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Chapter 8

Hydrology, Geology & Hydrogeology

Contents

Glossary

Term	Definition
Aquifer	A geological formation, group of formations or part of a formation that can store and transmit water in significant quantities.
Acrotelm	The acrotelm is one of two distinct layers in undisturbed peat bogs. It overlies the catotelm.
Baseflow	The component of the river flow that is derived from groundwater sources rather than surface run-off. The Base Flow Index (BFI) value provided by the Flood Estimation Handbook (FEH) is a measure of the proportion of a catchments long-term runoff that derives from stored sources.
Base enrichment	Refers to the interactions of water with bedrock / granular sediments and consequential dissolution of constituent anions and cations. The water may emerge as a spring at outcrop or diffusely beneath the soil and will provide plant communities with nutrients that would not be available from rainfall alone.
Buffer area	An area which protects the receptor such as watercourses from pollutants and sediment from the adjacent land.
Catotelm	The lower, water-saturated zone of a mire/peat bog.
Environmental Impact Assessment	Environmental Impact Assessment (EIA) is a means of carrying out, in a systematic way, an assessment of the likely significant environmental affects arising from a proposed development

Term	Definition
Environmental Impact Assessment Report	A document reporting the findings of the EIA and produced in accordance with the EIA Regulations
Daer Land Portion	Scottish Water Land Ownership, comprising of land south of Daer Reservoir. Wholly within the South Lanarkshire Local Authority Area.
Groundwater	Water located beneath the ground surface in soil pore spaces and in the fractures of rock formations.
Headwaters	A tributary stream of a river close to or forming part of its source. Normally wet flushes, bogs or springs at the head of first-order streams.
Hydrological regime	The statistical pattern of a river's constantly varying flow rate.
Hydromorphology	Term used in river basin management to describe the hydrological and geomorphological processes and attributes of rivers, lakes, estuaries and coastal waters.
Inhomogeneous	Not uniform in character.
Overland flow	Water passing rapidly over or through the surface layer of soil.
Peak flow	The maximum flow recorded during a high flow event.
Pour Point	The catchment pour point is the contributing area is normally defined as the total area contributing water flow to a given outlet.
Peat	A largely organic substrate formed of partially decomposed plant material.
Precipitation	Deposition of moisture including dew, hail, rain, sleet and snow.
Private water supply	Any water supply which is not provided by a water company and is not connected to mains supply. Most private water supplies are situated in more remote, rural parts of the country and may just serve one property or several properties through a network of pipes.
Proposed Development Area	The area within which the Proposed Development will be located
Return period	Is a measure of the rarity of an event: the longer the return period, the rarer the event.
Riparian zone	Land immediately adjoining the aquatic zone of a watercourse and influenced by it.
Runoff	Surface runoff is the flow of water over the surface that can result due to the surrounding soils lacking the capacity to infiltrate further water or due to the surface water flowing off infrastructure such as access tracks and hardstandings.
Sedimentation	The tendency for particles in suspension to settle out of the fluid in which they are entrained.
Standard percentage runoff	The percentage of rainfall that is likely to contribute to runoff. For example, an SPR value of 50 % would suggest that half of the rainfall during an event will contribute to runoff.
Surface water catchment	The area from which runoff would naturally discharge to a defined point of a river.
Topography	The physical features of a geographical area
Water resources	The supply of groundwater and surface water in a given area

List of Abbreviations

Abbreviation	Description
AOD	Above Ordnance Datum
BFI	Base Flow Index
BGS	British Geological Society
CAR	Water Environment (Controlled Activities) (Scotland) Regulations 2011
CC	Climate Change
CEMP	Construction Environmental Management Plan
CIRIA	Construction Industry Research and Information Association
DGC	Dumfries and Galloway Council
DTM	Digital Terrain Model
ECoW	Environmental Clerk of Works
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Report
FEH	Flood Estimation Handbook
GIS	Geographical Information System
GWDTE	Groundwater Dependent Terrestrial Ecosystems
IN	Infrastructure
IoH	Institute of Hydrology
JHI	James Hutton Institute
MSS	Marine Scotland Science
NE	Natural Environment
NS	NatureScot (formerly Scottish Natural Heritage)
PAN	Planning Advice Notes
PMP	Peat Management Plan
PPG	Pollution Prevention Guidelines
PPP	Pollution Prevention Plan
PPIP	Pollution Prevention & Incident Plan
PWS	Private Water Supply
QMED	Median flood flow

Abbreviation	Description
QBAR	Mean Annual Flood Flow
RBMP	River Basin Management Plans
SAAR	Standard Average Annual Rainfall
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SIFSS	Soil Information for Scottish Soils
SLC	South Lanarkshire Council
SPA	Special Protection Areas
SPP	Scottish Planning Policy
SPR	Standard Percentage Runoff
SSSI	Site of Special Scientific Interest
SuDS	Sustainable Drainage Systems
SW	Scottish Water
TWI	Topographic Wetness Index
WFD	Water Framework Directive

8.1 INTRODUCTION

8.1.1 This chapter of the Environmental Impact Assessment Report (EIAR) assesses the impacts on the hydrological, geological and hydrogeological environment at Daer Wind Farm, the "Proposed Development", and the likely significant environmental effects resulting from the construction and operation of the proposed turbines and associated infrastructure.

8.1.2 The assessment is also supported by the following technical appendices:

- Technical Appendix 8.1: Water Crossing Assessment;
- Technical Appendix 8.2: Peat Stability Risk Assessment;
- Technical Appendix 8.3: Peat Management Plan;
- Technical Appendix 8.4: Groundwater Dependent Terrestrial Ecosystems Assessment; and
- Technical Appendix 8.5: Borrow Pit Assessment.
- Technical Appendix 8.6: PPIP

8.1.3 The assessment is supported by the following figures:

- 8.1 Hydrology Overview;
- 8.2 Bedrock Geology;
- 8.3 Superficial Geology;
- 8.4 Carbon Soils;
- 8.5 Predominant Soils;
- 8.6 Peat Depth Interpolation;
- 8.7 Potential GWDTE & Contribution Zones;
- 8.8 Topographic Wetness Index; and
- 8.9 Flow Accumulation.

8.2 LEGISLATION AND POLICY CONTENT

Policy Content

8.2.1 The assessment takes account of 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 terrestrial ecosystems (GWDTE), estuaries and coastal waters.

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.

8.2.2 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, in the form of The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) or CAR, made it an offence to undertake the following activities without a regulatory authorisation:

- Discharges to all wetlands, surface waters and groundwaters;
- Disposal to land;
- 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.

8.2.3 Under the Water Environment (Miscellaneous) (Scotland) Regulations 2017 amendments were made to CAR and the Proposed Development will require a construction site licence for water management across the entirety of the Proposed Development site prior to any construction works taking place, including enabling works. No work will be able to commence on site until a Pollution Prevention Plan (PPP) has been prepared and agreed with the Scottish Environment Protection Agency (SEPA).

8.2.4 In addition to the national and regional policies presented in Chapter 4, the assessment takes account of the following hydrology specific legislation and policy:

- The Water Environment and Water Services (Scotland) Act 2003;
- The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended);
- The Water Environment (Miscellaneous) (Scotland) Regulations 2017;
- Flood Risk Management (Scotland) Act 2009;
- The Water Supply (Water Quality) (Scotland) Regulations 2001;
- The Public Water Supplies (Scotland) Regulations 2014;
- Private Water Supplies (Scotland) Regulations 2006;
- The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017;
- Part IIA of the Environment Protection Act 1990;
- Waste Management Licensing (Scotland) amendment Regulations 2016;
- Pollution Prevention and Control (Scotland) Regulations 2012;
- SEPA Technical Flood Risk Guidance for Stakeholders – Version 12, May 2019. SS-NFR-P-002;
- SEPA Land Protection. Reference EP054;
- SEPA Policy No. 19 Groundwater Protection Policy for Scotland;
- SEPA Policy No. 41 Development at Risk of Flooding: Advice and Consultation; and
- SEPA Policy No. 61 Control of Priority & Dangerous Substances & Specific Pollutants in the Water Environment.

8.2.5 In addition to the above national legislation and policy, the design and assessment presented herein has taken cognisance of the Scottish Water List of Precautions for Drinking Water Assets – Wind Farms EdC (Scottish Water, 2019).

Other Guidance and Good Practice

8.2.6 Table 8.1 below lists other key guidance and good practice documentation which have been considered as part of this assessment.

Table 8.1: Guideance and good practice

Topic	Source of Information
Scottish Government Planning Advice Notes (PANs)	• PAN 50: Controlling the Environmental Effects of Surface Mineral Workings; • PAN 51: Planning (revised 2006), Environmental Protection and Regulation; • PAN 1/2013: Environmental Impact Assessment; • PAN 61: Planning and Sustainable Urban Drainage Systems; • PAN 69 Flood Risk; and • PAN 79: Water and Drainage.
SEPA Guidance for Pollution Prevention (GPPs) and Pollution Prevention Guidelines (PPGs)	• PPG 1: Understanding your Environmental Responsibilities - Good Environmental Practices; • GPP 2: Above Ground Oil Storage Tanks; • GPP 4: Treatment and Disposal of Wastewater Where there is no Connection to the Public Foul Sewer; • GPP 5: Works and Maintenance in or Near Water; • PPG 6: Working at Construction and Demolition Sites; • PPG 7: Safe Storage - The Safe Operation of Refuelling Facilities; • GPP 8: Safe Storage and Disposal of Used Oils; • GPP 13: Vehicle Washing and Cleaning; • GPP 21: Pollution Incident Response Planning; • GPP 22: Dealing with Spills; and • GPP 26: Safe Storage - Drums and Intermediate Bulk Containers.
SEPA Position Statements (Published)	• WAT-PS-06-02: SEPA (2015), Culverting of Watercourses, Version 2; • WAT-PS-07-02: SEPA (2012), Bank Protection, Version 2; • WAT-SG- 78: SEPA (2012), Sediment Management Authorisation, Version 1; • 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;

Topic	Source of Information
	• WAT-SG-26: SEPA (2010), Engineering in the Water Environment, Good Practice Guide, Sediment Management, Version 1; and • WAT-SG-31: SEPA, (2006) Special Requirements for Civil Engineering Contracts for the Prevention of Pollution, Version 2.
Construction Industry Research and Information Association (CIRIA)	• CIRIA C692 Environmental Good Practice on Site (third edition); • CIRIA C753 SuDS Manual (2015); • CIRIA C532 Control of Water Pollution from Construction Sites; • CIRIA C648 Control of Water Pollution from Linear Construction Projects; and • CIRIA C689 Culvert Design and Operation Guide.
Other Guidelines	• SNH and Scottish Renewables Joint Publication, (2019) Good Practice During Wind Farm Construction Version 4; • FCE, SNH, (2010), Floating Roads on Peat; • Scottish Renewables, Joint Publication (2012), Development of Peatland: Guidance on the Assessment of Peat Volumes, Reuse of Excavated Peat and the Minimization of Waste; • SEPA, The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended), A Practical Guide, Version 8.4, October 2019; • Scottish Government, Scottish Natural Heritage, SEPA (2017) Peatland Survey Guidance on Developments on Peatland, on-line version only; • River Crossings and Migratory Fish: Design Guidance, A Consultation Paper, The Scottish Executive; • SEPA Land Use Planning Guidance CC1 (LUPS-CC1) (2019). Climate change allowances for flood risk assessment in land use planning. Issue 1. • SEPA Land Use Planning Guidance Note 4 (2017): Planning Guidance on On-Shore Windfarm Developments, Version 9; • SEPA Land Use Planning Guidance Note 31 (2017): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems, Version 3; and • SNIFFER. 2009. WFD95 A Functional Typology for Scotland.

8.3 SCOPING AND CONSULTATION

8.3.1 The scoping and consultation responses relating to the hydrological, geological and hydrogeological environment are summarised in Table 8.2 below.

Table 8.2: Consultation responses relating to hydrology, geology and hydrogeology

Organisation	Relevant response	Comments
Dumfries and Galloway Council (DGC)	• Developer needs to manage surface runoff from the site during and after construction. Runoff should mimic that of existing conditions and not be increased. • Developer should consider the rate of runoff into the watercourses which are located within the site. Any significant increase may increase the flood risk downstream	• Water mitigation measures are outlined in Section 8.7 *Mitigation Methods*; • Hydrological receptors, greenfield runoff rates, flood risk are detailed in Section 8.5 *Baseline Condition;* • Cumulative and residual effects are discussed in Section 8.10 & Section 8.11.
South Lanarkshire Council (SLC)	• Indicative peat mapping suggests areas of deep peat and priority peatland within the area and therefore peat depth and vegetation surveys will be required as part of the EIA Report.	• Peat and soils are characterised and discussed in Section 8.5 *Baseline Condition*; • Details concerning minimisation, management and reinstatement methods are presented in Technical Appendix 8.3 *Peat Management Plan*.
Marine Scotland Science (MSS)	• Proposed Development is situated within the catchments of the River Clyde and River Annan. The former is well known for its salmon and trout populations and the latter for trout and grayling. • The EIA must identify hydrological receptors and	• Hydrological receptors are characterised in Section 8.5 *Baseline Condition*; • Mitigation and monitoring proposals are outlined in Section 8.7 *Mitigation Methods* and will be supplemented by detailed mitigation in the *Pollution Prevention and Incident Plan (PPIP)*.

Organisation	Relevant response	Comments
	characterise fish species and water quality. • Monitoring proposals should be outlined.	
Royal Society for the Protection of Birds (RSPB)	• Peat is an important carbon store and we would expect turbines and associated infrastructure to avoid areas of peat over 0.5m.	• Figure 8.6 *Peat Depth Interpolation* illustrates how infrastructure was positioned in areas away from deeper peat where possible; • Details concerning minimisation, management and reinstatement methods are presented in Technical Appendix 8.3 *Peat Management Plan*.
Scottish Water (SW)	• The development is situated within a Drinking Water Protected Area (DWPA), with nearby Daer Reservoir supplying Daer Water Treatment Works (DWTW). • Several feeder streams flowing into the reservoir are at high risk. As such monitoring proposals for these and other inlets must be provided. • The proximity of the Shiel Burn and Sweetshaw burn inlets to the reservoir draw off tower could be an issue if there was any contamination, which could rapidly effect raw water quality entering the works. • The burns at the far end of the reservoir of slightly less concern as the dilution factor through the reservoir should be enough to buffer out any rapid changes. • Protection measures and mitigation must be outlined.	• Hydrological receptors within and adjacent to the Daer Reservoir and associated DWPA catchment are characterised in Section 8.5 *Baseline Condition*; • Embedded mitigation has avoided the placement of any infrastructure within the Sweetshaw Burn catchment and is more limited in the Shiel Burn catchment. • Mitigation and monitoring proposals are outlined in Section 8.7 *Mitigation Methods* and will be supplemented by detailed mitigation in the *Pollution Prevention and Incident Plan (PPIP)*.
Scottish Environment Protection Agency (SEPA)	• Map and assessment of all engineering activities in or impacting on the water environment including proposed buffers, details of any flood risk assessment and details of any related CAR applications; • Map and assessment of impacts upon Groundwater Dependent Terrestrial Ecosystems and buffers; • Map and assessment of impacts upon groundwater abstractions and buffers; • Peat depth survey and table detailing re-use proposals; • Map and table detailing forest removal; • Map and site layout of borrow pits; • Schedule of mitigation including pollution prevention measures; • Borrow Pit Site Management Plan of pollution prevention measures; • Map of proposed waste water drainage layout; • Map of proposed surface water drainage layout; • Map of proposed water abstractions including details of the proposed operating regime; and • Decommissioning statement.	• Details of all engineering requirements to be situated within the water environment are illustrated in Technical Appendix 8.1 *Water Crossing Assessment*; • Figure 8.1 *Hydrology Overview* presents all of the identified hydrological receptors (including abstractions) and associated buffer distances; • Hydrological receptors are characterised in Section 8.5 *Baseline Condition*; • Results of peat depth surveys are presented in Figure 8.6 with information detailing re-use in Technical Appendix 8.3 *Peat Management Plan;* • Details on forestry and areas of potential removal are presented in *Chapter 12 Forestry*; • Identification, avoidance and mitigation for GWDTE are presented in Technical Appendix 8.4 *GWDTE Assessment*; • Identification and justification of borrow pit areas is presented in *Technical Appendix 8.5: Borrow Pit Assessment* • Mitigation and monitoring proposals are outlined in Section 8.7 *Mitigation Methods* and will be supplemented by detailed mitigation in the *Pollution Prevention and Incident Plan (PPIP)*.

8.4 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

Effects to be Assessed

8.4.1 The greatest risk of the Proposed Development affecting the hydrological, geological and hydrogeological environment will occur during the construction phase, with effects reduced during the operational and decommissioning phase. Taking this into account the following issues will be addressed during all phases of development 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 levels;
- Effects on water resources i.e. Daer Reservoir and private water supplies;
- Effects on impediments to flow;
- On-site and downstream flood risk;
- Pollution risk;
- Effects on local geology;
- Effects on hydrological integrity of peat bodies; and
- Effects on groundwater and surface water quality.

Methodology

Overview

8.4.2 The assessment has involved the following:

- Detailed desk studies and site visits to establish baseline conditions of the area;
- Evaluation of the likely significant environmental effects of the Proposed Development and the impacts that these could have on the current site conditions;
- Identification of embedded good practice measures to avoid and mitigate against any identified adverse effects resulting from the Proposed Development;
- Evaluation of the likely significant environmental effects with consideration of the potential embedded mitigation measures, taking account of the sensitivity of the baseline features, the potential magnitude of these effects and the probability of these effects occurring; and
- The residual significance of the environmental effects following the consideration of additional mitigation measures.

Baseline Assessment

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

- Describe surface water hydrology, including watercourses, springs and waterbodies;
- Identify existing catchment pressures (e.g. point source and diffuse pollution issues);
- Identify all private drinking water abstractions and public water supplies within 3 km of the Proposed Development;
- Identify all flooding risks;
- Describe the hydromorphological conditions of watercourses;
- Collect information relating to recreational and fisheries resources;
- Collate hydrological flow and flooding data for the immediate area and main 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 of the Proposed Development.

8.4.4 Published information sources consulted for baseline information are outlined in Table 8.3 below.

Table 8.3: Baseline Information Sources

Topic	Source of Information
Topography	5m contour data derived from Digital Terrain Model (DTM) data and Ordnance Survey (OS) mapping
Designated Nature and Conservation Sites	NatureScot, https://map.environment.gov.scot/sewebmap/
Solid and Superficial Geology	BGS Geology of Britain Viewer, http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html
Soils and Peat	James Hutton Institute (JHI), Soil Information for Scottish Soils (SIFSS), http://sifss.hutton.ac.uk/ Scotland's Soils Interactive Map, Carbon and Peatland 2016 and National Soil Map of Scotland, http://soils.environment.gov.scot/
Climate	Met Office, https://www.metoffice.gov.uk/public/weather/climate/gcv3mcrf9 Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/
Surface Water Hydrology	1:10,000 OS Raster Data 1:50,000 OS Raster Data Flood Estimation Handbook (FEH): FEH Web Service, https://fehweb.ceh.ac.uk/ Flood Modeller Suite, https://www.floodmodeller.com/
Flooding	Indicative River and Coastal Flood Map (SEPA) http://map.sepa.org.uk/floodmap/map.htm

Topic	Source of Information
Water Quality	SEPA, River Basin Management Plans, Web Mapping Application, https://www.sepa.org.uk/data-visualisation/water-classification-hub/
Water Resources	Private water supply (PWS) information provided by Dumfries and Galloway Council (D&GC) and South Lanarkshire Council (SLC). Responses to PWS questionnaires sent to local residents included on the PWS database provided by the Council.
Hydrogeology	Scotland's Environment Web Interactive Map, https://map.environment.gov.scot/sewebmap/ BGS Geology of Britain Viewer, http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html SEPA, River Basin Management Plans (RBMP), Waterbody Classification. Web Mapping Application, http://gis.sepa.org.uk/rbmp/

Effects Evaluation

8.4.5 The likely significant environmental effects of the Proposed Development have been defined by taking account of two main factors; the sensitivity of the receiving environment and the potential magnitude should that effect occur. The sensitivity of the receiving environment i.e. its baseline quality as well as its ability to absorb the effect without perceptible change is defined in Table 8.4 below.

Table 8.4: Definition of Sensitivity of the Recving Environment

Sensitivity	Definition
High	National importance. 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 i.e. watercourse classified with "high" status under RBMP.
Medium	Regional importance. 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 i.e. watercourse classified as "moderate" status under RBMP.
Low	Local importance. 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 i.e. watercourse classified as "low" overall status under RBMP.

8.4.6 The magnitude of impact includes the timing, scale, size and duration of the likely significant environmental effects. For the purposes of this assessment the magnitude of impact criteria is defined in Table 8.5 below.

Table 8.5: Magnitude of Impact

Magnitude	Criteria	Definition
High	Total loss of or major/substantial alteration to key elements/features of the baseline (pre-development) conditions such that the post development character/composition/attributes will be fundamentally changed.	Fundamental (long term or permanent) changes to geology, hydrology, water quality and hydrogeology.
Medium	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of the baseline will be materially changed.	Material but non-fundamental and short to medium term changes to the geology, hydrology, water quality and hydrogeology.
Low	A minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible/detectable but not material. The underlying character/composition/attributes of the baseline condition will be similar to the pre-development circumstances/situation.	Detectable but non-material and transitory changes to the geology, hydrology, water quality and hydrogeology.
Negligible	Very little change from baseline conditions. Change barely distinguishable, approximating to a 'no change' situation.	No perceptible changes to the geology, hydrology, water quality and hydrogeology.

8.4.7 Assuming the successful implementation of industry good 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 8.6 below.

Table 8.6: Assessment matrix for determining likely significant effects

Magnitude	Sensitivity		
	High	Medium	Low
High	Major	Moderate/Major	Minor/Moderate
Medium	Moderate/Major	Moderate	Minor
Low	Moderate	Minor	Negligible/Minor
Negligible	Negligible	Negligible	Negligible

8.4.8 The results of this assessment are presented as residual effects i.e. the remaining effect following mitigation measures that would be adopted in the construction, operational and decommissioning phases of the proposed Development. Mitigation has been development based on current best practice and established construction techniques.

Assumptions and Limitations

8.4.9 The initial fieldwork carried out was a standard reconnaissance level walkover survey covering the main hydrological features within the Proposed Development.

8.4.10 Private water supply information has been provided by DGC and SLC with the information confirmed by some PWS owners through response to questionnaires that were sent to identified properties within 3 km of the Proposed Development.

8.4.11 The assessment of effects has been made based on the finalised layout with the assumption that any micro-siting during detailed design will not result in the movement of infrastructure into areas of higher impact as presented within the 50 m watercourse buffers provided in Figure 8.1 Hydrology Overview.

8.4.12 The information presented in this assessment is based on desk studies, fieldwork and onsite 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.

8.5 BASELINE CONDITIONS

Site Area

8.5.1 The Proposed Development is located in both Dumfries & Galloway and South Lanarkshire local authority areas, in the southern uplands of Scotland.

8.5.2 The hydrological study area is larger in extent than the actual Proposed Development Area and includes the upper and lower reaches of watercourse catchments that are present within the Proposed Development Area. The extent of the catchments is shown in Figure 8.1 Hydrology Overview which outlines the extent of the study area. Designated sites and relevant developments are considered from the perspective of assessing any potential hydrological linkages or cumulative effects.

Field Survey Techniques

8.5.3 Hydrology walkover surveys and peat surveys were undertaken by Natural Power at the Proposed Development prior to the submission of this EIA. The hydrology surveys comprise of a walkover survey, undertaken on foot by a hydrologist, where watercourses and other hydrological features are inspected in terms of their morphology and morphometry. Peat surveys include the collection of thickness values by advancing “peat probes” through to the underlying substrate. In addition to these, peat cores collected by a hand auger were also undertaken at strategic locations along with hand shear vanes. More information of peat surveys are presented in Technical Appendix 8.2: Peat Stability Risk Assessment and Technical Appendix 8.3: Peat Management Plan.

8.5.4 The phase 1 peat depth survey and hydrological walkover were undertaken in December 2019. Weather conditions were dry, cool and occasionally showery.

8.5.5 The phase 2 peat survey and further hydrological surveys were undertaken in August 2020. Weather conditions were predominately dry and bright. In September 2020, a further round of phase 2 peat probing was carried out to cover the primary proposed access route. The weather in September was showery.

Context

8.5.6 This subsection presents the information gathered on the existing (baseline) topographical, hydrological, geological and hydrogeological (including peat) conditions within the Proposed Development Area.

Climate

8.5.7 The standard average annual rainfall (SAAR) for the Proposed Development has been derived from the FEH Web Service as ranging from 1,679 - 1,900 mm based on the Proposed Development catchments. To put this into context, rainfall in Scotland varies from under 800 mm per year on mainland eastern Scotland in areas such as Fife, to over 3000 mm on the mainland Western Highlands.

8.5.8 The Met Office 1981-2010 annual rainfall total from the Eskdalemuir climate station is 1,742 mm with 187.4 days of rainfall greater than 1 mm recorded. This climate station is located approximately 20 km south east of the Proposed Development at an elevation of 242 m AOD. According to the 1981-2010 average for Eskdalemuir climate station, the highest rainfall totals are recorded during the winter months from October through to January as shown in Chart 8.1. Given the station’s distance from and lower elevation than the Proposed Development, average rainfall is likely to differ however rainfall patterns will be similar.

Source: Met Office

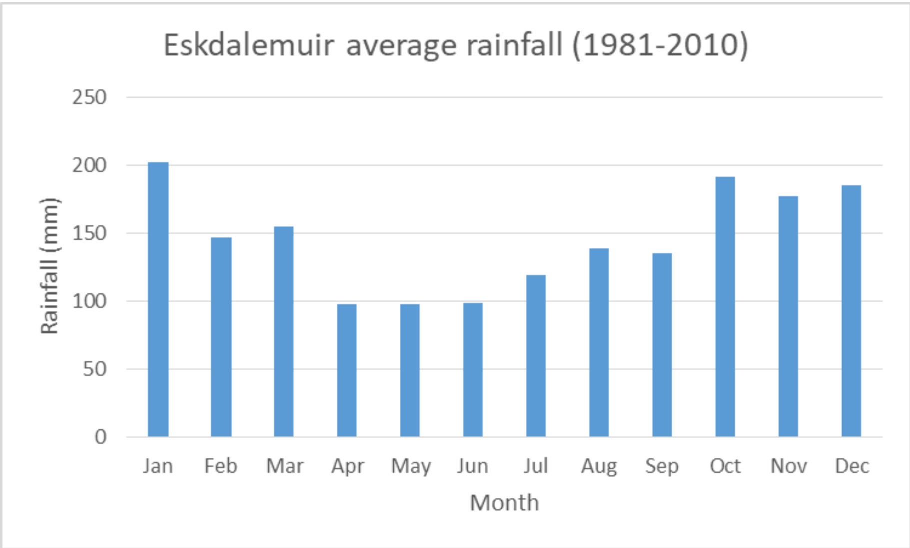

Chart 8.1: Average monthly rainfall data for climate period 1981-2010 for Eskdalemuir Climate Station

Designated Sites

8.5.9 There is one designated site within 5 km of the Proposed Development's site boundary. This is the Shiel Dod Site of Special Scientific Interest (SSSI). Between 5 km and 10 km there are a number of further SSSI sites, some of which are also designated as Special Areas of Conservation (SAC). These are: the Carron Water and Hapland Burn SSSI, the River Tweed SSSI and SAC, the Lochwood SSSI, the Coshogle Wood SSSI and lastly the Moffat hills SSSI and SAC. These are listed below in Table 8.7 along with the identification of potential hydrological connectivity between the Proposed Development and the designated site.

Table 8.7: Designated Sites in the vicinity of the Proposed Development

Designation	Location	Qualifying Feature	Hydrological connection to the Proposed Development
SSSI	Shiel Dod	This SSSI is designated for its upland assemblage. This includes blanket bog, subalpine dry dwarf-shrub heath, and calcareous types of spring-head, rill and flush. Its blanket bog is notable for the occurrence of extensive areas of Rubus chamaemorus. Above 450 metres the vegetation displays montane affinities. There are also small areas of calcareous grassland which support such species as quaking-grass Danthonia decumbens and Thymus polytrichus. The base-rich cleughs also support flush flora which includes the Nationally Scarce Sedum villosum. The calcareous habitat types are likely to be Ground Water Dependent Terrestrial Ecosystem (GWDTE).	None
SSSI	Carron Water and Hapland Burn	This site is noted by its natural geological features, namely its igneous petrology and stratigraphy.	None
SAC, SSI	River Tweed	These SAC and SSI designations are due to the importance of this area's freshwater habitats, and fish species. The Tweed and its tributaries are of high conservation and ecological value, containing a range of vascular plants, freshwater and estuarine fish, mammals and invertebrates. This includes the presence of River lamprey (Lampetra fluviatilis), Brook lamprey (Lampetra planeri), Otter (Lutra lutra), Sea lamprey (Petromyzon marinus) and Atlantic salmon (Salmo salar).	None
SSSI	Lochwood	Lochwood is an area of old parkland oakwood of a type rare in the Scottish Lowlands. This SSSI is designated for its wood pasture and parkland as well as the presence of the Butterflies such as the Purple hairstreak Neozephyrus quercus, its invertebrate communities and its lichen assemblage, some of which is unique to Scotland Lochwood is an area of old parkland oakwood of a type rare in the Scottish lowlands.	None
SSSI	Coshogle Wood	This designated area is notified for its acid-neutral, sessile oak dominated woodland. This is found on steep valley sides and is one of the best examples in upper Nithsdale.	None
SAC, SSI	Moffat Hills	Here the SAC and SSI designations are due to geological and biological features found within the area. Many of the Moffat hills (a massif of Silurian greywackes often rising above 750 m) show evidence of past glaciation, including a multitude of notable glacial features. The vegetation includes alpine and boreal heaths, dry heaths, blanket bog, tall herb communities plants in crevices on base-rich rocks, acid rocks and scree. There are also siliceous alpine and boreal grasslands.	None

Surface Water Hydrology

8.5.10 Hydrologically, the Proposed Development spans two main hydrological networks; Daer Water (incorporating Daer Reservoir), forming part of the River Clyde and also the upper River Annan. Figure 8.1 Hydrology Overview shows distribution of hydrological features across and adjacent to the Proposed Development. There are several burns which supply these networks situated in and around the Proposed Development Area.

Daer Reservoir & Clyde Catchments

8.5.11 The Daer and upper Clyde catchments drain northwards down Clydesdale. Within close proximity to the Proposed Development Area, the watershed is split from numerous smaller catchments, all of which feed directly into the Daer Reservoir. Of these, the catchments which could be potentially impacted by the construction, operation and decommissioning of the Proposed Development include, The Crook Burn, Black Burn (incorporating Sheil Burn) and the Sweetshaw Burn and Daer Water. These burns are discussed in the Sections below.

8.5.12 The Daer Reservoir itself is designated as a Drinking Water Protection Zone. In addition to this designation the Daer Water falls within the protection area for Freshwater Fish.

Sweetshaw Burn

8.5.13 The Sweetshaw Burn rises at 470 m AOD to the south west of Hods Hill (561 m AOD) and flows westwards for 2.1 km discharging into the north end of Daer Reservoir. The catchment is 2.24 km^2 and is dominated by open grassland used for rough grazing. The channel itself is typical of an upland headwater catchment, being incised into the superficial peat, with numerous falls and plunge pools. A combination of a review of aerial photography and field surveys reveals there are numerous artificial drainage ditches throughout the catchment and were likely to have been installed for agriculture.

Shiel Burn

8.5.14 The Shiel Burn rises at 460 m AOD to the west of Beld Knowe (507 m AOD) and flows westwards for 1.6 km to confluence with the Black Burn, before eventually discharging into Daer Reservoir. The catchment is 1.24 km^2 in area and similarly to the Sweetshaw Burn, is dominated by open grassland. The channel is again incised into the peat and flows over falls and through plunge pools. Artificial drainage ditches are present within this catchment.

Daer Water

8.5.15 The Daer Water rises south of Daer Head on the hills of Gana Hill (668 m AOD) and flows north for 6 km before discharging into the southern end of Daer Reservoir. The catchment is 18.4 km^2 in area and is dominated by moorland and open grassland. In the lower reaches, the channel is significant in size and meanders through the valley basin between the Reservoir and Daer Head, before rising more steeply into the various headwater coires. In these coires the channel is similar to other small burns in the region, being incised into the peat and falling over occasional outcrops of bedrock.

Black Burn

8.5.16 The Black Burn rises at 510 m AOD to the north of Whiteside Hill (554 m AOD) and flows northwards for 2.8 km before being joined by the Shiel Burn and shortly after discharging into Daer Reservoir. The catchment area is 6.01 km^2 and comprises of several minor tributary catchments situated on bounding ridges which run parallel to the Reservoir. The majority of the catchment is open moorland and grassland, with a small area of the catchment in the south east also being forested, however field surveys in 2020 confirms a large extent of the forested area has been clear felled. At the catchment pour point, the channel is wide and sinuous, becoming increasingly narrow and incised towards the headwaters (Photo Insert 8.1). Artificial drainage ditches are again present within this catchment.

Source: Natural Power

Photo Insert 8.1: Photographs of the Shiel Burn (left) and Black Burn (right)

Crook Burn

8.5.17 The Crook Burn is the largest of the Daer Reservoir catchments being discussed (8.3 km^2), rising at 590 m AOD on the southern flanks of Queensberry Hill (697 m AOD) approximately 7 km south of Daer Reservoir, where it eventually terminates. The Crook Burn is a linear catchment running from south to north and is fed by numerous small steep tributary catchments including Marlinn Grain, Berry Grain, Rushy Grain, Dicks Grain and Rushy Sike. The lower reaches of the catchment around the catchment pour point are dominated by rough grassland which have been improved for agriculture through the development of a network of artificial drainage ditches. The channel in this part of the catchment, is wide, shallow and sinuous (Photo Insert 8.2) with the bedload comprising of sand, gravel boulders. In the upper reaches of the catchment, the tributaries flow through open moorland with plunge pools and falls.

Source: Natural Power

Photo Insert 8.2: Photographs of the Crook Burn from the lower (left) and upper (right) catchment areas

Upper Annan Catchments

8.5.18 The upper Annan catchments drain south down Annandale discharging into the Solway Firth. Within the Proposed Development Area, the watercourses which supply this network are again divided into a number of smaller catchments discharging east through a forestry planation. This includes the Cloffin Burn, Garpol Water and Kinnel Water. These burns are discussed in the Sections below.

Cloffin Burn

8.5.19 The Cloffin Burn rises as several tributary catchments adjacent to the watershed of the Annan and the Clyde, the highest of which is at 470 m AOD north of Beld Knowe (507 m AOD). The Cloffin Burn catchment area is dominated by commercial forestry from the watershed down to the catchment pour point where it confluences with the River Annan ~6 km to the east. The morphology of the catchment contrasts with the Clyde catchments, being characterised by steep ravines throughout with flow obtained from a combination of spring rises and also from a network of forestry drainage ditches (Photo Insert 8.3). Lower in the catchment the burn widens becoming more sinuous. The bedload of the burn is generally sand, gravel and boulders however in the catchments upper reaches, peat and vegetation are also present.

Source: Natural Power

Photo Insert 8.3: Photograph of the Cloffin Burn

Garpool Water

8.5.20 Garpool Water also rises on the watershed between the Clyde and Annan catchments at 470 m AOD, just east of Annant Hill (538 m AOD). The Garpool Water catchment comprises of the main Garpool Burn and also a large tributary burn, the Rivox Burn, which confluences half-way between the headwaters and the catchment pour point at the River Annan. The morphology of the catchment is not as dramatic as the nearby Cloffin Burn, with the majority of headwater channels following subdued topographical re-entrants, discharging at a moderate gradient to the lower catchment where the channel again becomes sinuous. The surrounding landscape is improved grassland used for agriculture and forestry. Again, the bedload of the burn is generally sand, gravel and boulders however in the catchment's upper reaches, peat and vegetation are also present.

Kinnel Water

8.5.21 Kinnel Water rises at 530 m AOD north of Mid Height Hill (555 m AOD), running north then south east to discharge into the River Annan south of Beattock. The catchment in its upper reaches comprises of predominantly open moorland, used for rough grazing. In the lower catchment the land use is a combination of commercial forestry and also improved grassland for agriculture. The main channel is fed by numerous steep tributaries discharging from surrounding moorland and in these locations are characterised as being narrow, incised channels with falls and plunge pools. Further down the catchment the channel morphology becomes broader and more sinuous (Photo Insert 8.4).

Source: Natural Power

Photo Insert 8.4: Photograph of Kinnel Water

Hydrological Regime

Effects of Forestry

8.5.22 Whilst the majority of the Daer Land Portion is situated in open moorland, the Primary Proposed Access and a small area of the Black Burn is dominated by commercial forestry. The upper Annan catchments consist of forestry in varying stages of maturity. Large sections of forestry in the catchments have also been felled.

8.5.23 Areas of mature forestry help to attenuate peak flows due to the interception of precipitation by the closed canopy. Research into the effects on the hydrological regime of catchments suggests that forestry practices can have impacts on peak flows; and subsequently flood risk. Research also suggests that there may be a 1.5 – 2 % reduction of potential water yield for every 10 % of a catchment under mature conifer forest (Forestry Commission, 2011). In areas to be felled, a reduction in forestry cover will lead to a reduction in interception of precipitation and a subsequent increase in runoff and water yield.

Flow Estimation

8.5.24 Peak flows (up to 200 year + climate change (CC)) have been estimated for the key catchments described above using the FEH Rainfall Runoff (FEH RR) method for a range of return periods, with the results presented in Table 8.8 below. Catchment descriptors were derived from the FEH Web Service and used for calculating peak flows for the identified catchments above. Catchment boundaries have been used in their entirety, as opposed to their delineation along the site boundary area, which would otherwise generate potentially unrepresentative results. The annual median flood flow (QMED) is presented as the greenfield runoff rate.

8.5.25 The table also presents low flows (Q200+CC) for the catchments within the site boundary of the Proposed Development. The Q200+CC is the 200-year return period flow plus a 20 % mark up for climate change (CC) as per SEPA Land Use Planning Guidance CC1 (LUPS-CC1) (2019) *Climate change allowances for flood risk assessment in land use planning*.

Table 8.8: Estimated peak runoff for site-catchments calculated using the methodology prescribed by the FEH RR method.

Catchments	Area (km^2)	Estimated peak runoff ($m^3 s^{-1}$) for stated return period							
		2 (QMED)	5	10	25	50	100	200	200+CC
Sweets. Burn	2.2	2.65	3.92	4.83	6.24	7.49	8.72	10.2	12.2
Shiel Burn	1.2	1.49	2.21	2.75	3.55	4.27	4.97	5.84	7.00
Black Burn	6.0	6.51	9.59	11.9	15.3	18.3	21.3	25.0	30.0
Crook Burn	8.8	9.36	13.8	17.0	21.8	26.0	30.1	35.2	42.2
Garpool Water	13.8	10.4	15.2	18.8	24.1	28.8	33.5	39.2	47.8
Cloffin Burn	10.3	8.81	13.0	16.0	20.8	25.1	29.3	34.5	41.1

Catchments	Area (km^2)	Estimated peak runoff (m^3 s^{-1}) for stated return period							
		2 (QMED)	5	10	25	50	100	200	200+CC
Kinnel Water	24.6	22.9	33.3	41.5	53.2	63.9	73.9	86.5	103.8

8.5.26 Base Flow Index (BFI) and Standard Percentage Runoff (SPR) data for the catchments covering the Proposed Development was also taken from the FEH Web Service. The BFI is a measure of the proportion of a catchment's long-term runoff that derives from stored sources, with the BFI ranging from 0.1 in relatively impermeable catchments to 0.99 in highly permeable catchments. The SPR values represent the percentage of rainfall that is likely to contribute to runoff.

8.5.27 The BFI for the upper Clyde catchments ranged from 0.29 to 0.34, whilst the upper Annan catchments demonstrated BFI values of 0.34 to 0.37. This indicates that for the upper Annan catchments, a slightly larger proportion of streamflow is derived from stored sources such as groundwater within the catchment when compared to the upper Clyde catchments however for both catchments groundwater contribution to flow is low. The SPR values for the Annan catchments are ~43 % indicating that under half of the rainfall during a rainfall event contributes to runoff. The BFI and SPR values indicate that the upper Annan catchments are slightly more permeable than the upper Clyde catchments.

8.5.28 Figure 8.8 provides information on how the topography influences the surface saturation of the peat and soils across the Proposed Development. The analysis of the DTM derived a topographic wetness index (TWI). The TWI is a dimensionless index, defined by the equation: ln (a/tan b) where a = area draining through a point from an upslope contributing area and tan b is the local slope angle. The index provides results on the hydrological similarity of peat. All points with the same value of the 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.

8.5.29 Figure 8.9 provides information on the flow direction of the surface runoff within the Proposed Development. Flow accumulation 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 with lower flow accumulation. This figure illustrates the influence of topography on the accumulation and direction of surface water runoff across the Proposed Development.

8.5.30 As shown in Figure 8.8, 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 (18 plus) in the TWI form linear channels or where areas have a tendency to become saturated, are shown in blue and drier areas where there may be less tendency for the ground to saturate, are shown in yellow and orange. 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 is likely to represent areas of the Proposed Development where the topography allows the accumulation and saturation of peat and soils from subsurface or surface during prolonged and/or intense rainfall events. Whilst it is recognised that other areas of the Proposed Development are likely to become saturated, it is expected that any saturation will be dependent upon climatic conditions such as the intensity and duration of rainfall. Figure 8.8 suggests that away from the watercourses and riparian corridors, that the Proposed Development is generally quite dry with TWI at the lower end of the range.

Flood Risk

8.5.31 The assessment has been carried out in accordance with Scottish Planning Policy (SPP) (Scottish Government, 2014). The document states that *"Planning authorities should have regard to the probability of flooding from all sources – (coastal, fluvial (watercourse), pluvial (surface water), groundwater, sewers and blocked culverts) take flood risk into account when preparing development plans and determining planning applications."*

8.5.32 The Flood Risk Management (Scotland) Act sets in place a statutory framework for delivering a sustainable and risk-based approach to managing flooding (Scottish Government, 2009). This is also a requirement of the Local Development Plan – Flooding and Development Supplementary Guidance document (DGC, 2020). The main elements of flood risk management relevant to the Proposed Development is assessment of flood risk as well as undertaking structural and non-structural flood management measures.

8.5.33 The following paragraphs outline the results of the assessment for determining flood risk.

Fluvial Flooding Sources

8.5.34 Flood information available on the SEPA Flood Map indicates that the middle to lower catchment areas for the Black Burn and the Crook Burn have a high likelihood of fluvial (watercourse) flooding in any given year. The medium and high risk areas also extend around the edge of Daer Reservior, Kinnel Water, Garpool Water and Cloffin Burn. The areas indicated do not extend much beyond the riparian corridor. No other tributaries of the catchments shown on Figure 8.1 have been highlighted as being at a risk of fluvial flooding.

8.5.35 Downstream of Daer Reservoir, the catchment has extensive areas at a high risk of flooding encompassing road and rail networks, residential properties and farmland around the Elvanfoot. Within the lower River Annan catchment similarly extensive areas of high, medium and low risk extend within the riparian zones, particularly east of the town of Beattock.

8.5.36 The overall fluvial derived flood risks within the Proposed Development Area are considered to be low. However, it should be acknowledged that there is the potential for fluvial flooding further downstream.

Pluvial Flooding Sources

8.5.37 The SEPA Flood Map indicates that small isolated areas adjacent to the main watercourses and major tributaries have been highlighted as having a low to high likelihood of surface water flooding (SEPA, 2020). Within the Proposed Development the majority of the areas highlighted are around the periphery of Daer Reservoir. There are also numerous isolated areas of high and medium flood risk scattered throughout the forested upper Annan catchments. The likelihood of flooding and size of the flooding area increases marginally towards the bottom of the catchment and where the valley floor gradient decreases and width increases. The potential for flooded areas remains within the watercourse channels throughout the Proposed Development. Additional small pockets of land are at medium risk of pluvial flooding; however, this is limited in spatial extent, coinciding with areas likely to be hollows and depressions.

8.5.38 Significant extents of high, medium and low risk of surface water flooding are evident within farmland adjacent to the River Annan, particularly west of Moffat. More limited areas of medium and high risk are noted downstream of Daer Reservoir towards Elvanfoot.

Coastal Flooding Sources

8.5.39 The Proposed Development is located approximately 25 km from the nearest coast and due to this distance along with the topographical position, the Proposed Development will not be affected by tidal flooding.

Groundwater Flooding Sources

8.5.40 Flooding can also result from high groundwater levels if the water table rises above the surface level. Groundwater flooding can occur in a variety of geological settings including river valleys with thick deposits of alluvium and river gravels. Groundwater flooding happens in response to a combination of already high groundwater levels (usually during mid or late winter).

8.5.41 Groundwater flooding is often associated with the shallow unconsolidated sedimentary aquifers that overlie sediments with no / very low permeability. Such aquifers are susceptible to flooding as the storage capacity within these deposits is often low, which combined with high direct rainfall recharge, can subsequently increase the water levels within the groundwater and providing a good hydraulic connection with adjacent river networks.

8.5.42 Flood information available on the SEPA website indicates that the riparian basin around the River Annan east of the Proposed Development Area but bisected by the Primary Proposed Access is at a low risk of groundwater flooding. This may be attributable to the increased permeability of the catchment relative to the others as discussed later in this section. 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. The SEPA website indicates that the remainder of the Proposed Development is not at risk of groundwater flooding however local risks may exist around topographic hollows or where suitable bedrock / superficial conditions exist.

Flooding from Artificial Drainage

8.5.43 There is extensive evidence of artificial drainage associated with forestry and the upland moorland land management across the Proposed Development and on the Primary Proposed Access. There is the potential that this artificial drainage could cause some localised flooding by increasing runoff rates to the main watercourses within the catchments. At the time of the site visits there was only minor volumes of flow within the artificial drainage channels and occasional ephemeral standing water was observed across the Proposed Development.

Cumulative Flood Risks

8.5.44 Without appropriate drainage mitigation being in place the proposed infrastructure has the potential to increase flood risk especially to vulnerable areas downstream of the Proposed Development by altering existing runoff and flow regimes.

Water Quality

8.5.45 A number of waterbodies within the vicinity of the Proposed Development Area have been classified under SEPA's River Basin Management Plans (RBMP) (SEPA 2011). The RBMP are one of the requirements of the Water Framework Directive (WFD) (2000/60/EC) and are the plans designed for protecting and improving the water environment. Table 8.9 details the classified watercourses, water bodies and groundwaters associated with the Proposed Development.

Table 8.9: RBMP classification of surface waterbodies within the vicinity of the Proposed Development

Water Body	Current Overall Status (2018)	Reason for Classification	Target Status	
			2021	2027
Daer Reservoir	Good	-	Good	Good
Daer Water	Good	-	Good	Good
Cloffin Burn	Poor	Barrier to fish migration	Good	Good
Garpool Water	Good	-	Good	Good
Kinnel Water	Poor	Barrier to fish migration	Good	Good
Leadhills Groundwater	Poor	Legacy mining	Poor	Good
East Dumfries-shire Groundwater	Good	-	Good	Good
Annandale Sand & Gravel Groundwater	Good	-	Good	Good

Effects of Forestry

8.5.46 Acidification of water bodies in upland forested catchments in the UK is well documented by several landmark studies in the 1970s and 1980s. These studies identified that compared to open moorland catchments, forested catchments typically demonstrated more acidic pH, higher concentrations of major anions, changes in colour as well as more dissolved metals such as aluminium and manganese (Nisbet & Evans, 2014). Contributing factors included canopy scavenging of oxide species through dry and mist deposition and subsequent decomposition and mobilisation into watercourses as well as base cation soil depletion through uptake by tree roots.

8.5.47 More recently, investigations have concluded that whilst statutory changes in emissions targets of nitrate and sulphate species has resulted in chemical recovery of many upland waterbodies, forested catchments remain highly susceptible to changes in acidity particularly where the local geology limits catchments acid neutralising capacity to buffer variations in pH (Malcolm *et al*. 2014).

Effects of Peat

8.5.48 As discussed in later sections of this EIAR, blanket peat is present with the Proposed Development Area and as such will exert an influence on the water quality within surface and groundwater bodies, particularly during storm events or prolonged dry spells where peat is noted to be eroded or degraded. Effects within the UK are most commonly associated with discolouration arising from high levels of dissolved iron and dissolved organic carbon (DOC), of which the concentrations for the latter have been noted to increase steadily across Europe since the 1970s and is a trend which is predicted to continue (Xu *et al*. 2020). Whilst the mechanism facilitating these increases is highly speculated, the ultimate removal of DOC is a major component of potable water treatment particularly in catchments dominated by superficial peat.

Source: Natural Power

Photo Insert 8.5: Examples of stream discolouration identified during the hydrology surveys in August 2020

Hydrogeology

8.5.49 The following geological information has been obtained from digital data available from the British Geological Survey (BGS, 2020). The 1:50,000 scale BGS digital map indicates that the majority of the bedrock geology of the Proposed Development is comprised of sequences of Lower Palaeozoic greywacke and interbedded siltstone, mudstone and conglomerate as depicted in Figure 8.2.

8.5.50 The southern and eastern part of the site around the Crook Burn, Kinnel Water, Garpool Water and Shiel Burn are dominated by units of sandstone, mudstone and conglomerate from the Queensberry Formation, which are likely to be at least 100 m in vertical thickness but may be substantially more. On the western end of the site closer to the Daer Reservoir and around the pour point of the Crook Burn catchment the bedrock geology is that of the Gala Unit 4, which is comprised of highly indurated wacke deposits and are likely to be very similar in character to the to the Queenberry Formation. The depth of the Gala Unit 4 may be in excess of ~1500 m. It is likely that there will be an extensive zone of highly fractured, weathered bedrock in the near surface. Both the Queensberry Formation and Gala Unit 4 exhibit regional stratification and tectonic features exemplified by most of the Lower Palaeozoic rocks in southern Scotland. These are manifested through the occurrence of fault lines orientated south west to north east, dipping north west with less frequent strike-slip faults orientated south east to north west.

8.5.51 Overlying the bedrock are Quaternary tills, alluvium and organic peat accumulations. Owing to the low permeability of the underlying bedrock across most of the Proposed Development, the alluvium and peats may host a shallow superficial aquifer. Alluvium with a high content of sand and gravel deposited by glacial meltwater rivers or post-glacial riverine processes, will have the highest permeability. The alluvium and peat make up a very small part of the superficial deposits compared to the till, with the alluvium found near existing water channels and the peat found in small isolated patches across the Proposed Development. Conversely, the till will comprise of finer grained, lower permeability sediments such as silts and clays, and therefore water transmission will be more limited.

8.5.52 According to the 1:625,000 scale BGS Hydrogeology Sheet the Proposed Development is underlain by a low productivity aquifer with limited resource potential. This is on account of both the Queensberry Formation and the Gala Unit 4 bedrock being highly indurated and consequently of very low in permeability. Notwithstanding, its possible that groundwater may exist within the weathered zones, in tectonic features, or in superficial sands and gravel deposits. It should be noted however, that a consequence of this characteristic is that there is only limited potential for contaminant attenuation. Therefore, such aquifers are vulnerable to pollutants that are not readily absorbed or transformed (Classes 4a & 4b) according to The Groundwater Vulnerability Map of Scotland (BGS & SEPA, 2011). For the superficial deposits, the volume of water and corresponding transmissivity will be a function of the materials porosity derived from the content of clays and silts. Since most of these deposits are mapped to be around watercourses it is likely these locations may well support topographically constrained perched aquifers, supplying baseflow to some of the catchments. These may also support species and be considered as groundwater dependant terrestrial ecosystems (GWDTE).

Water Resources

Public Water Supply

8.5.53 Consultation was undertaken with Scottish Water, which confirmed the designation of the Daer catchment as a Drinking Water Protected Areas under the WFD. Daer Water Treatment Works (WTWs) is situated just north west of the reservoir and provides drinking water to ~250,000 customers in the central belt of Scotland and as of 2019 is also a source of hydro-electricity.

8.5.54 Whilst there are no Drinking Water Protected Areas adjacent to or immediately downstream of the upper Annan catchments, Scottish Water did indicate the location of several Mains Supply pipes within the Annan basin.

8.5.55 Mitigation will be outlined in the Construction Environmental Management Plan (CEMP) during detailed design for the sensitive locations, further details are provided in below Section 8.7 Mitigation Methods. Additional mitigation will also be outlined within the PPIP for the Daer Land Portion, situated within the Scottish Water Daer Reservoir catchment.

Water Use Authorisations

8.5.56 SEPA were contacted to establish if there are any abstractions or discharges within 3 km of the Proposed Development. A response was received that indicated six licensed sites with use including engineering works, sewage release, impoundment, abstraction and release for hydropower generation. Apart from a single engineering licence within the Cloffin Burn, all of the licenced sites were situated at Kirkhope (NS 96015 05604), east of the Proposed Development Area in a location outside of any potential hydrological or hydrogeological connectivity with the Proposed Development.

Private Water Supplies

8.5.57 DGC and SLC provided information on private water abstractions, both domestic and commercial use within 3 km of the Proposed Development. In total, 25 PWS source locations were identified serving 45 properties with a water supply.

8.5.58 In order to determine the potential risks to PWS, a source-pathway-receptor approach has been adopted to initially screen whether a pollutant linkage could exist between the Proposed Development and the water supply. Where PWS sources could be conceivably "hydrologically connected" (either by means of overland or groundwater flow) then further, more detailed assessment was undertaken to qualify the level of risk. Based on the hydrological and hydrogeological setting of the Proposed Development Area, it is considered that only PWS sources within the Proposed Development Area, the Proposed Primary Access or within 3 km of the Development Boundary could be hydrologically connected. The collated information on these supplies along with the results of the source-pathway-receptor screening has been presented at the end of this chapter in section 8.15 Supporting Information.

8.5.59 The results of the screening identified five PWS sources which could be hydrologically connected to the Proposed Development. Consultation with owners of these five PWS was undertaken through the submission of a questionnaire, requesting details concerning the supply location, the location of delivery infrastructure and general anecdotal information on temporal changes in water quality and quantity. In accordance the LUPS Guidance Notes 4 and 31 (SEPA, 2017) the PWS groundwater abstractions have been identified in Figure 8.1: Hydrological Overview along with their relevant buffer zones of i) of 100m from roads, tracks and trenches <1m in excavation depth and ii) and 250 m buffers from turbine or other foundations >1m in excavation depth. Further information obtained from each supply are presented below in Table 8.10.

8.5.60 As indicated within Table 8.10, Rivox, Easter Earshaig, Wester Easrshiag and Nunnerie were identified to have no infrastructure encroach on the SEPA LUPS 31 buffer being >100 metres from the nearest point of infrastructure. Whilst a request for further information was submitted to each PWS, the water source for each supply remains unconfirmed, however it is expected these will be either surface water fed, groundwater fed, or a combination of both.

Table 8.10: Further details obtained from consultation with PWS Users

PWS ID	Supply Name	Distance from infrastructure (km)	Infrastructure Within SEPA LUPS 31* Buffer?	PWS Type	Volume m3/d**	Detailed Assessment Required?
2	Holmshaw	0.03	Yes	Ground water Spring	0.6	Yes – see below
3	Rivox	0.47	No	Unconfirmed	0.6	No
5	Easter Earshaig	0.73	No	Unconfirmed	0.6	No
6	Wester Earshaig	0.43	No	Unconfirmed	0.6	No
24	Nunnerie	1.41	No	Unconfirmed	n/a	No
*SEPA (2017) LUPS 31						
**Scottish Government EIR Release https://www.gov.scot/publications/foi-18-00090/						

Source: Natural Power

8.5.61 In the absence of detailed information, the PWS at Rivox (3), Easter Earshaig (5), Wester Earshaig (6) and Nunnerie (24) are assumed to be fed from shallow, topographically constrained groundwater and surface water. Based on Natural Power's experience such supply types are commonplace in southern Scotland as a result of the generally low bedrock permeability combined with high annual volumes of rainfall, encouraging water saturation in the upper surface soils. As discussed in the Hydrogeology subsection of Section 8.5, the underlying bedrock is highly indurated and well cemented sandstone wacke and as such as classified as a low productivity aquifer and therefore should a PWS be entirely sourced from groundwater, such as a borehole, it is considered to have a lower magnitude of susceptibility to changes in water quality or quantity than assumed here. Whilst shallow groundwater pathways will be short, surface water and overland flow routes can be more considerable, up to several hundred meters.

8.5.62 Nunnerie (24) PWS is situated away from overland flow migration pathways being upslope from the Daer Water. Given this and its topographical position in relation to any plausible hydrogeological flow pathways, it is not anticipated the proposed Development will be hydrologically or hydrogeologically connected.

8.5.63 Rivox (3), Easter Earshaig (5) and Wester Earshiag (6) are positioned between 0.43 and 0.73 km downgradient of the Primary Proposed Access (existing access track to be upgraded). Whilst its plausible that overland flow routes from the proposed infrastructure could exist without appropriate management and mitigation, the limited extent of the works along the Primary Proposed Access combined with the distance downgradient to each of the PWSs will sufficiently reduce the potential for any adverse impacts.

8.5.64 Owing to the Holmshaw PWS being <100 m of the nearest point of infrastructure (existing access track to be upgraded) an inspection of the supply was undertaken in October 2020 with permission of the landowner and PWS user. The inspection indicated that a shallow spring intake is situated approximately 30 metres west of the existing track at NT 03632 04141. The spring comprises of a shallow cylinder sunk into a boggy area within a slight topographic depression. The water appears to be piped from the spring intake 60 m to the east downslope (under the existing track) to a series of collection tanks, which is made of plastic and situated above ground level. Water is then fed under gravity down another pipe towards the property ~0.5 km to the east. Photographs obtained during the inspection are presented in Photo Insert 8.7.

Source: Natural Power

Photo Insert 8.6: PWS Infrastructure at Holmshaw

8.5.65 As discussed previously, the underlying bedrock is highly indurated and well cemented sandstone wacke and as such as classified as a low productivity aquifer. A bedrock fault orientated south west to north east, dipping north west is also mapped within the vicinity of the PWS source, which may offer locally increased yield volumes which can be greater around tectonic features. Notwithstanding, the low permeability of the bedrock and shallow nature of the podzol soils will limit infiltration, encouraging near surface water saturation and overland flow.

8.5.66 Conceptually, the source appears to be a catch-pit type supply, which given the absence of a productive underlying source of groundwater and low infiltration capacity of the overlying soil is likely to be fed by a combination of shallow topographically constrained groundwater and surface overland flow. Whilst is possible the boggy area could also be nourished by diffuse emergence of groundwater from the bedrock, it is likely that the majority of recharge to the supply will be obtained from shallow groundwater / overland flow from upgradient areas. The supply pipework and collection tanks are made of plastic and will not be vulnerable to infiltration. Therefore whilst there is no risk of the supply source being impacted as all construction works will be downgradient, embedded and additional mitigation would be required to prevent any impact on the delivery infrastructure.

Fisheries & Recreation

8.5.67 The watercourses and waterbodies within the Proposed Development Area discharge into the River Clyde catchment, with those on the Primary Proposed Access discharging into the River Annan catchment. Fishing on the River Clyde (including Daer Reservoir) and River Annan is currently regulated due to low / recovering fish stocks, particularly with regards to salmon. Daer Reservoir is also used for fishing of brown trout.

8.5.68 Further information on fish populations and fisheries can be found in Chapter 6 of this EIAR.

Soils & Peat

8.5.69 The distribution of soils across the Proposed Development is dependent upon land use, geology, topography and hydrological regime of the area. Information on the Proposed Development soils has been obtained from Scotland's Environment Website[1] which brings together data from public organisations across Scotland including BGS, JHI, NatureScot and SEPA.

8.5.70 The generalised soil type according to the National Soil Map of Scotland within the site boundary includes peaty gleys, peaty podzols, peat, brown soils and mineral gleys as presented in Figure 8.5 (Scotland's Environment, 2020). The assemblage of these different soil types is closely related to both altitude and slope angle, with coarser and therefore more freely draining peaty podzols and brown soils being situated on steeper slopes and valley sides, with the latter tending to dominate below 250-300 m, with the former at higher elevations. These soils often have a thin iron-pan which restricts the flow of water deeper into the soil. These soils are largely rain-fed and mineral-poor and usually supports vegetation communities dominated by heathers and nutrient -poor grasses. As such peaty gleys dominate most of the steeper valley sides and headwater regions of the upper Clyde catchments and brown soils on the lower slopes of the upper Annan catchments. Where slope angles are more subdued water saturation is more common, peat soils are mapped, particularly in the basin of the Crook Burn and the Black Burn.

8.5.71 Isolated occurrences of peaty podzols are situated in upper Clyde catchment headwaters as well as the upper Annan catchments. Peaty podzols are acid soils with a wet peaty surface layer overlying a wet, greyish subsoil. These soils often have a thin iron-pan which restricts the flow of water deeper into the soil. These soils are largely rain-fed and mineral-poor and usually supports vegetation communities dominated by heathers and nutrient -poor grasses.

8.5.72 The Carbon and Peatland Map presented in Figure 8.4 shows a dominance of Class 3 (vegetation cover does not indicate priority peatland habitat) and Class 5 (vegetation cover does not indicate peatland habitat), with the former occupying steeper west facing slopes within the Crook Burn, Black Burn, Sweetshaw Burn and Shiel Burn with the latter dominated much of the upper Annan catchments. There are also occurrences of Class 1 (soils which are considered to be of national importance) situated within the lower catchment of the Black Burn and on the slopes north of Whiteside Hill in the centre of the Proposed Development Area. Further to the east towards the lower sections of the Annan catchments, the soil is classified as mineral soil, with occasional areas of Class 4 (area unlikely to be associated with peatland habitat).

8.5.73 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 (Warburton *et al.,* 2004). Unmodified peat consists of two layers; a surface acrotelm which is usually 10 – 30 cm thick, highly permeable and receptive to rainfall. Decomposition of organic matter 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.

8.5.74 A second layer, or catotelm, lies beneath the acrotelm and forms a stable colloidal substance which is generally impermeable. As a result, the catotelm 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.

8.5.75 Due to the distribution of peat and peaty soils underlying the Proposed Development, a Phase 1 peat depth survey, followed by Phase 2 detailed probing and a peat stability risk assessment (Refer to Technical Appendix 8.2) have been carried out to thoroughly understand the peat and its locality within the site boundary.

8.5.76 Technical Appendix 8.2: Peat Stability Risk Assessment provides details on the methodologies adopted and fieldwork undertaken to assess the potential for peat slides and Technical Appendix 8.3: Peat Management Plan outlines the approximate volumes of peat that will be excavated and reinstated, based on the survey results and the infrastructure. The following information provides a summary of the peat depths recorded during field surveys.

Peat Survey Results

8.5.77 A Phase 1 (100 m grid) peat depth walkover survey at the Proposed Development was undertaken in December 2019 in line with Scottish Government guidance. The results of which were used to inform preliminary design, before a subsequent detailed peat depth survey was undertaken. The detailed Phase 2 surveys were undertaken in August and September 2020.

8.5.78 A breakdown of points in each category of peat depth is provided in Table 8.11 below.

Table 8.11: Total number of peat depths surveyed within each catcgory during the

Peat Depth Range (m)	Results	% of points surveyed
<0.5	2224	56.9
≥0.5-1.0	1012	25.9
≥1.0-1.5	389	9.9
≥1.5-2.0	162	4.2
≥2.0	118	3.1
Total	3905	100

Source: Natural Power

[1] Available online: https://www.environment.gov.scot/ (last accessed 04/11/2020)

8.5.79 Table 8.11 shows that the highest proportion (~57%) of recorded peat depths fell within the ≤0.5 m range, with the next highest proportion (~26%) within the >0.5 – 1.0 range. The areas of deep peat (greater than 0.5 m) are largely located in the upper plateau areas across the Proposed Development, particularly across the east of the Daer Land Portion.

8.5.80 Further details on the peat survey results collected, including the phase 2 survey, can be found in Technical Appendix 8.2 and Technical Appendix 8.3. In summary, based on the peat survey results (displayed in Figure 8.6), there were small areas of deeper peat (greater than 1 m) predominantly situated on topographically elevated but level ground along ridge spurs in the east, as well as the west side of the Black Burn, in the north of the Daer Land Portion. The areas of deeper peat generally constrained to within the areas of classified Class 1 Peat.

Groundwater Dependent Terrestrial Ecosystems (GWDTE)

8.5.81 Information concerning GWDTE within the proposed development area have been considered within Technical Appendix 8.4: Groundwater Dependant Terrestrial Ecosystems. Areas of potential GWDTE have been identified in relation to proposed infrastructure within Figure 8.7.

8.5.82 The potential groundwater dependent habitats within the proposed development are diverse but comprised predominantly of wet heath and blanket peat with less frequent marsh grassland, acid / neutral flush and occasional spring communities. The M6 flush habitat is indicative of the interaction of rainwater and sphagnum, resulting in significant acidification. Where groundwater rises are present, water pH would be more basic which in turn would be reflected in the type of species present (i.e. M10, M11, M29, M32 / M38), however it is appreciated that diffuse spring sources would not necessarily enable the dominance of base dependent species. Further details are provided in Technical Appendix 8.4: Groundwater Dependant Terrestrial Ecosystems.

Modifying Influences

8.5.83 Information regarding climate change was obtained from the UK Climate Projections (UKCP18) website (Met Office, 2020). The UKCP18 is a climate analysis tool which features comprehensive projections for different regions of the UK. General climate change trends projected over UK land for the 21st century show an increased chance of warmer, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of weather extremes. This is seen in the Probabilistic (25 km), Global (60 km), Regional (12 km) and Local (2.2 km) projections.

8.5.84 Warmer and wetter winters suggest less snow and more rain. This will create increased risk for flood events, and issues with water quality as less precipitation will be held in its frozen state during the winter season. If climate predictions are correct, summer months will become drier. This will create pressure on the needs of water abstractions and on sensitive ecosystems that rely on aquatic habitats. Evidence also suggests that although the summer months will have an average decrease in rainfall, summer storms will be more frequent and intense. 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.

8.5.85 It is suggested that increased temperatures in the summer could also increase evapotranspiration and potentially cause desiccation of peat (Scottish Government, 2008). The desiccation could result in the peat being more susceptible to erosion due to increased intensity in summer storms and increased rainfall during the winter months. As peat and peat dominant soils are composed of vegetation remains, they contain a high proportion of carbon compared to other soils.

8.6 IDENTIFICATION AND EVALUATION OF KEY IMPACTS

Project Interactions

8.6.1 The Proposed Development will introduce physical changes which have the potential to alter the hydrological characteristics within the Proposed Development. During the construction phase and to a lesser extent during the operational phase, potential sources of pollution will be present. Hydrological surveys have been undertaken to establish the existing on-site baseline conditions and associated areas downstream, to assess the potential effect of the Proposed Development on the identified receptors, the significance of these effects and the potential for mitigation to reduce the significance of the identified effects.

Basis of Assessment

8.6.2 The Proposed Development will consist of 17 wind turbines, associated turbine foundations and transformers, hardstand areas for erecting cranes at each turbine location, a series of new on-site tracks connecting each turbine, underground cables linking the turbines to the national gird, temporary construction compounds and borrow pits. Existing tracks have been utilised where practicable and possible.

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

Mitigation by Design

8.6.4 A summary of the hydrological influences on the project layout are given below with full details of the project design evolution provided in Chapter 2 of the EIAR. Due to the nature of the environment occupied by the Proposed Development (specifically its designation as a Drinking Water Protected Area), it is important that the design and infrastructure helps maintain or even improve the local hydrology. Poor design of development infrastructure can result in significant implications to the hydrological environment with secondary effects on soils and ecology.

8.6.5 The findings of the peat depth survey (Table 8.11) show that the infrastructure has, as far as possible, when taking into account other environmental and engineering constraints, been sited outside areas of deep peat (>1.0 m thickness). However, eight turbines (Turbine 1, 3, 8, 9, 14, 15 & 17) are situated proximal to areas of peat between 0.5 m and 1.0 m depth with only Turbine 11 situated in an area of peat >1.0 m. Peat depths across the rest of the site are predominately shallow (<0.5 m) with an average site wide peat depth of 0.17 m.

8.6.6 The hydrological desktop study and site visits have identified a typical upland hydrological environment with commercial forestry plantation and open moorland. This steep upland topography and coverage across multiple catchments presents a considerable number of hydrological pathways and features associated with it. A modified hydrological environment as a result of the agriculture and commercial forestry operations exist where drainage patterns have modified the natural conditions.

8.6.7 To facilitate the reduction of potential impacts on the hydrological environment. a series of buffer distances have been adopted and have been designed proportionately to allow greater protection in more sensitive areas;

- All turbines and borrow pits – minimum 100 m buffer from nearest watercourse;
- All tracks and other infrastructure situated within the Shiel Burn or Sweetshaw Burn catchment areas - minimum 100 m buffer from nearest watercourse; and
- All tracks and other infrastructure – all other areas within the Proposed Development - minimum 50 m buffer from nearest watercourse.

8.6.8 Table 8.12 confirms that all turbines associated with the Proposed Development are located outside the buffer limits. Distances were calculated using functionalities provided within the QGIS package.

Table 8.12: Distance from turbine to nearest watercourse

Turbine ID	Turbine distance from watercourse (m)	Turbine ID	Turbine distance from watercourse (m)
1	268	**10**	184
2	152	**11**	455
3	309	**12**	435
4	264	**13**	337
5	221	**14**	276
6	261	**15**	301
7	291	**16**	204
8	447	**17**	357
9	454	-	-

8.6.9 Additional embedded mitigation integrated as part of the design of the Proposed Development is as follows:

- Borrow pits and their search areas associated with the Proposed Development, have been located across the site to minimise transportation movements of stone. They are located close to the proposed infrastructure and will be restored after use. All of the proposed borrow pits and search areas are located out with the 100 m buffer of watercourses. Further details are provided in Technical Appendix 8.5: Borrow Pit Appraisal;
- The layout of new tracks has been designed to minimise impacts on the hydrological environment and as far as possible avoid sensitive receptors such as watercourses, GWDTE and deep peat. For existing tracks situated on the Primary Proposed Access route, required track widening works will also aim to avoid these receptors and where unavoidable, widening works will be favoured to progress on the far side of the track i.e. the side with the shallowest peat depth and the opposite side from GWDTE parcels or PWS sources;
- A number of new watercourse crossing locations will be required for the Proposed Development in areas which do not utilise areas of existing track (Technical Appendix 8.1: Water Crossing Assessment). Where possible, utilising existing crossings will minimise the impact of disturbance on the hydrological environment. The number of new and existing watercourse crossings required is twenty seven in total, with six of these being within the Daer Reservoir Catchment Area and the rest situated along the Primary Proposed Access;
- A small amount of the Proposed Development and the majority of the Proposed Primary Access sits within the catchment of the River Annan, which is susceptible to flooding downstream. Through careful design of the supporting drainage, any required watercourse crossing upgrades and the implementation of good management practices, it is envisaged that the potential risk of increased flooding to downstream areas can be effectively mitigated; and
- The design of linear infrastructure elements will be done so to avoid modifying surface water and groundwater flow pathways. This includes the use of permeable materials for track construction, adoption of a site-wide drainage strategy integrating the use of regular cross drains and soakaways, and the use of regular clay plugs within buried structures such as cable trenches. Opportunities for the integration of floating track design could be identified during the detailed design state.

Receptor Sensitivity

8.6.10 On the basis of the baseline surveys and available information, Table 8.13 below presents the sensitivity of the identified receptors based on the criteria outlined earlier in Table 8.4.

Table 8.13: Justification for Receptor Sensitivity Classification

Receptor	Sensitivity	Justification
Surface Water		
Daer Water	High	Classified under RBMP as having “good” overall status. Watercourses of high status are of national importance in achieving good water quality status targets
Shiel Burn	High	Not classified under RBMP. The burn is short and discharges into Daer Reservoir close Daer WTW and therefore opportunities for mixing, dilution and attenuation of pollutants are limited
Black Burn	Medium	Not classified under RBMP. The burn has a large catchment area, with the majority of Proposed Infrastructure situated in headwaters
Cloffin Burn	Low	Classified under RBMP as having “poor” overall status on account of fish migration barriers
Garpool Water	High	Classified under RBMP as having “good” overall status. Water courses of high status are of national importance in achieving good water quality status targets
Kinnel Water	Low	Classified under RBMP as having “poor” overall status on account of fish migration barriers
Fisheries & Recreation	Medium	Daer Reservoir as well as the Annan and Clyde catchments are locally important fisheries and are currently regulated due to low / recovering fish stocks
Flood Risk		
The Proposed Development	Low	Only very limited areas of the Proposed Development fall within the flood inundation envelope (i.e. only at lower catchment watercourse crossing locations)
Watercourses Downstream of the Proposed Development	Medium	Downstream watercourses are at potential risk of flooding and any changes to the hydrological environmental that results in additional flow could exacerbate the likelihood of flooding. However, the impermeable nature of the bedrock and low permeability of the overlying peat and glacial till will naturally encourage high rainfall-runoff rates (as indicated in Section 8.5). The addition of the Proposed Development Infrastructure will not significantly alter the existing baseline hydrological regime and is likely to have a minimal effect on the existing rainfall-runoff scenario.
Water Resources		
Private Water Supplies	Medium	Private Water Supplies are of low regional importance, but high in a local context from the perspective of the water supply user
Daer Reservoir	High	Daer Reservoir WTW and the upstream catchment areas of the upper Clyde is a Drinking Water Protected Area. The reservoir is used as a potable water resource and is partially fed from catchments which contain the Proposed Development and is of national importance. The Reservoir is also import as a fishery.
Soils & Peat		
Site soils and peat < 0.5 m depth	Low	Over half of the surveyed soils (57 %) are less than 0.5 m deep and therefore not classified as peat and is of local significance
Site soils and peat > 0.5 m depth	High	There several small areas identified as consisting of Class 1 soils which are considered to be of national importance
Geology		
Geology	Low	Geology is typical of wider area with no designated sites of geological interest located within the Proposed Development or in a location downstream that could be impacted by the Development.
Hydrogeology		
Groundwater within Peat	Medium	Owing to the low permeability of the underlying bedrock across most of the Proposed Development, the peat may host a shallow superficial aquifer which is vulnerable to pollutants that are not readily absorbed or transformed.
Underlying Groundwater	Low	Low productivity and unlikely to support any significant volumes of groundwater. Potential for bedrock groundwater to support baseflow to streams and Daer Reservoir, however BFI & SPR values indicate surface water runoff as the predominant component of streamflow. Limited regional and local importance.
GWDTEs	Medium	Predominantly ombrotrophic or surface water fed habitats associated with modified bog, wet heath or acid / neutral flush but supported occasionally by shallow/diffuse groundwater seepage. Whilst not individually nationally important, areas highly dependent actual GWDTE may have some cumulative regional significance

8.7 MITIGATION METHODS

8.7.1 A number of planning, design and construction proposals have been identified during the assessment. Full details of the good practice construction management and mitigation measures to be implemented will be outlined in a site specific CEMP which would be prepared post consent as part of the conditions discharge process. A summary of the measures which are likely to be included in the CEMP are summarised in this chapter and have been assumed to be part of the proposals when the residual effects and their significance are reported.

8.7.2 To accommodate for increased hydrological sensitivity within the Daer Resevoir catchment area, a Pollution Prevention and Incident Plan (PPIP) has also been prepared and provided in Technical Appendix 8.6 and relates specifically to pollution prevention within the Daer Reservoir catchment area managed by Scottish Water. The PPIP comprises of the following key components:

- Pollution Prevention Plan – Describes the controls and mitigation to be implemented during the pre-construction and construction phases to prevent or mitigate potential adverse effects on the quantity / quality of surface water or groundwater.
- Pollution Incident Response Plan – Describes the arrangements to be followed in the event of a pollution incident and outlines the procedures to be adopted in relation to response, investigation, reporting and remediation requirements.
- Pollution Control Monitoring Plan – Describes the likely environmental and pollution control monitoring arrangements to be implemented in supporting the protection of the hydrological environment.

Some of the mitigation measures described in the following paragraphs can also be adopted during the operational phase of the Proposed Development.

Outline Construction and Environment Management Procedures

8.7.3 A detailed CEMP will facilitate the implementation of industry good practice measures in such a manner as to prevent or minimise effects on the surface and groundwater environment. The CEMP will include information on:

- Drainage – all runoff derived from construction activities and site infrastructure will not be allowed to directly enter the 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 hydrological area and it is imperative that the drainage infrastructure is designed to accommodate storm flows based on a 1 in 200-year event plus climate change to help maintain the existing hydrological regime;
- Storage – all 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 at a designated location (likely to be construction compound);
- 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. No refuelling will be permitted within the Sheil Burn catchment, owing to its limited length and the discharge location into Daer Reservoir being near the Daer WTW abstraction point;
- Maintenance – maintenance to construction plant will be carried out in designated zones, 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 allow the appropriate disposal of sewage. 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 Proposed Development for a soakaway. Any discharge requirements will comply with relevant requirements under SEPAs CAR;
- 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 through implementation of the buffer zones where applicable and good practice construction methods;
- Demarcation – where potentially sensitive receptors have been identified in areas proximal to Proposed Infrastructure, such as GWDTE or PWS (such as Holmshaw), demarcation on the ground as well as within Constraints Plans will be undertaken to facilitate their protection;
- Monitoring Plan – all activities undertaken as part of the Proposed Development will be monitored throughout the construction phase to monitor environmental compliance. Water quality monitoring, including PWS, , will also occur throughout each phase of the Proposed Development and will help to maximise the effectiveness of embedded mitigation measures whilst monitoring effects on the hydrological environment;
- Contingency Plans – a pollution prevention plan will be prepared and will be implemented to allow plans to be put in place to manage a spills or other pollution incidents. The 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; and
- 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.

8.7.4 Within the Daer Land Portion, agreement on the location of specific construction activities such as refuelling and contingency plans will be formulated in agreement with Scottish Water and SEPA. Further information is presented in Technical Appendix 8.5: PPIP.

8.7.5 Further details regarding the pollution prevention and mitigation measures that will be adopted during the construction and operation of the Proposed Development are detailed in the following paragraphs.

Runoff & Sediment Management

8.7.6 The following measures will be adopted to appropriately attenuate and treat runoff during the construction and operation of the Proposed Development.

8.7.7 The Proposed Development drainage system will convey water away from construction activities and built infrastructure, however, due to the nature of the works at the Proposed Development, the steepness of the slopes and the low 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. To reduce this potential, prior to the commencement of and during construction, plans showing site drainage and hydrologically sensitive areas (watercourse buffers, GWDTE, PWS source and properties) will be designed, constructed and regularly checked to review potential for runoff and ponding of water within the Proposed Development so that that runoff patterns are well known.

8.7.8 The drainage systems installed within the Proposed Development 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 within the Proposed Development. For all of the suggested control measures, regular inspection and maintenance is necessary, particularly after prolonged heavy rainfall.

8.7.9 Silt traps will be installed within the Proposed Development 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. If required, flocculents could also be used to treat runoff. Flocculents are very effective at removing suspended sediment from water but they can also have effects on water chemistry. As such, any requirement for flocculent application would be agreed with SEPA and Scottish Water prior to use.

8.7.10 It is also envisaged that Natural Flood Management measures embedded as part of the Habitat Management Plan (HMP) including ditch blocking, would facilitate a reduction in surface runoff rates. This would not only help to attenuate peak flows but also enable the gradual release of water, providing a source of long term storage to sustain rivers during periods of low flow.

Pumping & Dewatering of Excavations

8.7.11 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 (SEPA, 2019). Suitable measures to minimise the impact of the pumped water on the hydrological environment shall be taken.

8.7.12 Due to the expected low permeability of soils across the majority of the Proposed Development it is expected that the potential for groundwater ingress would be low. However, there remains the possibility for groundwater ingress at the interface between soil/peat layers and the substrate layer as well as through potential peat pipes and other sub-surface features. The time that excavations are open will be kept to a minimum to prevent water ingress, as well as secondary impacts on up-slope soils/peat due to dewatering upslope. The ingress of surface water into the excavations will be minimised through the use of up gradient drainage measures e.g. cut-off ditches that will also prevent shallow throughflow entering excavations. 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 being pumped from the excavation to a predesigned settlement lagoon or other suitable silt treatment area. The settlement lagoons would attenuate and treat runoff before discharging back into the natural drainage network, mimicking natural flow patterns as far as possible.

8.7.13 Owing to the peat and peaty soils on site, the throughput rate of runoff within the settlement treatment areas would be reduced to give longer settlement time within the excavations and settlement tanks. If required, a series of settlement lagoons or other silt treatment measures can be deployed to allow maximum settlement of sediment during the construction period.

8.7.14 The treated water from the settlement lagoons or other silt treatment measures will not be discharged directly into watercourses but directed onto vegetated surfaces where appropriate. Sediment will be removed from site and the treated water will be deposited amongst the rough surface vegetation, away from sensitive habitats or watercourses.

8.7.15 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 the 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.

8.7.16 The discharge can also utilise silt traps, silt fencing or other attenuation measures. The utilisation of such measures could help to prevent the formation of erosion channels.

8.7.17 To maximise the efficiency of the settlement measures e.g. Siltbusters or other holding lagoons or tanks, the sediment sludge that collects at the base will be removed as required.

Storage of Fuels / Chemicals & Bund Arrangements

8.7.18 Throughout 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 in the Construction Compound, compliant with the provisions of the PIPP and General Binding Rule 26, 27 and 28 to protect the surface and groundwater environment.

8.7.19 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 to be stored away from any watercourses. Chemicals, fuel and oil will be stored in tanks of sufficient strength and structural integrity to reduce the chances of bursting or leaking in ordinary use. They will also be sited on impervious bases within a secured bund of 110% of the storage capacity. No fuel storage will be permitted within the Shiel Burn;
- 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 minimise the risk of spillage;
- Standing machinery to 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

8.7.20 External fuel delivery lorries will only be allowed as far as the site compound where there will be a bunded refuelling/fuel storage area constructed on an impervious base. Delivery lorries will transfer fuel to the on-site fuel tank or truck located within the bunded refuelling area to minimise the amount of fuel being driven around the Proposed Development and minimise external drivers accessing the Proposed Development.

8.7.21 A designated fuel truck/bowser will be used for refuelling in designated refuelling areas. The bowser driver will receive extra training on spill prevention and response.

8.7.22 The refuelling area shall be equipped with a mobile spillage control kit containing oil absorbent booms and mats. Nominated personnel will be trained and responsible for refuelling. Other personnel will also be trained on spill response as part of the Proposed Development induction training or toolbox talks. Special attention will be paid to spillage control at/near watercourses.

8.7.23 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.

8.7.24 No refuelling activities will be permitted in the Shiel Burn catchment. Within the Daer Land Portion, all refuelling locations will be agreed with SEPA and Scottish Water. Further details are presented in Technical Appendix 8.5: PPIP.

Vehicle Maintenance & Management

8.7.25 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.

8.7.26 Maintenance of construction plant to be carried out only 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, and if deemed appropriate, straw bales, booms or entrapment matting would be 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 within the Proposed Development which will be highlighted to all operatives during the site induction; and
- Standing machinery and plant will have industry standard drip trays (or similar, e.g. plant nappies – open metal drip trays are not permitted) placed underneath to prevent oil and fuel leaks causing pollution.

Concrete Works

8.7.27 Concrete would be required for the construction of the wind turbine foundations and foundations for the substation/control room buildings. The following section provides best practice measures that are required to be implemented to prevent detrimental effects to the hydrological environment.

8.7.28 Care will be taken during the transportation of concrete to the turbine and building foundations and will be carried out following good practice measures. Freshly mixed concrete and/or dry cement powder will not be allowed to enter any watercourse. This will be avoided by:

- Locating turbines, 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 and predetermined at 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;
- A designated concrete wash-out area will be constructed within the Proposed Development at a location agreed with the relevant consultees to protect watercourses. The design and construction of these wash out areas will be agreed with SEPA and Scottish Water; and
- Wash out areas will be continually monitored, and findings recorded to reduce the chances of effluent spilling over into the environment.

Site Drainage

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

8.7.30 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. 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.

8.7.31 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.

8.7.32 To reduce the impact of the proposed development on the natural hydrological regime, the site drainage will mimic greenfield runoff response through the use of sustainable drainage practices.

8.7.33 Sustainable Drainage Systems (SuDS) will be taken into consideration as part of the water management and details of the proposed SuDS regime would be included in the CEMP and PPP that will be produced as part of the application that would be made to SEPA for a construction site licence.

8.7.34 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.

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

8.7.36 Access tracks crossing slopes will disrupt surface flow that consequently will collect in drains constructed upslope of the tracks. Cross-drains and/or water bars 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, although 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.

8.7.37 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, proximity to GWDTE and the hydrological regime.

8.7.38 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.

8.7.39 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 hardstands, and other excavations required across the Proposed Development. The purpose of this will be to help reduce the volume of surface water runoff entering the excavations and minimise any subsequent contamination.

8.7.40 The constructed drainage system will not discharge directly to any natural watercourse, but will discharge to buffer strips, trenches or 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 of water back into the soils and peat.

8.7.41 Drainage from the construction compounds, welfare facilities, 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 installed.

8.7.42 Mitigation will follow industry good practice. All mitigation and drainage will be subject to detailed design and approved by Scottish Water and SEPA prior to construction with the Environmental Clerk of Works (ECoW) ensuring compliance. The Proposed Development will also be subject to a complex construction site licence. Further suggested measures include ensuring the detailed design includes buffer areas indicating "no construction zones" whereby the infrastructure and construction activities, including stockpile storage are not located i.e. in the Sheil Burn catchment area.

8.7.43 New watercourse crossings will be required, along with upgrading of some of the existing watercourse crossings, as part of the access tracks associated with the Proposed Development (see Technical Appendix 8.1: Watercourse Crossing Assessment). 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 at a minimum of 1:200yr + CC event. All watercourse crossings will be designed with edge upstands or bunds e.g. straw bales, booms, sandbags or silt fences to prevent sediment laden runoff from construction plant movement from directly entering watercourses. Relevant CAR Authorisation from SEPA will be sought for construction of the crossings that are required over watercourses that are displayed on the 1:50,000 OS Landranger maps.

Welfare Facilities / Foul Water

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

- Any sewage associated with the temporary construction compounds, substation and welfare facilities will be collected in appropriately sized interceptor tanks and shall be located at the construction compounds. All wash basins, toilets and shower areas shall also be connected to an interceptor tank;
- 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. The final location will be in agreement with SEPA and Scottish Water; and
- Sewerage from these facilities will be disposed offsite in accordance with waste management legislation.

Emergency Water Management Measures

8.7.45 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 Proposed Development, with traffic volumes significantly reduced during wind farm operation.

8.7.46 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. A PPIP has been prepared and details the measures to protect and monitor water quality within the Daer catchment. The following emergency procedures are discussed in the PPIP and can be implemented to provide additional protection to the surface and groundwater environment during wind farm construction and operation:

- All relevant on-site staff to 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 so that these measures are carried out effectively to minimise the risk of a pollution incident;
- Contingency plans will be designed that clearly highlights the location of emergency equipment available on site (i.e. spill kits and absorbent materials), training on correct use and that advice is provided on actions to be taken and who would be informed, in the event of a pollution incident;
- Contingency planning procedures must be regularly reviewed to include changes to site operations that were not foreseen during design;
- 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; and
- 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.

8.7.47 Further information is presented in the PPIP.

Additional Mitigation

8.7.48 Where specific risks exist for individual receptors as a result of the construction and operation of the Proposed Development, additional mitigation will also be used alongside embedded mitigation to further reduce measurable impacts. The recommendations outlined will be incorporated into the CEMP and PPIP post-consent.

- The use of General Site Pollution Control and other Mitigation Measures outlined in this Chapter apply to the entire Proposed Development Area. The catchment areas in the north of the Proposed Development discharge into Daer Reservoir close the Scottish Water abstraction for Daer WTW and as identified in Table 8.13 are therefore more sensitive than other watercourses to environmental impacts. Mitigation, including the use of sediment management measures, has been outlined in the PIPP for the Daer Land Portion and will also be presented for the wider Proposed Development as part of the detailed design in the CEMP post consent. The establishment of communication channels for risk management and monitoring will be essential and is crucial to the delivery of the PIPP;

- Site-specific mitigation will be undertaken at Holmshaw Private Water Supply owing to its proximity to the Proposed Development. This will include;
  - Further investigation and demarcation of the area of the source and avoid movements/works in peripheral upgradient areas;
  - ECoW to carry out regular inspections to maximise the effectiveness of the mitigation and make recommendations for improvements as required. Photographic evidence shall be included;
  - All pipework associated with the PWS shall be demarcated. The pipework will be afforded additional protection under the track as well as the running surface, including:
    - Metal plates on the running surface over the crossing point;
    - Excavation of the track (existing) and installation of local protection measures around the pipe, concrete slabs, track make up material then placed over the top;
    - Provision of a temporary supply that can be deployed immediately in the unlikely event that the supply pipe is disrupted; and
  - The exact details of the mitigation to be used will be responsibility of the Principal Contractor. A programme of water quality monitoring will be developed to monitor this supply.

8.8 PREDICTED CONSTRUCTION EFFECTS

8.8.1 The potential for effects on the hydrological environment is greatest during the construction phase due to the high levels of activity on-site and when there is greatest change to the existing environment. The potential effects associated with the construction of the Proposed Development is discussed and assessed in the following sections. This information has taken account of the mitigation and management measures outlined in Section 8.7: Mitigation Methods.

8.8.2 The evaluation of construction effects is provided in Table 8.14 below. The assessment results are based on the successful implementation of the embedded good practice mitigation measures as well as the additional mitigation measures provided in Section 8.7: Mitigation Methods.

Predicted Construction Effects

Pollution Incidents

8.8.3 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 located within the Black Burn. In addition, there is the potential for contamination of the hydrological and terrestrial environment caused by spillages along the on-site access tracks, Primary Proposed Access and construction areas.

Erosion & Sedimentation

8.8.4 Soil 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 Proposed Development infrastructure.

8.8.5 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.

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

Changes in Water Quality

8.8.7 Excavation and disturbance of soils, subsoils and peat could result in changes in the chemistry of surface water runoff including colour, dissolved organic carbon (DOC), Turbidity and dissolved metals. As with erosion and sedimentation, this can have implications on both the quality of the aquatic habitat and also the resource potential of the water itself. For the Sheil Burn, opportunities for mixing, dilution and attenuation before entering Daer Reservoir close to the abstraction point for Daer WTW will be more limited than other watercourses.

8.8.8 Tree removal in the upper Annan catchment could also increase nitrogen mineralisation and nitrification, which can promote nitrate leaching and enhance acidity in waters draining some soils. The effect can last between two to five years after felling, depending upon the rate at which vegetation re-establishes. The filling of trenches with fresh brash could accentuate the effect by promoting leaching below the rooting zone.

8.8.9 Potential pollutants coming into contact with bedrock or the superficial sediments also have the potential to alter the quality of the groundwater resource. Such alterations including changes in pH or addition of chemicals, could be difficult to rectify and due to the fractured nature of the bedrock and limited extent of any superficial aquifer would attenuate very slowly.

Increases in Runoff

8.8.10 Turbine bases, hardstand areas and access tracks will act as impermeable areas, restricting the natural movement of water within the hydrological environment, potentially resulting in increased rates of runoff into the onsite and downstream catchments. The pre-construction, construction and permeant site drainage will be designed to mimic greenfield runoff response through the use of sustainable drainage practices.

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

8.8.12 In the areas which are to be felled along the Proposed Primary Access, localised runoff responses have the potential to increase due to the reduction in precipitation being intercepted by the closed canopy forestry. Felling and extraction would also be planned to minimise the number of drain crossings and reduce any increases in runoff.

8.8.13 The impermeable nature of the underlying bedrock and low permeability of the overlying peat and glacial till within the Proposed Development Area will naturally encourage high rainfall-runoff rates (as indicated in Section 8.5). Therefore, the addition of the Proposed Development Infrastructure will not significantly alter the existing baseline hydrological regime and is likely to have a minimal effect on the existing rainfall-runoff scenario.

Modification of Surface Drainage Patterns

8.8.14 The interception of diffuse overland flow by the Proposed Development 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 for water quality or quantity (including Private Water Supplies) and on flood issues downstream of the Proposed Development.

8.8.15 As well as potentially negative effects, construction may also positively effect surface drainage patterns through the blocking of artificial ditches during habitat restoration and therefore encouraging the development of a natural rainfall-runoff response.

Impediments to Surface Water Flow

8.8.16 The design and construction of watercourse crossings will be completed in accordance with SEPA Position Statements outlined in Table 8.1 (WAT-PS-06-02, WAT-SG-23 and WAT-SG-25), being appropriately sized to accommodate the 1 in 200 year + Climate Change flow. Where required, watercourse crossings should allow for the migration of fish and mammal movement in the riparian corridor.

Modification of Groundwater Flows and Levels

8.8.17 Deep excavations, such as those required for the turbine foundations are likely to disrupt the shallow groundwater systems and bedrock geology. Surface water ingress will be minimised by utilising upgradient cut-off drains or other drainage measures. The installation of cut-off drains has the potential to lower local groundwater levels within surrounding peat dominated soils.

8.8.18 The majority of temporary and permeant infrastructure (apart from foundations) would be permeable to some extent.

8.8.19 Access tracks and other linear infrastructure elements such as cable trenches have the potential to disrupt flow pathways as granular backfill may create preferential infiltration and throughflow pathways. These may interrupt shallow groundwater flow or alter the hydrological regime impacting baseflow to watercourses, GWDTE and Private Water Supplies.

Compaction of Soils

8.8.20 The movement of construction traffic within the Proposed Development is likely to cause localised compaction of the ground surface, 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 altering groundwater flows and levels.

Assessment of construction effects

8.8.21 Table 8.14 identifies the likely construction effects on the identified receptors and their residual significance assuming the **successful implementation of good practice, embedded mitigation and additional measures**. The residual significance of the effect taking into account good practice and embedded mitigation (and additional mitigation if applicable) is underlined. A further column has also been provided considering the significance of effect upon receptors following the implementation of additional mitigation.

Table 8.14: Assessment of Construction Effects

Potential Effect	Identified Receptor(s)	Sensitivity	Magnitude of Effect	Significance of Residual Effect	
				Embed. Mitigation	Additional Mitigation
Surface Waters					
• Pollution incidents • Erosion and sedimentation	Daer Reservoir	High	Low	*Mod*	Minor/Mod
• Changes in Water Quality • Increase in Runoff	Daer Water	High	Low	*Mod*	Minor/Mod
• Modifications to Surface Drainage Pattern	Shiel Burn	High	Low	*Mod*	Minor/Mod
• Impediments to Surface Water Flow	Black Burn	Medium	Low	*Minor*	Minor/Mod
	Cloffin Burn	Low	Low	Neg./Minor	-
	Garpool Water	High	Low	Minor/Mode	-
	Kinnel Water	Low	Low	Neg./Minor	-
Flooding					
• Increase in runoff • Modifications to Surface Drainage Patterns	The Proposed Development	Low	Negligible	Negligible	-
• Impediments to Surface Water Flow • Compaction of Soil	Watercourses downstream of the Proposed Development	Medium	Negligible	Negligible	-
Water Resources					
• Pollution incidents • Erosion and sedimentation • Changes in Water Quality	Holmshaw Private Water Supply	Medium	Medium	*Moderate*	Minor/Mod
• Increase in Runoff • Modifications to Surface Drainage Pattern • Impediments to Surface Water Flow • Modification of Groundwater Flows and Levels	All other Private Water Supplies (not hydrologically connected or outside of LUPS31 Buffer)	Medium	Low	Minor	-
	Daer Reservoir				

Potential Effect	Identified Receptor(s)	Sensitivity	Magnitude of Effect	Significance of Residual Effect	
				Embed. Mitigation	Additional Mitigation
• Compaction of Soils		High	Low	*Moderate*	Minor/Mod
	Clyde catchment fisheries	Medium	Low	Negligible	-
	Annan catchment fisheries	Low	Low	Neg./Minor	-
Soils & Peat					
• Pollution incidents • Modifications to Surface Drainage Patterns • Modification of Groundwater Flows and Levels • Compaction of Soils	Site soils and peat < 0.5 m depth	Low	Low	Minor	-
	Site soils and peat > 0.5 m depth	High	Low	Minor/Mod	-
Geology					
• Excavation and removal required for construction	On-site Geology	Low	Low	Neg./Minor	-
Hydrogeology					
• Pollution incidents • Modification of groundwater flows and levels • Compaction of Soils	Groundwater within Peat	Medium	Low	Minor	-
	Underlying Groundwater	Low	Low	Minor	-
	GWDTEs	Medium	Medium	Moderate	-

8.9 PREDICTED OPERATION EFFECTS

8.9.1 The effects of the Proposed Development will be substantially lower during the operational phase. The following paragraphs discuss and assess the potential effects that are predicted to occur during the operational phase of the Proposed Development.

Predicted Operation Effects

Pollution Incidents

8.9.2 The potential risk of pollution is substantially lower during operation than during construction because of the reduced levels of activity in the operational phase. Most potential pollutants will have been removed when construction was completed; however, lubricants for turbine gearboxes, and transformer oils may be stored on site and there is the risk of possible fuel leaks from maintenance vehicles whilst onsite.

Erosion & Sedimentation

8.9.3 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 are still possible on the access tracks and drainage ditches as a result of scouring during extreme rainfall events. Similarly, there could be some short term increases to erosion and sedimentation around new stream crossings as watercourses reach new equilibrium primarily within the construction and early in the operational phases of the Proposed Development.

Changes in Water Quality

8.9.4 During the operation phase there will be no continued construction works associated with excavation and exposure of soils, peat and sediments. Opportunities for erosion and transportation of materials will be considerably reduced during the operational phase as previously exposed surfaces become vegetated.

Increases in Runoff

8.9.5 Some of the drainage management features such as silt ponds and silt fencing will be dismantled, with retained features designed to blend into the landscape, but also provide protection against erosion. A reduction in the number of drainage management features overall is likely to reduce the rate of runoff compared to the construction phase with permeant drainage designed to mimic greenfield hydrological regimes.

Modification of surface drainage patterns

8.9.6 Modification of surface runoff will occur as a result of the construction of the new infrastructure associated with the Proposed Development. The operational effects could result in changes to volume and/or changes to runoff rate, however the permeant drainage will be designed to avoid this.

Impediments to Surface Water Flow

8.9.7 During the operational phase impediments to flows can generally occur as a result from blockages to watercourse crossings, ditches and watercourses themselves, resulting from vegetation and erosion debris. The cost of maintaining the mitigation measure shall be met by the Operator through the lifetime of the planning permission.

Modification of Groundwater Flows and Levels

8.9.8 Cut tracks and their drainage as well as turbine foundations and hardstands will potentially alter the water table within the upslope and downslope peat and bedrock groundwater, which can also have implications for the long-term functionality of peatland environments.

Compaction of Soils

8.9.9 The compaction of soils/peat will be significantly reduced during the operational phase as a result of settlement of infrastructure following initial construction and significantly reduced traffic movements.

Assessment of Predicted Operation Effects

8.9.10 Table 8.15 below identifies the likely operational effects on the identified receptors and their significance based on **the successful implementation of good practice, embedded mitigation and additional measures**. The residual significance of the effect taking into account good practice and embedded mitigation (and additional mitigation if applicable) is underlined. Apart from at Holmshaw PWS, where additional armouring and protection measures will be utilised during track construction and be left in-situ, no additional mitigation will be required as part of the management of predicted operation effects.

Table 8.15: Assessment of predicted operational effects

Potential Effect pre Mitigation	Identified Receptor(s)	Sensitivity	Magnitude of Effect	Significance of Residual Effect	
				Embed. Mitigation	Additional Mitigation
Surface Waters					
• Pollution incidents • Erosion and sedimentation • Changes in Water Quality • Increase in Runoff • Modifications to Surface Drainage Pattern • Impediments to Surface Water Flow	Daer Reservoir	High	Negligible	Negligible	-
	Daer Water	High	Negligible	Negligible	-
	Shiel Burn	High	Negligible	Negligible	-
	Black Burn	Medium	Negligible	Negligible	-
	Cloffin Burn	Low	Negligible	Negligible	-
	Garpool Water	High	Negligible	Negligible	-
	Kinnel Water	Low	Negligible	Negligible	-
Flooding					
• Increase in runoff • Modifications to Surface Drainage Patterns • Impediments to Surface Water Flow • Compaction of Soil	The Proposed Development	Low	Negligible	Negligible	-
	Downstream of the Proposed Development	Medium	Negligible	Negligible	-
Water Resources					
• Pollution incidents • Erosion and sedimentation • Changes in Water Quality • Increase in Runoff	Holmshaw Private Water Supply	Medium	Negligible	*Negligible*	Negligible
• Modifications to Surface Drainage Pattern • Impediments to Surface Water Flow • Modification of Groundwater Flows and Levels • Compaction of Soils	All other Private Water Supplies (not hydrologically connected or outside of LUPS31 Buffer)	Medium	Negligible	Negligible	-
	Daer Reservoir	High	Negligible	Negligible	-
	Clyde catchment fisheries	Medium	Negligible	Negligible	-
	Annan catchment fisheries	Low	Negligible	Negligible	-
Soils & Peat					
• Pollution incidents • Modifications to Surface Drainage Patterns • Modification of Groundwater Flows and Levels • Compaction of Soils	Site soils and peat < 0.5 m depth	Low	Negligible	Negligible	-
	Site soils and peat > 0.5 m depth	High	Negligible	Negligible	-
Geology					
• Excavation and removal required for construction	On-site Geology	Low	Negligible	Negligible	-
Hydrogeology					
• Pollution incidents • Modification of groundwater flows and levels • Compaction of Soils	Groundwater within Peat	Medium	Negligible	Negligible	-
	Underlying Groundwater	Low	Negligible	Negligible	-
	GWDTEs	Medium	Negligible	Negligible	-

Source: Natural Power

8.10 CUMULATIVE EFFECTS

Predicted Cumulative Effects

8.10.1 There are no other existing wind farm developments within the Daer Reservoir catchments or immediately adjacent to the Proposed Development.

8.10.2 Within the wider Clyde catchment, there are several wind farms situated within 10 km of the Proposed Development including Clyde Wind Farm and Crookedstane Wind Farm. There are also wind farms located within the River Annan Catchment including the Crossdykes Wind Farm, the Minnygap Wind Farm and the Harestanes Wind Farm.

8.10.3 Off-site cumulative hydrological effects are primary related to changes in water quality and increases in flood risk. Mitigation has been presented in Section 8.7 to adequately protect on-site hydrological receptors and therefore will be suitable to ensure the protection of those situated downstream, and should not contribute to or exacerbate any effects arising from other developments, land uses or activities. With regards to flood risk specifically, the design of the drainage will mimic the existing hydrological and greenfield regime of the Proposed Development Area, as outlined in Section 8.7.

8.10.4 It is concluded that following the successful implementation of the mitigation outlined in Section 8.7, cumulative impacts of the Proposed Development during construction and during operation will be negligible.

Monitoring

8.10.5 A programme of surface water quality monitoring within the Daer Land Portion has been outlined within the PPIP. Monitoring for the wider Proposed Development will also be required and will be confirmed post-consent. A breakdown of the proposed monitoring methodologies has been provided to consider sensitivities of the on-site and downstream environments.

8.10.6 The details of any required water quality monitoring should be discussed and agreed with Scottish Water, SEPA, Marine Scotland, SLC and DGC 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 Proposed Development 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;
- Reduce or remove any impacts on the water environment (including Daer Reservoir and Private Water Supplies); and
- Understand the long-term effects of the Proposed Development on the natural environment.

8.10.7 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 Development infrastructure are also established at the same time.

8.10.8 A suitably qualified ECoW will be employed throughout the construction of the Proposed Development. The appointed ECoW 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, soils and associated habitats.

8.10.9 Monitoring will be undertaken throughout construction of the Proposed Development. The monitoring will help to identify areas where infrastructure is having a negative effect on peaty soils and utilise the appropriate methods to prevent further deterioration and/or promote further enhancement.

8.10.10 All construction management and water management techniques will be agreed prior to construction. The techniques would be agreed following consultation with Scottish Water, SEPA, Marine Scotland, SLC and DGC. In conjunction with this, there should be a programme of visual monitoring to ensure that the designed drainage system is compliant with the requirements under CAR with respect to GBR 10 and in particular; clauses d, g and h. In addition to this, PWS monitoring will be undertaken to ensure that supply quality and quantity is not altered as a result of the construction and operation of the Proposed Development.

8.11 DECOMISSIONING

8.11.1 During decommissioning of the Proposed Development, potential impacts on the Hydrological, Hydrogeological and Geological environment are expected to be less than those encountered during the construction phase and therefore "not significant". No specific mitigation measures are therefore identified.

8.11.2 The decommissioning of the Proposed Development would adhere to the latest legislative and guidance requirements at the time.

8.12 FUTURE BASELINE

8.12.1 Without the Proposed Development, the recorded baseline scenario for the hydrological, geological and hydrogeological of the site would be unlikely to significantly change. However the widespread occurrence of artificial drainage ditches and the reduced permeability of the degraded bog habitats mean that potential increases in rainfall as depicted in Section 8.5 Modifying Influences as a result of climate change could continue to increase soil erosion and place additional stresses upon nearby water resources. This could also be exacerbated by the harvesting of timber resources in the east of the Proposed Development and along the Primary Access Route. There is also the potential that the landowners may choose to pursue alternative development opportunities which cover a greater footprint of the site area than current proposals.

8.12.2 It is considered that alternative development proposals or continuation of current land-uses would not favour the habitat and peatland restoration potential as identified outlined in Daer Wind Farm EAIR Chapter 6: Ecology. The adoption of permeant drainage as part of the Proposed Development will also seek to mitigate pressures on the water environment through the incorporation of sustainable design features as well as impacts of peatland habitat improvement which will have been proven to attenuate peak flows and improve water quality.

8.13 SUMMARY

8.13.1 An assessment has been carried out of the likely impacts of the Proposed Development on the hydrological, hydrogeological and geological environment. The assessment has considered site preparation, construction and operation of the Proposed Development.

8.13.2 The potential effects on the hydrological, geological and hydrogeological environment have considered, pollution incidents, erosion and sedimentation, changes in water quality, changes to water resources i.e. Daer Reservoir and private water supplies, modification of surface water and groundwater flows, modification of natural drainage patterns, impediments to flow and flood risk, peat instability and compaction of soils.

8.13.3 Following the identification and assessment of the key receptors, taking into account the potential effects listed above, mitigation and good practice measures has been incorporated into the design, including extensive buffer areas. In addition, a PPIP and a Site-specific CEMP as well as detailed design of infrastructure and associated mitigation will be implemented to protect the groundwater and surface water resources from pollution and minimise changes to the hydrological environment.

8.13.4 The impact assessment has taken into account the hydrological regime, highlighting that the principal effects will occur during the construction phase. Following the successful design and implementation of mitigation measures the significance of construction effects on all identified receptors are not defined as significant. The assessment of predicted operational effects has determined that the significance of effects on all receptors to be of no significance. Table 8.16 below summarises the likely significant environmental effects of the Proposed Development.

8.13.5 Good practice design and construction of the Proposed Development delivered through a skilled team of competent workers, with mitigation and compliance monitored in collaboration with Scottish Water, SEPA, SLC, DGC and other engaged stakeholders, will result in a risk that is considered to be **not significant** in terms of the EIA Regulations.

Table 8.16: Summary of Likely Significant Environment Effects of the Proposed Development

Likely Significant Impact	Mitigation Proposed	Means of Implementation	Significance of Residual Effect
Construction Phase			
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 poor 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.	Preparation of detailed CEMP prior to construction. Hydrological elements of the CEMP can include, but not limited to the following: A Drainage Management Plan; Pollution Prevention and Incident Response Plan Watercourse crossing assessment (detailed design prior to construction); and Water quality monitoring programme.	**Minor / Moderate, Minor, Negligible / Minor, Negligible**
Impacts to PWS on and near to the Proposed Development	Demarcation of PWS infrastructure during construction		
Peaty gley soils as a result of interrupting surface and sub-surface drainage pathways. Modification of groundwater flows and levels with consequential impacts on GWDTEs	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. Appropriate design of tracks, watercourse crossings etc in areas of flushes.	Preparation of detailed CEMP 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 / habitat monitoring programme.	**Moderate, Minor / Moderate, Minor, Negligible / Minor, Negligible**
Operational Phase			
Detrimental impacts to on-site and downstream water quality through degradation of The Proposed Development infrastructure such as unmaintained drainage or track surfaces.	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 a 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; Regular water quality monitoring for a period post construction to determine potential long terms effects of Wind Farm on water quality.	**Negligible**
Detrimental effects to on-site and downstream fisheries as a result of changes to water quality (as described above)			**Negligible**
Increases to on-site and downstream flood risk as a result of degradation of infrastructure and/or poor maintenance/monitoring of infrastructure			**Negligible**

8.14 REFERENCES

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8.15 SUPPORTING INFORMATION

Table 8..17: PWS information provided by the LPAs and a summary of hydrological screening to determine possible hydrological connectivity with the Proposed Development

PWS ID	Supply Name	No. of Prop.	Type of supply	Within catchment?	Distance from infrastructure (km)	Further assessment?
1	Auchen Castle Hotel	7	A	No	3.33	No – topographically and hydrologically separated
2	Holmshaw	1	B	Yes	0.03	**Yes – Possible hydrological or hydrogeological linkage**
3	Rivox	1	B	Yes	0.47	**Yes – Possible hydrological or hydrogeological linkage**
4	Blaebeck	1	B	No	6.76	No – topographically and hydrologically separated
5	Easter Earshaig	1	B	Yes	0.73	**Yes – Possible hydrological or hydrogeological linkage**
6	Wester Earshaig	1	B	Yes	0.43	**Yes – Possible hydrological or hydrogeological linkage**
7	Kinnelhead Cottage	2	B	No	1.05	No – topographically and hydrologically separated
8	Ericstane	3	B	No	7.25	No – topographically and hydrologically separated
9	Stidriggs	1	B	No	1.83	No – topographically and hydrologically separated
10	Newton	3	B	No	7.86	No – topographically and hydrologically separated
11	Lawesknowe	3	B	No	2.60	No – topographically and hydrologically separated
12	Middlegill	3	B	No	2.27	No – topographically and hydrologically separated
13	Meikleholmside Cottage	2	B	No	5.58	No – topographically and hydrologically separated
14	Granton	1	B	No	7.67	No – topographically and hydrologically separated
15	Granton Cottage	2	B	No	7.09	No – topographically and hydrologically separated
16	The Hope	1	B	No	5.34	No – topographically and hydrologically separated
17	Well Cottage	1	B	No	6.25	No – topographically and hydrologically separated
18	Chapel Hill Cottage	1	B	No	3.72	No – topographically and hydrologically separated
10	Craiks's Craig	1	B	No	3.29	No – topographically and hydrologically separated
20	Lochanhead	1	B	No	1.13	No – topographically and hydrologically separated
21	Longbedholm,	1	B	No	2.71	No – topographically and hydrologically separated
22	Milton	1	B	No	2.97	No – topographically and hydrologically separated
23	Railway House	1	B	No	2.52	No – topographically and hydrologically separated
24	Nunnerie	3	Unconfirmed	Yes	1.41	**Yes – Possible hydrological or hydrogeological linkage**
25	Crookedstane Rig	2	Unconfirmed	Yes	1.36	No – topographically and hydrologically separated

Source: D&GC and SLC