Bowdun Offshore Wind Farm, Onshore EIA Report

Volume 2, Appendix 11.1: Flood Risk and Drainage Assessment

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Contents

List of Tables

List of Figures

Glossary

Defined Term	Definition
Annual Exceedance Probability (AEP)	The probability of a flood event occurring in any year, expressed as a percentage.
Base Flow Index (BFI)	A measure of the proportion of a catchment's long-term runoff derived from stored sources.
Flood Estimation Handbook (FEH)	A UK-wide standard procedure for estimating flood frequencies.
National Planning Framework 4 (NPF4)	Scotland's national spatial plan, setting out long-term plans for development and infrastructure.
Potentially Vulnerable Area (PVA)	Defined as geographical areas designated for flood management under the Flood Risk Management Act (Scotland) 2009.
Qbar	Refers to the mean annual maximum flow rate in the context of greenfield runoff estimation.
Standard Percentage Runoff (SPR)	The percentage of rainfall that is likely to contribute to runoff.
Sustainable Drainage Systems (SuDS)	A sequence of management practices and control structures designed to drain systems (SuDS) surface water in a more sustainable fashion than some conventional techniques.

Acronyms

Acronym	Definition
AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BFI	Base Flow Index
CC	Climate Change
CEMP	Construction Environmental Management Plan
DMRB	Design Manual for Road and Bridges
EIA	Environmental Impact Assessment
FEH	Flood Estimation Handbook
FRDA	Flood Risk and Drainage Assessment
GCP	Grid Connection Point
HDD	Horizontal Directional Drilling
MDS	Maximum Design Scenario
NPF4	National Planning Framework 4
OWF	Offshore Wind Farm
PPP	Planning Permission in Principle
PVA	Potentially Vulnerable Area
SPR	Standard Percentage Runoff
SuDS	Sustainable Drainage Systems
QBAR	Mean Annual Maximum Flow Rate

Table of Units

Units	Definition
ha	Hectare
km	Kilometre
km2	Square kilometre
m	Metre
%	Percent

1 Introduction

1.1 Scope of Work

1.1.1 This Technical Report presents a Flood Risk Assessment (FRA) and a Drainage Assessment for the onshore elements of the Bowdun Offshore Wind Farm (the 'Project'). For ease of reference the onshore elements of the Project, landward of the Mean Low Water Springs (MLWS), are referred to as the 'Proposed Development'.

1.1.2 The Proposed Development is located within the local authority area of Aberdeenshire Council and contained within the administrative area of Kincardine and Mearns. It covers a broad area of land stretching from the coastal area between Gourdon and Benholm Beach, passing through the wider Arbuthnott and Drumlithie areas before reaching the proposed Grid Connection Point (GCP) within the Fetteresso Forest.

1.1.3 This Technical Report acts as an accompanying Appendix to the Onshore Environmental Impact Assessment (EIA) Report for the Proposed Development and should be read in conjunction with this document, specifically Volume 1, Chapter 11: Water Quality and Flood Risk. This Onshore EIA Report accompanies the application to Aberdeenshire Council for Planning Permission in Principle (PPP) for the Proposed Development.

1.1.4 The scope of this Technical Report is to consider potential flood risk to the Proposed Development from all sources and provide an outline approach for the management of surface water runoff in accordance with sustainable drainage principles to ensure there is no increased risk to the Proposed Development or downstream receptors.

1.2 Project Description

1.2.1 The Proposed Development will include the following infrastructure elements:

- Landfall and Transition Joint Bays (TJBs) – situated approximately 1.3 km south-west of Gourdon where the Offshore Export Cables are jointed to the Onshore Export Cables within the TJBs;
- Onshore Export Cable Corridor – area within which the 220/275 kV Onshore Export Cable route will be located; this corridor runs from the Landfall to the Substation Site;
- Substation – the proposed Substation containing the components for transforming the power supplied from the Project from 220/275 kV up to 400 kV;
- 400 kV Cable Corridor – the area within which the 400 kV Cables will be located providing the onward transmission to the grid; this connects the Project Substation to the GCP at the proposed Hurlie Substation; and
- Any temporary ancillary onshore infrastructure required for the construction phase of the Onshore Export Cable Corridor, 400 kV Cable Corridor and the Substation (such as construction compounds and access routes).

1.2.2 Full details of the Proposed Development are provided in Volume 1, Chapter 2: The Proposed Development.

1.2.3 The Onshore Export Cable Corridor and 400 kV Cable Corridor will pass through areas designated by Scottish Environment Protection Agency (SEPA) to be at risk of flooding. Impacts associated with the Cable Corridors will be temporary, arising as a result of cable installation. Following their installation, the land will be reinstated so the only permanent surface elements will be link box covers. Therefore, there is no potential for significant operational impacts associated with the Onshore Export Cable Corridor or the 400 kV Cable Corridor. This FRA therefore focuses on the temporary and permanent impacts associated with the Substation and temporary impacts associated with the construction of the Landfall, Onshore Export Cable Corridor and the 400 kV Cable Corridor.

1.3 Flood Risk Study Area

1.3.1 The Flood Risk Study Area is described in the following sections and is presented in Figure 11.1 within Volume 1, Chapter 11: Water and Flood Risk, and includes the area of land to be temporarily or permanently occupied during the construction, operation and maintenance and decommissioning phases of the Proposed Development.

1.3.2 The Flood Risk Study Area comprises the following:

- PPP Application Boundary, within which the proposed cable route and associated infrastructure and access tracks will be located;
- One kilometre (km) buffer zone of the PPP Application Boundary; and
- The upper and lower reaches of watercourse catchments that are present within the PPP Application Boundary.

1.3.3 The buffers have been chosen to identify any existing receptors, assets or infrastructure that have the potential to be affected by temporary flood risk as a result of the construction phase of the Proposed Development and operation and maintenance of the Substation. Activities associated with decommissioning will operate within the same parameters of those established for the construction phase.

2 Policy Context

2.1 National Planning Policy

National Planning Framework 4

2.1.1 This FRA has been produced in accordance with the policies and guidance presented within the National Planning Framework 4 (NPF4) (Scottish Government 2023). NPF4 sets out spatial principles, regional priorities, national development and national planning policy. Table 2.1 provides an overview of the NPF4 planning policies relevant to the Proposed Development.

Table 2.1: NPF4 Planning Policies Relevant to the Proposed Development

Policy Reference	Policy Issue
Policy 2 (Climate mitigation and adaptation)	Development proposals will be sited and designed to adapt to current and future risks from climate change.
Policy 10 (Coastal development)	Development proposals in undeveloped coastal areas will only be supported where necessary for essential infrastructure, where there is a specific locational need and no other suitable site.
Policy 11 (Energy)	Development proposals for all forms of renewable, low-carbon and zero emissions technologies will be supported. These include wind farms including repowering, extending, expanding and extending the life of existing wind farms. In addition, project design and mitigation shall demonstrate how the impacts on hydrology, the water environment and flood risk are addressed.
Policy 22 (Flood Risk and Water Management)	Development proposals at risk of flooding or in a flood risk area shall only be supported if they are for essential infrastructure where the location is required for operational reasons. Development proposals will: • Not increase the risk of surface water flooding to others, or itself be at risk. • Manage all rain and surface water through sustainable drainage systems (SuDS), which should form part of and integrate with proposed and existing blue-green infrastructure. All proposals should presume no surface water connection to the combined sewer. • Seek to minimise the area of impermeable surface.

2.2 Local Planning Policy

Adopted Local Plan

2.2.1 The adopted Aberdeenshire Local Development Plan (Aberdeenshire Council 2023) contains a number of policies in relation to flood risk and drainage. These are summarised in Table 2.2.

Table 2.2: Aberdeenshire Council Local Development Plan Policies Relevant to the Proposed Development

Policy Reference	Policy Issue
Policy R1 Special Rural Areas	In order to safeguard the special nature of the coastal zone, development opportunities will be restricted and subject to various considerations. Development in the coastal zone must require a coastal location or present clear social, economic, environmental or community benefits. In either case there must be no coalescence of coastal developments or adverse impacts on natural coastal processes or habitats.
Policy PR1 Protecting Important Resources	New development which will generate discharges or other impacts on water bodies, or which could affect the water quality, quantity, flow rate or flood plains of water bodies much not prejudice water quality or flow rates, or their ability to achieve or maintain good ecological status.
Policy C4 Flooding	Flood risk assessments should be undertaken in accordance with SEPA Technical Flood Risk Guidance and will be required for development in the indicative medium to high category of flood risk of 0.5% or greater annual probability (1 in 200 years or more frequent). Assessments should include an allowance for freeboard and climate change. Development should not increase flood risk vulnerability and should avoid areas of medium to high risk, functional floodplain or other areas where the risks are otherwise assessed as heightened or unacceptable, except where is essential infrastructure. This means that the location is essential for operational reasons, for example, for water-based navigation, transport or utilities infrastructure and an alternative lower risk location is not available. Development will not be approved that may contribute to flooding elsewhere, SuDS principles apply to all sites. Opposed to the enclosed culverting of watercourses for land gain and will actively seek to discourage such proposals. Encourage the daylighting (or de-culverting) of existing culverted watercourses.
Policy RD1 Providing Suitable Services	All new developments must be served satisfactorily either by a mains water supply or by a private water supply if the developer is able to show that the private water supply is adequate. Surface water drainage much be dealt with in a sustainable manner, in ways that promote its biodiversity value, and in ways that avoid pollution and flooding through the use of an integrated SuDS. This includes runoff from major construction sites.

Supplementary Documents

2.2.2 The North East Local Plan District Local Flood Risk Management Plan 2022-2028 (Aberdeenshire Council 2022) provides actions to avoid and reduce the risk of flooding and prepare and protect communities within identified potentially vulnerable areas.

2.3 Climate Change

2.3.1 SEPA requires the consideration of the impacts of climate change on new development proposals. This is to ensure that future development can provide a safe and secure living and / or working environment throughout its lifetime. National planning policy requires proposals in area of high flood risk to be accompanied by an assessment of flooding consequences to and from the development, taking into account the impacts of climate change.

2.3.2 Climate change allowances considered by SEPA (SEPA, 2025) have been informed by the latest available information on climate change projections and different scenarios of carbon dioxide emissions to the atmosphere. Allowances are provided for different epochs (periods) of time over the next 100 years.

2.3.3 SEPA climate changes allowances are derived from UK Climate Projections 2018 (UKCP18) datasets for the year 2100 and are presented by River Basin Regions.

Peak River Flow

2.3.4 Peak river flow climate change allowances are applicable to the following:

- River catchments greater than 50 km^2 excluding catchments in Orkney and Shetland; and
- River catchments (excluding those in Orkney and Shetland) between 30 km^2 and 50 km^2 where the peak river flow uplift is greater than the flow increase resulting from using the peak rainfall intensity uplift.

2.3.5 The Study Area is located within the Tay River Basin Region and the peak river flow allowance for this region is 53%.

2.3.6 The SEPA future fluvial flood risk map accounts for a 35% increase in peak river flows in the Tay River Basin Region, based on the 2080's epoch high emissions scenario.

Peak Rainfall Intensity

2.3.7 Peak rainfall intensity climate change allowances are applicable to the following:

- River catchments smaller than 30 km^2;
- River catchments (excluding those in Orkney and Shetland) between 30 km^2 and 50 km^2 where the peak river flow uplift is smaller than the flow increase resulting from using the peak rainfall intensity uplift; and
- Surface water flooding.

2.3.8 The Study Area is located within the Tay River Basin Region and the peak rainfall intensity allowance for this region is 39%.

Sea Level Rise

2.3.9 SEPA expect sea level rise to increase over the coming decades due to the impacts of climate change, but to be partially offset by glacial rebound. The cumulative sea level rise from 2017 to 2100 is based on outputs from the UKCP18 projections.

2.3.10 Sea level rise is expected to increase the geographical extents at risk from tidal flooding. Between 2017 and 2100, 0.85 m of sea level rise is projected in the Tay River Basin Region.

2.3.11 Future coastal flood risk mapping accounts for a 0.85 m increase in sea level rise, based on the 2080's epoch high emissions scenario.

3 Environmental Setting

3.1 Site Description

3.1.1 The Study Area is situated in the north-east of Scotland within Aberdeenshire Council region.

3.1.2 The Landfall for the Offshore Export Cables is within the coastal area between Gourdon and Benholm in Haughs Bay. The Offshore Export Cables will be brought under the intertidal area using a trenchless technique to a location above MHWS where they will be connected to the Onshore Export Cables in TJBs. The Onshore Export Cable Corridor generally follows a north west direction over a distance of approximately 22 km towards the Substation. The Substation is located within Fetteresso Forest and is required to convert the voltage of the Onshore Export Cables to allow transmission and use of electricity in the National Grid. Once converted, the electricity will be transported within the 400 kV Cables within Fetteresso Forest up to a distance of approximately 2 km to connect to the proposed Hurlie Substation.

Topography

3.1.3 The Proposed Development ranges from sea level at the Landfall to 230 m above ordnance datum (AOD) at the 400 kV Cable Corridor and Substation location. The gradient within the PPP Application Boundary is variable from undulating towards the Landfall, with steeper slopes towards the Substation.

Land Cover

3.1.4 Primary land use from the Landfall to Elf Hill (220 m AOD) is agricultural with various existing roads, such as the A92 and A90. Elf Hill to the Substation is dominated by commercial forestry plantation.

Soils

3.1.5 The National soil map of Scotland (The James Hutton Institute 2022) indicates that much of the south and centre of the Study Area is underlain by brown earths (most with humus-iron podzols), with the north underlain by humus-iron podzols and peaty gleyed podzols. Small areas of noncalcareous gleys are found in the south and an area of alluvial soils is recorded in the centre.

3.1.6 The economic resource value of soil is primarily measured by its ability to support agricultural uses. This is quantified by its Land Capability for Agriculture (LCA) classification with seven grades defined (Soil Survey of Scotland Staff 1981) as follows:

- Class 1 (land capable of producing a very wide range of crops).
- Class 2 (land capable of producing a wide range of crops).
- Class 3 (land capable of producing a moderate range of crops).
- Class 4 (land capable of producing a narrow range of crops).
- Class 5 (land capable of use as improved grassland).
- Class 6 (land capable only of use as rough grazing).
- Class 7 (land of very limited agricultural value).

3.1.7 It is noted that "*Class 3 and 4 have two divisions based on increasing restrictions to arable cropping*" and "*Class 5 land has three divisions based on potential for successful reclamation and Class 6 three based upon the value of the existing vegetation for grazing purposes*" (Scotland's Environment 2024).

3.1.8 Class 1, 2, and 3.1 agricultural land are classified as prime agricultural land meaning that the land is the most flexible land in terms of the range of crops that can be grown, the level and consistency of yield and the cost of obtaining yield.

3.1.9 The LCA soil classifications across most of the Study Area in the south consist of LCA classes 3.1 and 3.2 with areas of class 4.1, 4.2, 5.1, 5.2 and 6.2 in the north. Class 5.1 soils underlie the Substation Search Area.

3.1.10 The carbon and peatland 2016 mapping classifies soils according to the following classes (The James Hutton Institute 2016):

- Class 1 (areas of peat soil and peatland habitats).
- Class 2 (areas dominated by peat soil and peatland habitats).
- Class 3 (dominant vegetation cover is not a priority peatland habitat but is associated with wet and acidic types. Occasional peatland habitats can be found. Most soils are carbon-rich soils, with some areas of deep peat).
- Class 4 (area unlikely to be associated with peatland habitats or wet and acidic type. Area unlikely to include carbon-rich soils).
- Class 5 (areas of high-carbon and deep soil but no peatland habitat recorded).
- Class 0 (area of mineral soil, i.e., no peat).
- Class -2 (non-soil e.g., loch, built up area, rock, and scree).
- Class -1 (unknown soil type).

3.1.11 The mapping indicates that the Study Area is predominantly underlain by class 0 (mineral) soils. A small area to the north of Drumlithie and the most northerly extents of the Study Area are underlain by Class 4 soils. Localised areas of Class 3 and Class 5 soils are present to the north of the Substation Search Area. The soils in the Substation Search Area consist of Class 4 soils which are "*unlikely to be associated with peatland or to include carbon-rich soils*".

3.2 Hydrology

3.2.1 The Proposed Development is situated across multiple catchments along the entirety of the Onshore Export Cable route; these are:

- Burn of Benholm (Waterbody ID: 23260);
- Bervie Water (ID: 23264);
- Carron Water (ID: 23257);
- Cowie Water – Fetteresso Forest (ID: 23254); and
- Forthie Water (ID: 23263).

3.2.2 The catchments are shown in Volume 1, Chapter 11: Water Quality and Flood Risk within Figure 11.3. An assessment of the hydrological characteristics of these catchments was carried out using data from the Flood Estimation Handbook (FEH) web service (UK Centre for Ecology & Hydrology 2025) with the catchment characteristics presented in Table 3.1.

Table 3.1: Overview of Watercourse Catchments

Catchment Name	Area (km^2)	Base Flow Index	Standard Percentage Runoff (%)	Standard Average Annual Rainfall (mm)
Burn of Benholm	10.93	0.534	42.87	770
Bervie Water (including Forthie Water)	132.36	0.555	40.33	882
Carron Water	42.82	0.581	37.15	869
Cowie Water – Fetteresso Forest	73.26	0.458	41.60	938

3.2.3 Base Flow Index (BFI) is a measure of the proportion of a catchments long-term runoff that derives from stored sources. The range of the BFI values derived indicate that just approximately 50% of the catchments long-term runoff is derived from stored sources. The Standard Percentage Runoff (SPR) represents the percentage of rainfall that is likely contribute to runoff. The SPR ranges indicate that around a third of the rain during a rainfall event would contribute to runoff. The BFI and SPR values indicate that the Proposed Development is likely located within catchments of relatively permeable geology with a mixture of surface water inputs and a baseflow component. The rainfall values of the catchments indicate that rainfall totals are lowest at the coast, with rainfall values increasing inland.

Climate

3.2.4 The Met Office 1991-2020 average annual rainfall total for Inverbervie No 2 Climate Station (134 m AOD) is 703.44 mm with 131.82 days of rainfall greater than 1 mm recorded (Met Office 2025). The Inverbervie No 2 Climate Station is positioned approximately 3 km east of the Proposed Development. The highest rainfall totals are typically experienced during the winter months and the lowest rainfall occurs in March with only 42.22 mm recorded.

Existing Drainage Infrastructure

3.2.5 The Proposed Development currently drains via natural overland flow and channels to existing watercourses and tributaries. However, modifications are evident, including straightened natural watercourses and a network of artificial drainage ditches serving agriculture and forestry. Existing roads and tracks feature additional drainage infrastructure, such as roadside ditches, field boundary drains, bridges over larger watercourses, and culverts at minor watercourses.

3.3 Hydrogeological Setting

3.3.1 The geological setting of the Study Area is outlined in the following sections from British Geological Survey (BGS) data (BGS, 2025).

Bedrock Geology

3.3.2 The bedrock geology is highly variable across the Study Area. The main bedrock bodies, from southeast to northwest comprise the following:

- Dunnottar-Crawton Group (interbedded conglomerate and sandstone).
- Arbuthnott-Garvock Group (sandstone with subordinate conglomerate, siltstone and mudstone).
- Unnamed extrusive rocks (lava and solidified volcanic ash).
- Strathmore Group (sandstone with subordinate conglomerate, siltstone and mudstone).
- Stonehaven Group (sandstone with subordinate conglomerate and siltstone).
- Highland Border Complex (Serpentinite, metabasalt, metalimestone)
- Southern Highland Group (metamorphosed mudstone).
- Southern Highland Group (metamorphosed mudstone and sandstone).
- Unnamed igneous intrusion.

3.3.3 The Southern Highland Group (metamorphosed mudstone and sandstone) underly the Substation Search Area.

Superficial Deposits

3.3.4 The Study Area is underlain by a number of different types of superficial deposits, these are summarised below.

3.3.5 Superficial deposits underlying much of the Study Area are recorded by the British Geological Survey (BGS) as Till. Narrow bands of alluvial deposits are mapped which align to surface watercourses and Raised Marine deposits are mapped beneath the Onshore Export Cable Corridor in the southeast of the Study Area. Other superficial deposits include Drumlithe Glacial and Glaciofluvial deposits and small pockets of peat.

Groundwater

3.3.6 Groundwater within superficial deposits underlying the Study Area is likely to be predominantly present within the Raised Marine Deposits of Holocene Age, Alluvium, the Drumlithie Sand and Gravel Member, the Lochton Sand and Gravel Member, the Devensian Raised Marine Deposits and the River Terrace Deposits. There is likely to be a high degree of connectivity between these deposits where contact exists.

3.3.7 Four SEPA identified bedrock aquifers are located within the Study Area:

- St Cyrus aquifer (moderate to very high productivity);
- Drumlithie aquifer (moderate to very high productivity);
- Stonehaven aquifer (moderate to very high productivity); and
- Portlethen aquifer (very low to low productivity).

3.3.8 There is a potential for there to be a connection between the bedrock aquifers and the water bearing superficial deposits. However, the presence of Glacial Till and cohesive layers, such as silt and clay, within the superficial deposits may act as barriers or aquitards between the bedrock aquifers and water bearing superficial deposits where present.

4 Flood Risk Classification

4.1 Methodology

4.1.1 The assessment has been carried out in accordance with NPF4 which requires that all risks of flooding are understood and addressed. Details are provided in Policy 22 of NPF4 that outlines the flood risk considerations for developments which includes the placement of development outside of future functional flood plain and consideration for managing runoff.

4.1.2 Flooding can be derived from the following sources:

- Rivers;
- Surface Water;
- Coastal;
- Groundwater; and
- Artificial Sources.

4.1.3 The SEPA Flood Maps (SEPA 2025a), present the likelihood of flooding from River, Surface Water and Coastal flooding sources are classified as the following:

- High – land assessed as having a 10% Annual Exceedance Probability (AEP) (1 in 10) of flooding each year;
- Medium – land assessed as having a 0.5% AEP (1 in 200) of flooding each year; and
- Low – land assessed as having a 0.1% AEP (1 in 1000) of flooding each year.

4.1.4 Also available on the SEPA Flood Maps (SEPA 2025a), the likelihood of future flooding for River, Surface Water and Small Watercourses and Coastal can be categorised as the following:

- River Medium Likelihood – By the 2080s, each year this area may have a 0.5% AEP of flooding;
- Surface Water and Small Watercourses Medium Likelihood – By the 2070s, each year this area may have a 0.5% AEP of flooding; and
- Coastal Medium Likelihood – By the 2080s, each year this area may have a 0.5% AEP of flooding.

4.2 Source of Flood Risk

Fluvial/River Flooding

4.2.1 The SEPA Flood Mapping (SEPA 2025a) identifies areas as being at risk from fluvial flooding within the Study Area are located along the channels of the main watercourses as shown in Figure 4.1 (Annex – Figures).

4.2.2 These watercourses include the Bervie Water, Carron Water, and Cowie Water. In addition, tributaries of these watercourses have also been identified as presenting fluvial flood risk which include the Forthie Water, Killer Burn, Burn of Annamuick, East Dumer Burn and Black Burn.

4.2.3 The risk associated with the watercourses ranges from low, medium and high likelihood of flooding each year. However, the extent of the low, medium and high risk is typically constrained to the channel extent.

4.2.4 The area associated with the Substation and the 400 kV Cable Corridor does not feature any risk of flooding associated with river flooding.

4.2.5 It should be noted that the SEPA Flood Mapping (SEPA 2025a) displays river flood risk for catchments greater than 3 km^2.

Pluvial/Surface Water Flooding

4.2.6 The SEPA Flood Mapping (SEPA 2025a) confirms that the surface water flood risk areas within the Study Area are primarily along the tributaries of the main watercourses as shown in Figure 4.2 (Annex – Figures).

4.2.7 There are also localised pockets of surface water flooding that may reflect topographical variations across the Study Area, with depressions in the land accumulating water during intense periods of rainfall.

4.2.8 The area associated with the Substation and 400 kV Cable Corridor features low, medium and high likelihood of surface water flooding with pockets of flooding being within commercial forestry plantation associated with topographical depressions and minor drainage channels.

4.2.9 It should be noted that the SEPA Flood Mapping (2025) includes surface water flooding for small watercourses with catchment areas less than 10 km^2. This results in some overlap with fluvial flooding data. To avoid repetition, where both types of flooding are present, the fluvial flooding data is considered the primary source of information.

Coastal Flooding

4.2.10 The SEPA Flood Mapping (SEPA 2025a) confirms coastal flood risk areas within the Study Area, and in particular the area associated with the Landfall as shown in Figure 4.3 (Annex – Figures).

4.2.11 The risk associated with the coastal flooding covers low, medium and high likelihood.

4.2.12 The area associated with the Onshore Export Cable, Substation and 400 kV Cable Corridor do not feature any risk of coastal flooding due to a combination of increasing distance from the coast and increasing elevation.

Groundwater Flooding

4.2.13 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) and intense or unusually lengthy storm events. Such flooding also often lasts much longer than flooding caused by a river over-flowing its banks.

4.2.14 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 Flood Map (SEPA 2025b) does not highlight any risk of groundwater flooding within the Study Area.

4.2.15 Groundwater flooding is often associated with the shallow unconsolidated sedimentary aquifers that overlay non-aquifers. Such aquifers are susceptible to flooding as the storage capacity with these deposits is often limited and direct rainfall recharge can be relatively high, subsequently increasing the water levels within the groundwater and providing a good hydraulic connection with adjacent river networks.

4.2.16 Based on the information presented above, it is considered that there is no risk of groundwater flooding.

Flooding from Artificial Sources

4.2.17 There are no artificial structures, i.e. canals and reservoirs upstream or downstream of the Study Area. Therefore, there is no associated risk of flooding.

4.2.18 A further factor which requires consideration is the risk of flooding associated with the failure of flood defences within the catchment that may expose protected receptors. The SEPA Flood Risk Management Map (SEPA 2025b) indicates that there is no existing flood defences present within the relevant catchments.

Historic Flooding

4.2.19 According to the SEPA Flood Risk Management Plan for the North East (SEPA 2021), Stonehaven is designated as a Potentially Vulnerable Area (PVA). The Stonehaven PVA (target area 419) encompasses an area east of the Substation and north east of Drumlithie covering the Carron and Cowie Water catchments.

4.2.20 Historic flooding is detailed within the Flood Risk Management Plan with the primary focus being on the town of Stonehaven. The town has suffered from major flooding from the River Carron and from the sea. River flooding was the main source of flooding and was exacerbated by surface water flooding. There is a long record of flooding in Stonehaven from the Carron Water and its tributary, the Glaslaw Burn from 1829 to 2012. The risk of flooding is to people, property, community facilities (Dunnottar School), utilities, the transport network (A90, A92, A957, Aberdeen to Dundee railway line), designated sites and agricultural land. The Stonehaven Flood Protection Scheme included the construction of walls, embankments, culverts and alteration to five bridges along the Carron Water (and tributaries) to protect the homes and businesses that were previously affected by flooding events around the lower River Carron (Aberdeenshire Council 2023b).

Future Flood Risk

Fluvial/River Flooding

4.2.21 The SEPA Flood Mapping (SEPA 2025a) confirms that the river flood risk areas within the Study Area are along the channels of the main watercourses. The risk

associated with the watercourse is of medium likelihood and identifies small additional pockets when compared to the present day layers. The Substation location does not feature any risk of flooding associated with future river flooding.

Pluvial/Surface Water Flooding

4.2.22 The SEPA Flood Mapping (SEPA 2025a) confirms that the surface water flood risk areas within the Study Area are primarily along the tributaries of the main watercourses. The risk associated with the surface water and small watercourses is of medium likelihood and identifies small additional pockets when compared to the present day layers. The Substation and 400 kV Cable Corridor features a medium likelihood of future surface water and small watercourses flooding associated with the drainage network contained within Fetteresso Forest.

Coastal

4.2.23 The SEPA Flood Mapping (SEPA 2025a) confirms coastal flood risk areas within the Study Area which are associated with the Landfall. The risk associated with the coastal flooding is of medium likelihood and extends slightly beyond that of the present day flood extents. The area associated with the Onshore Export Cable Corridor, Substation and 400 kV Cable Corridor do not feature any risk of future coastal flooding.

4.3 Initial Assessment

4.3.1 The results of the initial assessment for potential flood risk during construction to the Proposed Development are presented in Table 4.1. The initial assessment determines the need for further consideration and the justification. For this assessment, the Proposed Development has been split into two distinct elements: the Landfall and 220/275 kV Cable Corridor and the Substation and 400 kV Cable Corridor.

Table 4.1: Flood Risk during Construction

Sources of Flooding	Sensitivity	Further Consideration Required?	Justification
Landfall and Onshore Export Cable Corridor			
Fluvial/River	High	Yes	The Landfall and Onshore Export Cable Corridor feature areas of medium and high likelihood of river flooding.
Pluvial/Surface Water	High	Yes	The Landfall and Onshore Export Cable Corridor feature areas of medium and high likelihood of surface water flooding.
Coastal	High	Yes	At the Landfall, the Proposed Development features areas of medium and high likelihood of coastal flooding.

Sources of Flooding	Sensitivity	Further Consideration Required?	Justification
Groundwater	Negligible	No	There is no risk of groundwater flooding within the Landfall and Onshore Export Cable Corridor.
Artificial Sources	Negligible	No	There are no artificial sources or defences that may cause flooding in the event of failures.
Substation and 400 kV Cable Corridor			
Fluvial/River	Negligible	No	There is no risk of river flooding within the Substation and 400 kV Cable Corridor.
Pluvial/Surface Water	High	Yes	The Substation and 400 kV Cable Corridor features areas of medium and high likelihood of surface water flooding.
Coastal	Negligible	No	There is no risk of coastal flooding within the Substation and 400 kV Cable Corridor.
Groundwater	Negligible	No	There is no risk of groundwater flooding within the Substation and 400 kV Cable Corridor.
Artificial Sources	Negligible	No	There are no artificial sources or defences that may cause flooding in the event of failures.

4.3.2 Based on the results of the initial assessment, the Landfall and Onshore Export Cable Corridor requires further assessment due to the existing high and medium likelihood of flooding from river, surface water and coastal sources. The Substation and 400 kV Cable Corridor require further assessment due to the existing high and medium likelihood of flooding from surface water.

4.4 Flood Risk Management Measures

4.4.1 This section outlines the flood risk management measures for the Proposed Development. These measures will be further developed in a detailed FRDA post-consent. The FRDA will inform a site-specific Construction Environmental Management Plan (CEMP) (Mitigation reference GEN2), which will include a Detailed Drainage Strategy discussing the drainage approach and the implementation of SuDS. An outline of these flood risk management measures is provided in Volume 2, Appendix 2.2: Outline CEMP, which serves as a foundation for the more comprehensive strategies to be developed.

Landfall

4.4.2 The cable Landfall will be required to cross areas of coastal flood risk at the location.

4.4.3 At the Landfall, the cable will be installed through a trenchless installation technique from above the shoreline. Landfall construction operations will be

managed from locations set back from the shoreline to minimise exposure to flood risk.

4.4.4 While installation platforms will not be located in areas of identified coastal flooding, stormy weather may cause larger waves and significant spray that could be carried inland from the coast. To effectively manage this risk, the following measures will be implemented:

- Maintain a watching brief on weather forecasts, particularly during the winter months when storms events are more likely;
- If storms are forecast, operations will be paused where considered necessary;
- Any sensitive equipment and plant will be relocated to a safe area outside of any potential danger zone;
- All personnel will be trained in flood awareness and relocate to a safe area when severe weather is imminent; and
- A Flood Evacuation and Response Plan will be developed and communicated to all site personnel.

4.4.5 The Landfall area will be reinstated upon completion of construction activities. Any remaining infrastructure will be constructed to be flood-resilient in the event of storm events. Critical infrastructure will be designed to remain operational and accessible during extreme flood events, including those with a 0.1% annual probability (1 in 1,000-year flood).

Onshore Export Cable Corridor

4.4.6 Due to the nature of the works, the Onshore Export Cable Corridor will not require installation of long-term drainage infrastructure as the cables are considered to be flood-resilient infrastructure once buried and the ground is reinstated. However, construction activities will take place within areas of identified flood risk (i.e. Landfall and watercourse crossing points). Temporary storage of materials and any temporary buildings will be located outside of identified flood risk areas, including future flood extents, to minimise potential impacts.

4.4.7 The relevant flood risk management measures for these identified areas of flood risk are discussed below.

River Crossings

4.4.8 Crossings of the Bervie Water, Forthie Water and Carron Water are required and will be facilitated using HDD. These watercourses have flood risk areas associated within the main channel. The preferred approach will be for HDD platforms to be located outside of these flood risk areas on either side of the watercourse, minimising potential flood risk to personnel and associated equipment during the HDD process.

4.4.9 If works within flood risk areas are unavoidable, a robust monitoring system will be implemented. This will include regular checks of weather forecasts and any local river level gauges, with defined trigger levels for action. Operations within flood risk areas will be postponed and personnel and equipment

relocated to safe areas if these trigger levels are reached. This will be captured within a Flood Evacuation and Response Plan which will form part of the CEMP.

4.4.10 In addition to the major watercourse crossings, several smaller watercourse crossings will be required along the Onshore Export Cable route as detailed in Volume 2, Appendix 11.2: Schedule of Watercourse Crossings.

4.4.11 For all watercourse crossings, including those with identified surface water flood risk:

- Works will be planned to coincide with periods of typically lower flow where possible, based on long-term hydrological data;
- Temporary flood defences or pumping equipment will be deployed where necessary, based on site-specific risk assessments;
- Construction activities will be sequenced to minimise the duration of works within flood-sensitive areas;
- Stockpiles of materials will be located away from watercourses and areas of flood risk; and
- Weather forecasts will be monitored, with clearly defined protocols for stopping works and site evacuation in the event of flood warnings.

4.4.12 A Flood Evacuation and Response Plan will be prepared and communicated to all site personnel. This will detail safe areas to which staff should evacuate in the event of an incoming storm event or period of significant rainfall. All personnel working in flood risk areas will receive specific training on flood awareness and emergency procedures as part of their site induction.

Substation and 400 kV Cable Corridor

4.4.13 The Substation and 400 kV Cable Corridor features localised pockets of flood risk associated with surface water sources, primarily linked to manmade drainage ditches for the plantation forestry. The design of the Substation will take into account the potential risk of surface water flooding, with the Substation being categorised as ‘Essential Infrastructure’.

4.4.14 The design of the Substation will include a permanent impermeable paved area approximating 13 ha. To account for this increase in impermeable area, a surface water drainage system will be designed to manage increased runoff volumes. A preliminary surface water storage estimation using the UK SuDS tool (HR Wallingford 2025) has been undertaken, see Section 5.

4.4.15 The design of the Substation will include:

- A detailed assessment of surface water flow paths and potential ponding areas;
- Implementation of SuDS measures (i.e. settlement and storage ponds) to manage and treat surface water runoff;
- Appropriate sizing and positioning of drainage infrastructure to accommodate predicted rainfall events, including allowances for climate change; and

- Consideration of ground levels and landscaping to direct surface water away from critical infrastructure.

4.4.16 A finalised detailed design will be produced as part of detailed design phase, however an Outline Drainage Strategy is presented in Section 5.4, which provides preliminary information on the proposed surface water management approach.

4.4.17 During construction, temporary storage areas and buildings will be located outside of identified current and future flood risk zones to reduce potential flood impacts. In addition, temporary drainage measures will be implemented to manage surface water runoff and prevent ponding in work areas. All construction activities will adhere to good practice guidelines for working in areas with surface water flood risk.

4.5 Land Use Vulnerability and Flood Risk

4.5.1 The Bowdun Offshore Wind Farm comprises the offshore and onshore infrastructure required to generate and transmit electricity from the Array Area to the onshore Grid Connection Point at the proposed Hurlie Substation.

4.5.2 The SEPA Flood Risk and Land Use Guidance (SEPA 2024a) is used to define development classification in regards to flood risk and has been used to assess that the Project falls within the development classification of 'Essential Infrastructure' which includes "all forms of renewable, low-carbon and zero emission technologies for electricity generation and distribution and transmission electricity grid networks and primary sub stations".

4.5.3 As defined in NPF4 Policy 22, 'Development proposals at risk of flooding or in a flood risk area will only be supported if they are for:

- Essential infrastructure where the location is required for operational reasons.
- Water compatible uses.
- Redevelopment of an existing building or site for an equal or less vulnerable use, or
- Redevelopment of previously used sites in built up areas where the Local Development Plan has identified a need to bring these into positive use and where proposals demonstrate that long-term safety and resilience can be secured in accordance with relevant SEPA advice.

4.5.4 The location of the Onshore Export Cable Corridor, Substation and 400 kV Cable Corridor are defined by the requirement to connect the fixed location of the generation assets to the proposed Hurlie Substation. The location of the Landfall and the Onshore Export Cable Corridor have been considered in terms of environmental, community and consenting considerations. For more information, see Volume 1, Chapter 5: Site Selection and Reasonable Alternatives Considered.

4.5.5 The Onshore Export Cable Corridor, and 400 kV Cable Corridor will pass through areas identified as 'low' to 'high' risk of flooding. Impacts to flood risk associated with these cable routes will be temporary in nature arising as a

result of cable installation during the construction phase. These impacts are to be mitigated through the implementation of the detailed CEMP and associated management plans.

4.5.6 Following installation of the cables, the land will be reinstated, and the only permanent elements along the cable corridor will be cable joint bay and link box covers. Surface water runoff from these elements of the Proposed Development will be minimal and flows will be absorbed by the surrounding ground. As a result, there is no potential for significant operational runoff associated with the Landfall, Onshore Export Cable Corridor and 400 kV Cable Corridor.

4.5.7 Aside from the aforementioned cable joint bays and link boxes, the only permanent above ground development associated with the Proposed Development is the Substation. The Substation will be served by an operational drainage strategy which will ensure that surface water flows arising from impermeable areas will be discharged from site at the greenfield runoff rate. An outline version of the operational drainage strategy is provided in Section 5 of this report.

4.5.8 Given the level of flood risk posed to the Proposed Development, and the requirement of its location, the Proposed Development is considered to be acceptable in line with NPF4.

4.6 Flood Risk Assessment Summary

4.6.1 Through the review of existing baseline flood risk data, an initial assessment identified the risk of flooding through various sources within the Study Area. The risk was considered to be high due to the presence of areas considered to be high likelihood with a 10% (1 in 10) and medium likelihood 0.5% (1 in 200) chance of flooding each year.

4.6.2 The assessment of significance for each source of flooding identified is provided in Volume 1, Chapter 11: Water Quality and Flood Risk (Section 11.10).

4.6.3 The primary flood risks to the Proposed Development are from river, surface water and coastal sources along the Cable Corridor and at the Landfall. The Substation Search Area is primarily at risk from surface water flooding. These risks have been carefully considered in the design and planning of the Proposed Development, with appropriate mitigation and management measures as outlined in Section 4.4 and Chapter 11: Water Quality and Flood Risk (Section 11.9).

4.6.4 The Proposed Development, once operational, is not expected to significantly increase flood risk to surrounding areas. The buried cable infrastructure will not alter existing surface water flow pathways. For the Substation, the increase in impermeable area will be managed through appropriate surface water drainage systems and SuDS measures, ensuring that runoff rates and volumes do not exceed pre-development levels.

4.6.5 In summary, when considering the level of works required for the Proposed Development and the assumption of successful implementation of flood risk

management measures and the commitment of a detailed design strategy, it can be concluded that the effects of the Proposed Development are not significant.

5 Drainage Assessment

5.1 Introduction

5.1.1 This section details the existing drainage conditions for the Substation location and provides an outline drainage strategy with the objective being to maintain site runoff within the catchment and mimic natural flow conditions. The drainage considerations for the Onshore Export Cable Corridor are addressed separately in Paragraphs 5.4.14 - 5.4.16.

5.2 Existing Drainage

5.2.1 The Substation location is situated within existing commercial forestry plantation. This land use will feature an existing drainage system comprising of artificial drainage ditches with furrows between tree rows.

5.2.2 The existing drainage, owing the topography of the catchment flows generally to the north east towards the Burn of Day.

5.3 Greenfield Runoff Estimation

5.3.1 The greenfield runoff rates have been estimated using the Greenfield Runoff Rate Estimation Tool (HR Wallingford 2025) for the Substation location and are shown in Table 5.1 below. The Greenfield Runoff Rate Estimation tool gives estimated greenfield runoff rates for a site for the for the 1:1 year, 1:30 year, 1:100 year and 1:200 year plus climate change return periods. It also provides an estimation of Qbar which is the mean annual maximum flow rate (HR Wallingford 2025).

Table 5.1 Greenfield Runoff Rate Estimates

Site Area (ha)	Estimated Greenfield Runoff (l/s) for Stated Return Periods				
	QBAR	1	30	100	200+CC
24	58.5	49.8	114.1	145.2	227.7
per ha	2.4	2.1	4.8	6.1	9.5

5.3.2 The greenfield runoff rate has been estimated for the Substation location is 58.5 l/s or 10.5 l/s/ha using the IH124 method.

5.3.3 The generated report output from the Greenfield Runoff Rate Estimation Tool (HR Wallingford 2025) for the Substation location has been provided in Annex A.

5.4 Outline Drainage Strategy

Sustainable Drainage Systems

5.4.1 In accordance with the SuDS Manual – C753F (CIRIA 2015), a hierarchical approach to surface water management is as follows:

- **Prevention** – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution;
- **Source Control** – control of runoff or very near the source; and

- **Site Control** – management of runoff from several sites, typically in a retention pond or wetland.

5.4.2 With regards to surface water disposal, the following options should also be considered:

- Infiltration to ground;
- Discharge to surface waters; and
- Discharge to sewer.

5.4.3 Based on the Substation location and the impact on the existing drainage patterns associated with the current land use, it is likely that infiltration to ground or discharge to surface waters will be suitable for surface water disposal. The nature of the Substation location means that it is highly unlikely that sewers are located nearby and does not serve as a viable discharge option.

5.4.4 Therefore, it is proposed that the surface water runoff should be managed by appropriate and proportionate SuDS measures which seek to provide surface water runoff, soil erosion control and attenuation across the Substation Search Area. These measures are as follows:

- Swales and filter strips;
- Filter drains;
- Check dams;
- Silt fences and straw bales;
- Settlement ponds;
- Sumps; and
- Permeable paving.

Substation

5.4.5 During the construction phase, the Substation will require temporary drainage infrastructure utilising the SuDS measures discussed previously.

5.4.6 Implementation of these SuDS measures should occur in advance of construction to ensure that potential impacts derived from construction activities are mitigated appropriately. Excavations will be designed and constructed with a slight gradient to encourage runoff to enter settlement ponds that will encourage infiltration into vegetated areas.

5.4.7 For any associated access tracks, trackside drainage will be implemented with cross-drains under the tracks to ensure that natural drainage patterns are mimicked where practicable and will comply with Forestry and Land Scotland requirements.

5.4.8 In terms of long-term drainage measures, the Substation design will implement drains around the perimeter to divert surface water and flooding away from the Substation. This would also be through SuDS and will implement measures such as swales and filter drains.

5.4.9 As the Substation will result in an increase of impermeable area, attenuation storage will be required through attenuation ponds. The location of these ponds

will be determined post-consent during detailed design. The outfall of attenuation ponds should return to existing hydrological regime.

5.4.10 If appropriate, it may be practical to utilise permeable paving to manage surface water runoff and encourage infiltration, however this will be determined post-consent as part of detailed design.

5.4.11 Drainage implemented during the construction phases should incorporate long-term drainage as SuDS measures will still be effective during the operational phase.

5.4.12 A monitoring and maintenance program will be established that will involve regular inspections of the drainage infrastructure to ensure that blockages, debris or damage is not present that will impede flow and effectiveness. Maintenance should be undertaken immediately when an issue is identified.

5.4.13 As a result of this monitoring and maintenance program, the drainage infrastructure utilised during construction and operation may be used during decommissioning phase.

Landfall, Onshore Export Cable Corridor and 400 kV Cable Corridor

5.4.14 During the construction phase of the Landfall, Onshore Export Cable Corridor and 400 kV Cable Corridor, it is expected that temporary drainage infrastructure will be required. These measures will be installed as necessary and will include the following:

- Temporary cut-off ditches;
    - Check dams may also be implemented to reduce runoff velocity and reduce erosion and allow sediments to settle;
- Silt fencing;
- Settlement ponds;
- Geotextile silt matting to protect bare soils; and
- Soil bunds to divert clean water away from excavations and stripped ground.

5.4.15 These surface water and sediment management measures will be removed and natural ground conditions fully reinstated at the end of the construction phase.

5.4.16 Details relating to the temporary drainage will form part of the detailed design post-consent.

Mitigation Proposals and Consultation

5.4.17 The outline drainage strategy presented above provides a framework for managing surface water and mitigating potential impacts. However, site specific mitigation proposals will be developed and refined through consultation with SEPA. This collaborative approach ensures that all drainage measures align with local regulations and good practice for flood risk management and environmental protection.

5.4.18 As part of the ongoing design process, drawings will be created post-consent to support refinement to this section of the document. These will include:

- Layout of SuDS features within the PPP Application Boundary;
- Sizing of attenuation ponds based on estimated runoff volumes;
- Cross-sections of swales, filter drains, and other key SuDS components; and
- Schematic representation of how the drainage system integrates with the existing hydrological regime.

6 Conclusion

6.1.1 This Flood Risk and Drainage Assessment has been undertaken to support the PPP for the Proposed Development. In accordance with current planning policy and guidance, an assessment of flood risk from all sources has been carried out. The assessment confirms that there are no significant effects of flooding, assuming the implementation of embedded mitigation measures relating to flood risk.

6.1.2 The drainage assessment has established baseline conditions and an outline drainage strategy to manage and attenuate runoff from the proposed infrastructure. This focuses on the Substation location throughout construction, O&M and decommissioning. Consideration has also been given to the construction phase requirements to manage runoff from the Landfall, Onshore Export Cable Corridor and 400 kV Cable Corridor.

6.1.3 The primary approach for managing surface water and sediment will be through SuDS measures. However, a final drainage design and layout will be prepared as part of detailed design phase post-consent.

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ANNEX A. GREENFIELD RUNOFF RATE ESTIMATION

A1 Report generated for the Substation

hr wallingford

Greenfield runoff rate estimation tool

www.uksuds.com | Greenfield runoff rate estimation tool (https://www.uksuds.com/)

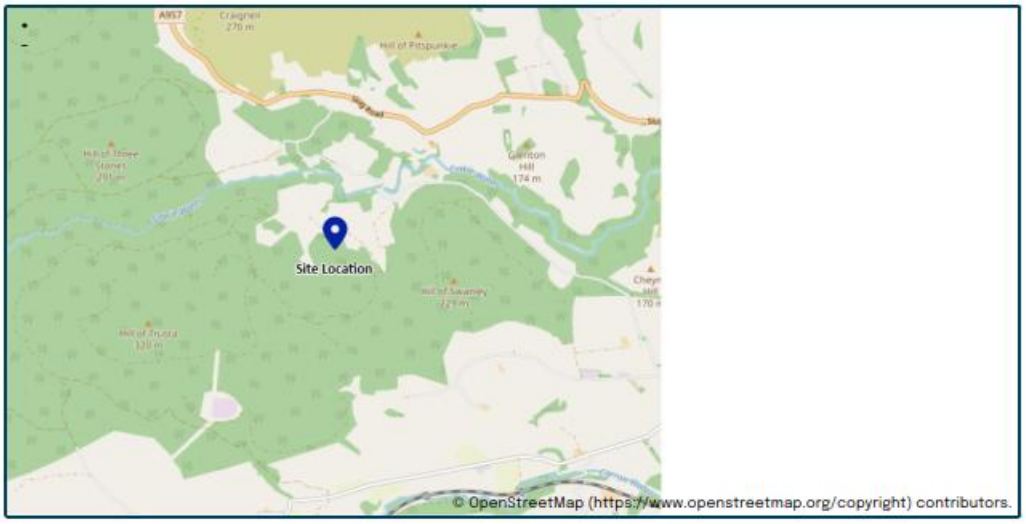
This is an estimation of the greenfield runoff rates that are used to meet normal best practice criteria in line with Environment Agency guidance "Rainfall runoff management for developments", SC030219 (2013), the SuDS Manual C753 (CIRIA, 2015) and the non-statutory standards for SuDS (Defra, 2015). This information on greenfield runoff rates may be the basis for setting consents for the drainage of surface water runoff from sites.

Project details

Date	08/08/2025
Calculated by	EB
Reference	A1
Model version	2.1.2

Location

Site name	Bowdun
Site location	Aberdeenshire



Site easting (British National Grid)	380161
Site northing (British National Grid)	787483

Site details

Total site area (ha)	24 ha

Greenfield runoff

Method

Method	IH124

IH124

	My value		Map value
SAAR (mm)	898 mm		898
How should SPR be derived?	WRAP soil type		
WRAP soil type	2		2
SPR	0.3		
QBar (IH124) (l/s)	58.54 l/s		

Growth curve factors

	My value		Map value
Hydrological region	1		1
1 year growth factor	0.85		
2 year growth factor	0.9		
10 year growth factor	1.45		
30 year growth factor	1.95		
100 year growth factor	2.48		
200 year growth factor	2.84		

Results

Method	IH124
Flow rate 1 year (l/s)	49.8 l/s
Flow rate 2 year (l/s)	52.7 l/s
Flow rate 10 years (l/s)	84.9 l/s
Flow rate 30 years (l/s)	114.1 l/s
Flow rate 100 years (l/s)	145.2 l/s
Flow rate 200 years (l/s)	166.2 l/s

Please note runoff estimation is subject to significant uncertainty. Results are therefore normally reported to only 1 decimal place. Where 2 decimal places are provided, this does not indicate accuracy to this level, it has been adopted to prevent 'zero' figures from being reported. Outputs less than 0.01 l/s are reported as 0.01 l/s.

Disclaimer

This report was produced using the Greenfield runoff rate estimation tool (2.1.2) developed by HR Wallingford and available at uksuds.com (https://www.uksuds.com/). The use of this tool is subject to the UK SuDS terms and conditions and licence agreement, which can both be found at uksuds.com/terms-conditions (https://www.uksuds.com/terms-conditions). The outputs from this tool have been used to estimate Greenfield runoff rates. The use of these results is the responsibility of the users of this tool. No liability will be accepted by HR Wallingford, the Environment Agency, Centre for Ecology and Hydrology, Wallingford Hydrosolutions or any other organisation for the use of these data in the design or operational characteristics of any drainage scheme.

Annex – Figures