout the use of upgradient drainage measures e.g. cut-off ditches. It is recognised that water can still enter the excavation and would need to be removed. This can be achieved by allowing the water to gravity drain to a designated area before discharging back into the natural drainage network. The treated water from the settlement lagoons or other silt management measures will not be discharged directly into watercourses but directed onto vegetated surface where appropriate.

11.7.15 To reduce the likelihood of erosion channels being formed by the discharge from the sediment treatment outfalls it is recommended that the water is discharged at a slow rate, or spread evenly across a surface. For discharge onto rough vegetation to be effective, the discharge must be spread efficiently and the vegetation, soils and topography be carefully considered to determine an appropriate discharge location. For example, filtering water through a length of pipe with multiple discharge points will allow attenuation as well as diffuse dispersion, thus reducing the erosive potential of the runoff.

11.7.16 This discharge method can also utilise silt traps, straw bales or other attenuation measures. The utilisation of such measures could help to prevent the formation of erosion channels.

Storage of Fuels/Chemicals and Bunding Arrangements

11.7.17 Throughout the construction and to a lesser extent during the operational phase of the proposed development a number of oils and chemicals will be used. Such materials will be used and stored in a safe manner to ensure that the surface and groundwater environment is not adversely affected.

11.7.18 The following measures will be adopted to protect the surface and groundwater environment from the inappropriate storage and use of substances hazardous to the environment:

- All equipment, materials and chemicals will be stored away from any watercourses. Chemicals, fuel and oil will be stored in tanks of sufficient strength and structural integrity to ensure that it is unlikely to burst or leak in ordinary use. They will also be sited on impervious bases within a secured bund of 110% of the storage capacity;
- Where oil is stored in a bunded area, oil residue can build up. This residue build up will reduce the storage capacity of the bund and will be removed regularly. The residue will be disposed of by a specialist contractor;

- Locks shall be fitted to all fuel storage tanks or containers and there shall be a nominated trained person to oversee the refuelling and delivery to ensure there is no spillage; and
- Standing machinery will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable refuelling of vehicles and machinery will be carried out at a central designated area, on an impermeable surface, which will be located at least 50 m away from any watercourses.

Refuelling

11.7.19 A fuel bowser will be used for refuelling on the access tracks or hardstanding. The bowser driver shall be responsible for ensuring that refuelling of mobile plant does not take place within 50 m of a watercourse. The bowser driver will receive extra training on spill prevention and response.

11.7.20 The refuelling bowser shall be equipped with a mobile spillage control kit containing oil absorbent booms and mats. All site personnel will be trained in their use as part of the site induction training or toolbox talks. Special attention will be paid to spillage control at watercourses.

11.7.21 Oil booms will be provided and maintained downstream of the works at all watercourse locations that the access track crosses for the duration of the construction period to act as a defence against the unlikely event of an oil or fuel spillage.

Vehicle Maintenance and Management

11.7.22 All plant used during the construction of the proposed development will be in suitable condition and fit for purpose to carry out the works and will be maintained as per manufacturers guidelines.

11.7.23 Maintenance of construction plant to be carried out in designated areas, on an impermeable surface away from any watercourse or drainage. Only if vehicles have broken down will maintenance be permitted out with a designated area, and this would only be carried out after implementing special precautions. Such precautions include, but are not limited to:

- Ensure that drip trays are placed underneath vehicles during maintenance;
- As a precautionary measure, ensure that straw bales or entrapment matting are placed downstream of the maintenance area;
- All heavy construction plant will be inspected daily by the operating personnel and any defects or issues resolved immediately prior to starting works. All heavy construction plant shall be issued with spill-kits. Should a spillage occur, larger spill kits shall also be positioned at various areas of the site which will be highlighted to all operatives during the site induction; and
- Standing machinery and plant will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Where practicable refuelling of vehicles and machinery will be carried out at a central designated area, on an impermeable surface, which will be located at least 50 m away from any watercourses.

Concrete Works

11.7.24 Concrete would be required for the construction of the wind turbine foundations. The following section provides best practice measures that are required to be implemented to prevent detrimental effects to the hydrological environment. These measures should be considered irrespective of whether there is an on-site concrete batching plant.

11.7.25 Care will be taken to ensure that the transportation of concrete to the turbine and building foundations uses best practice measures. Freshly mixed concrete and/or dry cement powder will not be allowed to enter any watercourse. This will be ensured by:

- Locating turbines and concrete batching or wash out areas at least 50 m from watercourses;
- Concrete wagons will only be permitted to wash-out into specifically designed wash-out areas at predetermined and agreed locations site wide;
- The drivers will be informed at their site induction of the location of the designated wash-out areas and issued with a location map;
- Loads will be managed and assessed with regards to the size of vehicle and ground conditions whilst keeping at appropriate speed limits to avoid spillage;
- Tools and equipment will not be cleaned in watercourses. Should it be necessary to clean tools and equipment on site, this will be done in the predetermined wash-out areas;
- Designated concrete wash out areas will be constructed on site in a location agreed with the relevant consultees to ensure protection of watercourses. The design and construction of the wash out area will be agreed with SEPA; and
- Wash out areas will be continually monitored and findings recorded to ensure effluent levels do not spill over into the environment.

Site Drainage

11.7.26 The following section discusses the conventional site drainage measures that can be installed during the construction and operation of the proposed development.

11.7.27 Surface drainage ditches will be installed alongside tracks only where necessary. The length, depth and gradient of individual drains will be minimised to avoid intercepting large volumes of diffuse overland flow and generating high velocity flows during storm events. The type of drainage ditches which can be installed at the proposed development will vary depending on the type of access track. For example, “v” shaped intercepting ditches are more appropriate for cut tracks that have resulted in the removal of the surrounding peat and would trigger settlement. An alternative to this is to construct “flat ditches” solely within the acrotelm. The flatter ditch will result in a smaller lowering of the water table within the peat than the deeper “v” ditch which can result in the removal of the acrotelm as well as being partially installed into the catotelm[14].

11.7.28 Access tracks crossing slopes will disrupt surface flow that consequently will collect in drains constructed upslope of the tracks. Cross-drains and or waterbars will be constructed at regular intervals to conduct this surface flow below or across the track where it will be discharged back into the drainage system. All efforts will be made to segregate this runoff from more silty runoff originating from track surfaces and other exposed construction areas, thus reducing the silt load and volume discharging to all silt treatment areas. Regular discharge points will limit the concentration of surface runoff and the diversion of flows between catchments. Such cross drains need to be strong enough to withstand the expected traffic loadings[15].

11.7.29 Sediment traps, settlement ponds and buffer strips will be incorporated into the drainage system as necessary and will serve the dual purpose of attenuating peak flows, by slowing the flow of runoff through the drainage system, and allowing sediment to settle before water is discharged from the drainage system.

[14] FCE, SNH (2010), Floating Roads on Peat
[15] Scottish Renewables, SNH, SEPA (2010), Good Practice During Wind Farm Construction

11.7.30 As well as utilising sediment traps, structures such as v-notched weirs and/or check dams will be installed within the drainage channels. Such structures will throttle the flow within the channel, thus reducing erosive potential of any runoff and allowing sediment and/or pollutants to settle.

11.7.31 During storm events there is likely to be some ponding on the uphill side of tracks, as percolation alone is unlikely to be able to accommodate surface flows. To minimise this ponding, small diameter cross drains or perforated pipes (similar to plastic pipe field drains) would be incorporated into the track base at regular intervals to allow more flow to pass through the track and maintain the current flow regime. It is recommended that such pipes are surrounded by free draining material that is wrapped in a separator geotextile. The number of pipes and associated dimensions will be dependent upon the width of the flush/boggy area and the hydrological regime.

11.7.32 The sizing and location of the various drainage elements will be influenced by the topography, gradient and catchment runoff characteristics and the volumes of runoff intercepted by each drain. These factors will be determined at the detailed design stage.

11.7.33 Prior to track construction, site operatives will identify flush areas, depressions or zones which may concentrate water flow. These sections will be spanned with plastic pipes to help maintain hydraulic conductivity under the road, and reduce water flow over the road surface during heavy precipitation.

11.7.34 Due to the poor permeability of the surrounding peat, peaty soils and bedrock, it is also recommended that drains and/or cut-off drains are installed on the upstream/upgradient sides of the turbine foundations, crane hardstandings, and other excavations required across the site. The purpose of this will be to help reduce the volume of surface water runoff entering the excavations and minimise any subsequent contamination.

11.7.35 The constructed drainage system will not discharge directly to any natural watercourse, but will discharge to buffer strips, trenches or Sustainable Drainage Systems (SuDS) measures, preferably on flatter, lower lying ground. These buffers will act as filters and will minimise sediment transport, attenuate flows prior to discharge and maximise infiltration back into the soils and peat.

11.7.36 Drainage from the construction compound, borrow pits and concrete wash out areas will be collected and treated separately from the main site drainage, as the runoff from these areas is more likely to be contaminated and therefore will require treatment. Appropriate treatment, such as oil interceptors and treatment for high alkalinity, will be subject to detailed design and approval.

11.7.37 As discussed in Section 11.6, seven new watercourse crossings will be required as part of the construction and subsequent operation of the proposed development. The crossings will be appropriately designed so that they do not alter the natural drainage, hinder the passage of aquatic fauna and can accommodate flow for a 1:200yr plus climate change event. Any ecological considerations should be implemented during the design of the watercourse crossings, further details of specific considerations are covered in Chapter 8: Ecology. All watercourse crossings will be designed with edge upstands or bunds e.g. straw bales, sandbags or silt fences to prevent sediment laden runoff from construction plant movement from directly entering watercourses. Authorisation from SEPA under The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) will be sought for construction of the crossings that are required over watercourses that are displayed on the 1:50,000 OS Landranger maps.

Site Tracks

11.7.38 The construction of new tracks will vary depending on the ground conditions. As outlined above, 16.4 km of track will be required across the proposed development. Cut tracks (10.8 km in length) will be constructed on harder ground, where peat depths are typically less than 1 m, and on steeper slopes. Floating tracks (2.0 km in length) will be constructed on softer areas, where peat is typically greater than 1 m in depth over a minimum stretch of 100 m. With the remaining 3.6 km of existing estate access track which will require upgrading. The preservation of the local hydrology will be the key aim and consideration in the drainage arrangements associated with access tracks, which have been discussed above.

11.7.39 The tracks will be constructed with sufficient camber or crossfall to minimise ponding of surface water on the track surface. Tracks constructed on steep gradients will have waterbars installed at regular intervals to divert longitudinal runoff from the track surface and into the drainage network. These measures will minimise the risk of erosion of the track surface and the subsequent risk of sedimentation.

11.7.40 A proportion of the site tracks will cross areas of wet peat and boggy ground, usually with greater diffuse flow than areas with defined channels. Hydrological connectivity within such areas must also be maintained and it is recommended that prior to construction site operatives identify such areas so that appropriate crossings are designed and construction management measures are implemented.

11.7.41 Within the proposed development, 2.0 km of track will be considered for floating construction. The use of suitable geotextiles in the track construction will ensure that the load is sufficiently spread to minimise compression of the peat and disruption to peat pipes and subsurface flow. It is likely that some compression may occur in the upper layers of the peat however, the majority of subsurface flow will take place through peat pipes or fractures that occur deeper within the peat, usually close to its base where any compression effects should be negligible.

11.7.42 A thorough survey of all sections of floating track will be carried out prior to construction to identify the extent of subsurface drainage features such as peat pipes. Once identified, such features will directed be through the floating track with a permanent structure, such as a pipe culvert. The pipe culvert will be of sufficient size to maintain the flow expected with the peat pipe[16].

Welfare Facilities/Foul Water

11.7.43 The following measures will be adopted for the design of the foul water drainage system:

- Any sewage associated with the temporary construction compound and welfare compounds will be collected in appropriately sized interceptor tanks and shall be located at the construction compound. All wash basins, toilets and shower areas shall also be connected to an interceptor tank; and
- The interceptor tanks and the tanks within any site portable toilets, which shall be situated not less than 50 m from any watercourse, will be emptied regularly by a suitably licensed contractor. Sewerage from these facilities will be disposed off-site in accordance with waste management legislation.

Sustainable Water Management

11.7.44 To reduce the impact of the proposed development on the natural hydrological regime, the site design will aim to mimic the greenfield runoff response at source through the use of sustainable drainage practices.

[16] FCE, SNH (2010), Floating Roads on Peat.

11.7.45 As detailed in the SEPA guidance document[17] under General Binding Rule 10, Sustainable Drainage Systems (SuDS) should be taken into consideration as part of the water management.

11.7.46 SuDS are used to attenuate rates of runoff from development sites and can also have water purification benefits. The implementation of SuDS as opposed to conventional drainage systems provides several benefits by:

- reducing peak flows to watercourses and potentially reducing risk of flooding downstream;
- reducing the volumes and frequency of water flowing directly to watercourses;
- improving water quality by removing pollutants;
- reducing potable water demand through rainwater harvesting; and
- replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

11.7.47 Whilst it is understood that the scope for infiltration SuDS measures is limited as a result of the hydrological environment it is recommended that the installed drainage measures adopt the principles highlighted above.

Watercourse Crossings

11.7.48 Following the initial design layout, a desk study was carried out to identify watercourses that will require the construction of crossings. The proposed watercourse crossings associated with the total of 16.4 km of access track required as part of the proposed development will be minimised to seven in total, six of which will be new constructions.

11.7.49 These locations were visited during the site walkover survey conducted during March 2014 and details of each crossing, including a series of photographs were taken. For each crossing, an evaluation has been made of the type of crossing required. These assessments and methodologies used for characterisation and crossing type selection are provided in Technical Appendix 11.3: Watercourse Crossing Assessment.

11.7.50 The underlying soil and geological conditions of the proposed development mean that there are areas which effectively have diffuse flow. These locations have not been explicitly mentioned within the watercourse crossing assessment but will require appropriate drainage to be installed during construction to prevent disruption to surface flows and potential damage to the access tracks.

11.7.51 The type and design of each crossing is dependent upon the stream morphology, peak flows, local topography and ecological importance and will be finalised at the detailed design stage. As mentioned, any ecological impacts should be considered during the detailed design of watercourse crossings. Discussions will be held with SEPA to agree designs and construction methodologies for each stream crossing. This information will form one element of the data to be submitted to SEPA in support of the applications that will be sought under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended).

11.7.52 All structures will be designed and constructed using best practice techniques and will be of sufficient design capacity to accommodate storm flows for a 1 in 200 year event, with an allowance for increased flows that may

[17] SEPA (2014), The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 7.1.

occur as a result of climate change. By ensuring that structures have sufficient capacity the risk of upstream flooding and increased erosion and sedimentation will be reduced.

11.7.53 Crossing structures will not form a barrier to fish migration, and will be designed and constructed following design guidance given by the Scottish Executive[18] and SEPA[19][20] relating to river crossings and migratory fish. Where the structure has an invert within the stream channel, this will be set low enough to enable the same level and gradient as the original stream bed to be maintained, and will carry similar bed material and flow to the original bed. Crossings will not have a hanging outflow and erosion protection measures will not inhibit fish passage during low flows, similarly, crossings will be constructed with a mammal ledge or similar to ensure the unobstructed movement of mammals in the riparian corridor.

Construction and Environmental Management

11.7.54 Construction traffic access will be restricted wherever possible, and the number of vehicle movements limited as much as possible. The land surrounding the immediate construction area will be fenced off or otherwise demarcated to prevent inadvertent intrusion by construction plant. This will help limit peat disturbance and subsequent reduction in the potential for erosion.

11.7.55 The water management measures described above are designed to help treat and attenuate runoff to ensure that the surface and groundwater environment is protected during all phases of the proposed development. Watercourses, culverts, drainage ditches and SuDS measures will be inspected and cleared regularly to prevent blockages and reduce the risk of flooding. Silt traps and sediment settlement ponds, if applicable, will be inspected and cleared regularly to ensure they remain fully operational and effective. Silt fences and mats will be used to ensure minimum sediment runoff from stockpiles.

11.7.56 A document register will be utilised to ensure that all maintenance to site drainage, floating tracks and any associated issues are recorded throughout each phase of the proposed development.

Emergency Water Management Measures

11.7.57 As previously mentioned a significant volume of oils and chemicals will be stored on site during the construction phase and to a lesser extent the operational phase. Site traffic will also be present in significant numbers during the construction phase of the wind farm, with traffic volumes significantly reduced during wind farm operation.

11.7.58 The appropriate storage of oils, chemicals and maintenance of site plant has been discussed above. However, despite these measures, accidents can happen and these can have significant impacts upon the quality of the surface and groundwater environment. The following emergency procedures can be implemented to ensure that the surface and groundwater environment is protected during wind farm construction and operation:

- All relevant on-site staff will be trained in both normal operating and emergency procedures, and be made aware of highly sensitive areas on site. The staff training and implementation of site procedures will be overseen by the Infrastructure Contractor to ensure that these measures are carried out effectively to minimise the risk of a pollution incident;

[18] The Scottish Executive (2000), River Crossings and Migratory Fish: Design Guidance, A Consultation Paper
[19] SEPA (2008), WAT-SG-23: Engineering in the Water Environment, Good Practice Guide – Bank Protection Rivers and Lochs, Version 1
[20] SEPA (2010), WAT-SG-25: Engineering in the Water Environment, Good Practice Guide – Construction of River Crossings, Version 2

- Contingency plans that ensure that emergency equipment is available on site (i.e. spill kits and absorbent materials), and that advice is provided on actions to be taken and who would be informed, in the event of a pollution incident; and
- Contingency planning procedures must be regularly reviewed to include changes to site operations that were not foreseen during design.

11.7.59 The procedures set out in site contingency plans need to be prepared in conjunction with the assessment of the risk of a pollution incident occurring and the measures to be taken to minimise pollution. The location of the procedures will be publicised and it is essential that they are set out clearly so that they can easily be understood and acted upon.

11.7.60 The emergency procedures can include the following:

- Containment measures;
- Emergency discharge routes;
- List of appropriate equipment and clean-up materials;
- Maintenance schedule for equipment;
- Details of trained staff, location, and provision for 24-hour cover;
- Details of staff responsibilities;
- Notification procedures to inform the relevant environment protection authority;
- Audit and review schedule;
- Telephone numbers of statutory and local water company; and
- List of specialist pollution clean-up companies and their telephone numbers.

Operational Mitigation

11.7.61 The management measures discussed previously are designed to help treat and attenuate runoff and to ensure that the surface and groundwater environment is protected during the construction of the proposed development. However, it is anticipated that the majority of these measures can be implemented throughout all phases. If the water management measures are not properly maintained, they can result in adverse and long term impacts on the hydrological environment, as well as secondary effects on peat stability and ecology (habitats and species). Where appropriate mitigation measures are employed throughout operation, the risk to the hydrological environment, including secondary effects can be minimised. The successful management of such measures will demand strict management of the hydrological regime across the proposed development area. Further details on the geotechnical mitigation measures to reduce the risk of peat slide are provided in Technical Appendix 11.1: Peat Stability Assessment, with ecological mitigation measures provided in Chapter 8: Ecology.

11.7.62 Watercourses, culverts and SuDS measures will be inspected and cleared regularly to prevent blockages and remove and minimise the risk of flooding.

11.7.63 All sediment management measures will be inspected and cleared regularly to ensure they remain fully operational and effective.

Receptor Sensitivity

11.7.64 On the basis of the baseline surveys and available information, Table 11.13 identifies the sensitivity of receptors, as outlined in Table 11.4, with justification for their categorisation.

Table 11.13: Receptor Sensitivities

Receptor	Sensitivity	Comments
Surface Water		
Water Quality		
Allt Ghlas	High	The Allt Ghlas is classed as Poor status under the SEPA RBMP.
River Ericht	High	The River Ericht is classed as Poor ecological status under the SEPA RBMP.
Flooding		
Allt Ghlas River Ericht Allt a' Choire Odhair Bhig Allt Caochan an t-Seilich Loch Mheugaidh	High High High High High	Watercourses within these catchments are at risk of flooding from the 1:200 year event in any given year. Construction and operation of infrastructure could cause downstream flooding issues by increasing volume of runoff into water courses.
Water Resources		
Private Water Supplies	Low	There are no private water supplies identified in the same catchments as the proposed development.
Soils, Geology and Hydrogeology		
Site Soils and Peat Geology Hydrogeology and Groundwater	High Low High	The soils across most of the site comprise of peaty gleys and peaty rankers. Geology is typical of the wider area with no designated sites of geological interest within the proposed development. Bedrock aquifers are vulnerable to pollution as a result of excavations to bedrock and areas where there is no peat cover. Areas of shallow groundwater across the proposed development would be susceptible to changes as a result of wind farm construction and operation.

Predicted Construction Effects

11.7.65 The potential for effects on the hydrological environment is greatest during the construction phases due to the high levels of activity on site and when there is the greatest change to the existing environment. The following sections discuss the potential effects that can still occur during the construction of the proposed development taking into account the design and best practice mitigation measures outlined above.

11.7.66 An evaluation of the construction effects is provided in Table 11.14.

Pollution Incidents

11.7.67 During the construction phase, a number of potential pollutants will be present onsite, including oil, fuels, chemicals, unset cement and concrete, waste and wastewater from construction activities and staff welfare facilities. The majority of these potential pollutants will be located or stored within the construction compound, which is located in the catchment of Allt Ghlas. Despite this, there is also the potential for contamination of the hydrological environment caused by spillages along the access tracks and construction areas.

Erosion and Sedimentation

11.7.68 Soil erosion and sediment generation may occur in areas where the ground has been disturbed, particularly where surface runoff has been concentrated. Drainage ditches are particularly prone to this problem, due to the high velocities of surface water runoff passing through the drainage network. Considerable sediment generation is expected where the ground has been excavated for the site infrastructure and borrow pits.

11.7.69 Sediment transport in watercourses can result in high turbidity levels which can impact on the water quality, particularly affecting the ecological potential of the watercourses. High turbidity in watercourses can reduce the light and oxygen levels in the watercourses, while sediment deposition can smother plant life and spawning grounds. Sediment deposition can also reduce the flood storage capacity of the watercourses and block culverts, resulting in an increased flood risk.

11.7.70 As a result of the construction operations, all catchments with new and upgraded infrastructure present are vulnerable to erosion and sedimentation.

Increase in Runoff

11.7.71 Turbine bases, hardstanding areas and access tracks will act as impermeable areas, restricting the natural movement and pathways of water within the hydrological environment, potentially resulting in increased volumes and differing patterns of runoff into the catchments draining the proposed development.

11.7.72 Localised increases could cause issues for downstream flood storage capacity and/or pollution incidents. Increases in the volume of runoff entering the watercourses could also cause erosion and sedimentation, therefore, having detrimental effects on surface water hydrology.

Modification of Surface Drainage Patterns

11.7.73 The interception of diffuse overland flow by the site infrastructure and associated drainage may disrupt the natural drainage regime of the area, concentrating flows and potentially diverting flows from one catchment to another. This may have implications on flood issues downstream of the site as well as depriving soils/peat of surface flows that can help maintain hydrological continuity.

Impediments to Surface Water Flow

11.7.74 The construction and upgrading of watercourse crossings may restrict flow in the various channels and reduce hydraulic capacity, resulting in an increase in flood risk, and promotion of erosion and sedimentation. In addition, poorly designed culverts may impede the movement of mammals in the riparian corridor.

Modifications to Groundwater Flow and Levels

11.7.75 Deep excavations, such as those required for the turbine foundations and borrow pits are likely to disrupt the shallow groundwater systems within the peat and bedrock geology. Due to the poor permeability of the underlying peat and peaty soils groundwater ingress is expected to be minimal. Surface water ingress will be minimised by utilising up-gradient cut-off drains or other drainage measures, this has the potential to lower the local groundwater levels within the surrounding peat and/or peat dominated soils.

11.7.76 The access tracks are likely to bisect hydrogeological units in the peat, interrupting shallow groundwater flow. Cut and fill as well as floating access tracks also have the potential to disrupt existing drainage networks underlying the peat as a result of the removal or compression of peat. The removal or compression of the peat will result in an alteration to the existing hydrological regime that will cause the build up of water on the upslope side of construction and the reduction in water on the downslope side. This build up of water can cause ponding which can increase the shear stress on the peat. Drying out of peat on the downslope side could cause desiccation of the peat which will make it more susceptible to erosion.

11.7.77 In areas where there is a concentration of access tacks and drainage, there is the potential for more widespread lowering of the water table, resulting in the indirect and long-term impact on the future restorability and functionality of adjacent peat/peaty soils as well as affecting the overall integrity of peatland environments.

11.7.78 Modifications to the hydrogeological regime may have influences on GWDTEs, although not identified on site, as well as the quality and quantity of water serving the surrounding area. Further information on the effects and potential impacts to habitats of the proposed development is presented in Chapter 8: Ecology.

Peat Instability

11.7.79 Peat slides do occur naturally, however, because of the remote nature of most peatlands, the frequency of natural events may be under reported. As a result, peatslides and their causes are poorly understood, although it is recognised that they are the result of multiple causes.

11.7.80 As stated in the SNH publication[21], peat can either react slowly or rapidly when load is applied to its surface. If the peat reacts slowly it will allow a steady settlement and change in volume as water is forced out of the peat mass. This reaction permits the peat to gradually compress and consolidate allowing time for it to gain in strength and take up the new load. However, if the peat reacts rapidly to load being applied to its surface this can be accompanied by a sudden spread and shear of the peat causing failure.

11.7.81 A peatslide occurs when a portion of the peat mass becomes detached and flows downhill, usually as blocks of solid peat rafted on a slurry of semi-liquid peat. A peatslide may have a significant effect on river water quality and ecology. The land affected by peatslides usually re-vegetates quickly, although the original balance of vegetation species is unlikely to be re-established as a consequence of the changes in local topography and

[21] FCE, SNH (2010), Floating Roads on Peat

drainage patterns. Where peat habitats or future restoration have been identified, peat instability can have serious and detrimental effects.

11.7.82 A Peat Stability Assessment can be found in Technical Appendix 11.1.

Compaction of Soils

11.7.83 The movement of construction traffic throughout the site is likely to cause compaction in the peat and soils, leading to changes in both the hydrological and hydrogeological regime. The impacts of compaction are likely to be highly localised but will damage the vegetation, and result in a reduction in the soil permeability and rainfall infiltration, thereby increasing the potential for flood risk and erosion as well as increasing the risk of peatslide. Increasing the potential for flood risk and erosion or a peatslide event could also have direct effects on the surface water quality, as well as reducing the potential for enhancement and restoration of peat.

Assessment of Construction Effects

11.7.84 Table 11.14 identifies the likely construction effects on the identified receptors and their significance assuming the successful implementation of the best practice and mitigation measures provided later in this chapter. The likely receptors are listed in Table 11.13 with details of each effect provided in the following paragraphs above. The assessment is based in the criteria outlined in Table 11.6.

Table 11.14: Assessment of Construction Effects

Potential Effects	Identified Receptor(s)	Sensitivity	Magnitude of Effect	Significance of Effects Post Construction
Surface Water				
Water Quality				
Pollution Incidents	River Ericht	High	Minor	Minor
Erosion and Sedimentation	Allt Ghlas	High	Minor	Minor
Increase in Runoff	Allt a' Choire Odhair Bhig	High	Minor	Minor
Modifications to Surface Drainage Patterns	Allt Caochan an t-Seilich	High	Minor	Minor
Impediments to Surface Water Flow	Allt Coire a' Mhor-fhir	High	Minor	Minor
Peat Instability	Loch Mheugaidh	High	Minor	Minor
Flooding				
Increase in Runoff	River Ericht	High	Minor	Minor
Modifications to Surface Drainage Patterns	Allt Ghlas	High	Minor	Minor
	Allt a' Choire Odhair Bhig	High	Minor	Minor
Impediments to Surface Water Flow	Allt Caochan an t-Seilich	High	Minor	Minor
Compaction of Soils	Loch Mheugaidh	High	Minor	Minor
Soils, Geology and Hydrogeology				
Soils and Peat				
Pollution Incidents	Site Soils and Peat	High	Minor	Minor

Modifications to Surface Drainage Patterns Impediments to Surface Water Flow Modification of Groundwater Flows and Levels Compaction of Soil				
Geology				
Disruption to local geological features from deep turbine excavation and other excavations required for construction	On-site Geology	Low	Minor	Not Significant
Hydrogeology				
Pollution Incidents Modifications to Surface Drainage Patterns Modifications of Groundwater Flows and Levels Peat Instability Compaction of Soils	Underlying groundwater aquifers Groundwater within peat	High High	Minor Minor	Minor Minor

Predicted Ongoing and Operational Effects

11.7.85 The effects of the proposed development are expected to be substantially lower during the operational phase. The following paragraphs discuss the potential effects that are predicted to occur during the operational phase of the wind farm.

Pollution Incidents

11.7.86 The potential risk of pollution is substantially lower during operation than during construction because of the decreased levels of activity in the operational phase. The majority of potential pollutants will have been removed when construction is complete. However, lubricants for turbine gearboxes, transformer oils and possible fuel leaks from maintenance vehicles will remain.

Erosion and Sedimentation

11.7.87 Levels of erosion and sedimentation during operation will be much lower than construction as there will be no excavations or bare exposed ground. Some erosion and sedimentation is still possible on site tracks and drainage ditches as a result of scouring during extreme rainfall events. Similarly there could be some erosion and sedimentation around new stream crossings as watercourses reach a new equilibrium.

Modification of Surface Drainage Patterns

11.7.88 Modification of surface runoff will occur as a result of the construction of the new and upgraded infrastructure associated with the proposed development. The operational effects are likely to result in changes to volume and/or changes to runoff rate.

11.7.89 Site tracks and associated drains will intercept some overland flow, interrupting the natural drainage regime by concentrating flows and potentially diverting them from one catchment to another. Poorly designed site tracks and associated drainage could allow surface water to travel through a catchment much faster than if it were to travel as diffuse overland flow. This could result in an increase in runoff rates, peak flows and influence response times during storm events.

Impediments to Surface Water Flows

11.7.90 During the operational phase, impediments to flow can generally occur as a result from blockages to watercourse crossings, ditches and watercourses resulting from vegetation and erosion debris.

Modifications of Groundwater and Levels

11.7.91 Cut and floating tracks and their drainage as well as turbine foundations, hardstandings and borrow pits will potentially alter the water table within the upslope and downslope peat and upper bedrock aquifers, which can also have implications for the long term functionality of peatland environments. Backfilled cable trenches can also provide preferential flow pathways for groundwater.

Peat Instability

11.7.92 It is recognised that natural peat failure may still occur during the operational phase of the proposed development. However, there is also the potential for the construction activities to increase the risk of peat slide during this phase. For example, the construction of tracks parallel to the slope can result in the removal of peat that subsequently increases the upslope pressure on the exposed peat face. Unless mitigated accordingly, changes in the hydrological connectivity of the peat could result in the build up of water upslope that could potentially fail over a period of time.

11.7.93 The land affected by peatslides usually re-vegetates quickly, although the original balance of vegetation species is unlikely to be re-established as a consequence of the changes in local topography and drainage patterns.

11.7.94 Full details of the measures that can be implemented to mitigate effects on the stability of peat are provided in Technical Appendix 11.1: Peat Stability Assessment. It is recommended that an ongoing appraisal of peat slide is carried out across the site throughout the operation of the proposed development.

Compaction of Soils

11.7.95 The compaction of soils/peat is likely to be significantly reduced during the operational phase as a result of less heavy traffic movement. However, the construction of floating roads that are not properly maintained could result in long term settlement of the soils/peat that could also cause secondary effects to groundwater movement and peat stability.

Assessment of Operational Effects

11.7.96 Table 11.15 identifies the likely operational effects on the identified receptors and their significance assuming the successful implementation of the best practice mitigation measures outlined previously. The assessment is based on the criteria outlined in Table 11.6.

Table 11.15: Assessment of Predicted Operational and Ongoing Effects

Potential Effects	Identified Receptor(s)	Sensitivity	Magnitude of Effect	Significance of Effects Post Mitigation
Surface Water				
Water Quality				
Pollution Incidents Erosion and Sedimentation Increase in Runoff Modifications to Surface Drainage Patterns Impediments to Surface Water Flow Peat Instability	River Ericht Allt Ghlas Allt a' Choire Odhair Bhig Allt Caochan an t-Seilich Allt Coire a' Mhor-fhir Loch Mheugaidh	High High High High High High	Negligible Negligible Negligible Negligible Negligible Negligible	Not Significant Not Significant Not Significant Not Significant Not Significant Not Significant
Flooding				
Increase in Runoff Modifications to Surface Drainage Patterns Impediments to Surface Water Flow Compaction of Soils	River Ericht Allt Ghlas Allt a' Choire Odhair Bhig Allt Caochan an t-Seilich Loch Mheugaidh	High High High High High	Negligible Negligible Negligible Negligible Negligible	Not Significant Not Significant Not Significant Not Significant Not Significant
Soils, Geology and Hydrogeology				
Soils and Peat				
Pollution Incidents				

Modifications to Surface Drainage Patterns Impediments to Surface Water Flow Modification of Groundwater Flows and Levels Peat Instability Compaction of Soils	Site Soils and Peat	High	Negligible	Not Significant
Geology				
Disruption to local geological features from deep turbine excavation and other excavations required for construction	On-site geology	Low	Negligible	Not Significant
Hydrogeology				
Pollution Incidents Modifications to Surface Drainage Patterns Modification of Groundwater Flows and Levels Peat Instability Compaction of Soils	Underlying groundwater aquifers Groundwater within peat	High High	Negligible Negligible	Not Significant Not Significant

Predicted Cumulative Effects

11.7.97 The application of a hydrological catchment methodology enables a logical evaluation of the potential for cumulative effects of the hydrological environment.

11.7.98 The land use activities are likely to have little or no impact on the local water quality and groundwater conditions of the area.

11.7.99 All developments currently operational, under construction, consented, or with planning application submitted to the PKC, within 10 km of the proposed development were considered as part of the assessment of cumulative impacts[22]. Based on the information available, there no other developments within the search radius. As outlined previously, it is not expected that the proposed development will impact on the operations of the hydropower station. It is expected that there will be no negative cumulative impact on the flows or quality of the Allt Ghlas watercourse and wider River Ericht catchment.

11.8 Monitoring and Enhancement Measures

11.8.1 Due to the baseline conditions within and downstream of the proposed development and the potential for these conditions to be altered as a result of construction and operational activities, a detailed programme of water monitoring shall be implemented prior to, during and post construction. A breakdown of the proposed monitoring methodologies has been provided to take into account sensitivities of the onsite and downstream environments.

11.8.2 The details of any required monitoring should be discussed and agreed with SEPA, SNH, Local Fisheries Trust and PKC prior to commencement. The extent and the frequency of the monitoring will be proportionate to the level of activity on site during the construction, operation and decommissioning of the proposed development. Appropriate monitoring is important to:

- Provide reassurance that established in-place mitigation measures are effective and that the site is not having any significant adverse impact upon the environment;
- Indicate whether further investigation is required and where pollution is identified, the need for additional mitigation measures to prevent, reduce or remove any impacts on the water environment; and
- Understand the long term effects of the site on the natural environment.

11.8.3 A baseline surface water monitoring programme will be undertaken prior to the commencement of construction works. The establishment of a baseline is very important as it provides a suite of parameters against which to compare samples taken during the proposed development's lifetime, and with which to assess any impacts and the requirement for any appropriate remedial measures. However, due to the variance in climatic conditions, recording like for like water quality prior to and during construction is likely to be unusual. Therefore, it is also recommended that control sites, situated outside the area affected by the proposed infrastructure are also established.

11.8.4 It is also recommended that a suitability qualified Ecological Clerk of Works (ECoW) is employed throughout the construction of the site. The appointed consultant can provide advice to the contractors about how environmental effects can be minimised, and what methods can be employed to reduce effects on water quality and peat and

[22] Development status obtained from SNH Onshore Windfarms in Scotland Map (August 2013)

associated habitats, and can assist in providing statutory consultees appropriate comfort in relation to the discharge of conditions associated with the implementation of the proposed development.

11.8.5 Monitoring should be undertaken throughout construction of the site. The monitoring will help to identify areas where infrastructure is having a negative effect on peat and utilise the appropriate methods to prevent further deterioration and/or promote further enhancement.

11.8.6 The monitoring methodologies detailed below are designed to monitor the effects of the site on the quality of the hydrological environment. It is also recommended that a suitably qualified geotechnical engineer is appointed to monitor the risk of peatslide that could have secondary effects on water quality.

11.8.7 It is also recommended that all construction management and water management techniques are agreed prior to construction. The techniques would be agreed following consultation with SEPA, the Local Fisheries Trust and PKC.

11.8.8 The monitoring programme will be site-specific and tailored so as to provide a meaningful and pragmatic indication of the state of the water environment. A summary of the elements associated with the monitoring programme are provided below:

- Periodic and ad-hoc sampling and analysis of surface water during construction in order to complement the programme of visual inspection. Periodic analysis enables monitoring of trends in levels of critical parameters so the deviations from the norm can be identified and actioned;
- Regular visual inspection of surface water management features such as culverts and receiving watercourses in order to establish whether there are increased levels of suspended sediment, erosion or deposition. It is likely that there will be an ongoing need to maintain these structures, for example by the removal of debris, to ensure that they continue to function as designed;
- Regular visual inspection of watercourses during construction and decommissioning stages, particularly during periods of high rainfall in order to establish that levels of suspended solids have not been increased by on-site activities; and
- Additional monitoring as required as a condition of discharge consents, abstraction licences or other environmental regulation.

11.9 Summary

11.9.1 An assessment has been carried out on the likely impacts of the proposed development on the hydrological and hydrogeological environment. The assessment has considered site preparation, construction and operation of the wind farm.

11.9.2 The potential effects on the surface waters, groundwater and peat that have been considered are:

- Pollution incidents;
- Erosion and sedimentation;
- Modification of surface water and groundwater flows;
- Modification of natural drainage patterns;
- Impediments to flow and flood risk;

- Peat instability; and
- Compaction of soils.

11.9.3 Following the identification and assessment of key receptors, taking into account the potential effects listed above, a comprehensive suite of mitigation and best practice measures has been incorporated into the design, including extensive buffer areas.

11.9.4 The impact assessment has taken into account the hydrological regime, highlighting that the principal effects will occur during the construction phase. Assuming the successful design and implementation of mitigation measures the significance of construction and operational effects on all identified receptors is considered to be of minor or no significance.

11.9.5 The significance of effects on the site hydrological, hydrogeological and geological environment is not significant under the terms of the Electricity Work (Environmental Impact Assessment) (Scotland) Regulations 2000. Table 11.16 summarises the potential impact of the proposed development.

Table 11.16: Summary of potential impacts of the proposed development

Likely Significant Impact	Mitigation Proposed	Means of Implementation	Outcome
Construction			
Detrimental impacts to on-site and downstream water quality Detrimental effects to on-site and downstream fisheries as a result of changes to water quality Increases to on-site and downstream flood risk as a result of poor construction practices (including construction of watercourse crossings)	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities. Appropriate storage and handling of potential pollutants. Refuelling of construction plant in designated areas. Adoption and agreement on emergency measures should significant effects occur. Mitigation should include appropriate design of watercourse crossings to maintain hydraulic connectivity.	Preparation of site specific Construction Environmental Management Plan (CEMP), or similar, prior to construction. Hydrological elements of the CEMP can include, but not limited to the following: • Drainage Management Plan; • Watercourse Crossing Assessment (detailed design prior to construction); and • Water Quality Monitoring Programme (prior to and during construction).	Minor to Not Significant
Degradation of peat or peat dominated soils as a result of interrupting surface and sub-surface drainage pathways.	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from construction activities. Measures will be designed to encourage water retention within peat/soils. Identification of subsurface hydrological pathways prior to construction. Appropriate design of watercourse	Preparation of site specific Construction Environmental Management Plan (CEMP), or similar, prior to construction. Hydrological elements of the CEMP can include, but not limited to the following: • Drainage Management Plan (designed to maintain drainage pathways); • Water Quality Monitoring Programme (prior to and during construction); and • Peat Management Plan	Minor to Not Significant

	crossings in areas of flush.	(providing information on re-use and management of excavated peat).	
Increase risk of peat slide as a result of poor construction and management of peat stockpiles.	Adoption of geotechnical risk register	Geotechnical Risk Register	Minor to Not Significant
Operation			
Detrimental impacts to on-site and downstream water quality through degradation of site infrastructure and poor storage of materials. Detrimental effects to on-site and downstream fisheries as a result of changes to water quality. Increases to on-site and downstream flood risk as a result of degradation of infrastructure and/or poor maintenance/monitoring of infrastructure.	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from wind farm infrastructure. Appropriate storage and handling of potential pollutants. Adoption of long-term monitoring programme to monitor degradation of infrastructure (including the removal of blockages from watercourse crossings).	Operational drainage and monitoring plan (designed prior to construction) Plan can detail the appropriate monitoring methods, including: • Visual monitoring and completion of checklists signed off by SEPA; and • Regular water quality monitoring for a period post-construction to determine potential long term effects of the wind farm on water quality.	Minor to Not Significant
Long term degradation of peat as a result of interrupting surface and sub-surface drainage pathways. Disruption of drainage patterns can cause pooling and/or desiccation of peat. Increase the risk of peatslide as a result of desiccation or wetting of peat. Risk can also increase due to settlement of infrastructure that disrupts hydrological pathways.	Appropriate drainage design that incorporates sediment management measures to attenuate and treat runoff from wind farm infrastructure. Appropriate re-use and management of waste peat in line with principles of best practice guidance and site conditions. Long-term monitoring of peat/soils to determine any issues with stability.	Peat Management Plan Geotechnical Risk Register.	Minor to Not Significant