Offshore Wind Power Limited

West of Orkney Windfarm Onshore EIA Report

Volume 2, Supporting Study 3: Flood Risk and Drainage Assessment

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West of Orkney Windfarm

Offshore Wind Power Limited

West of Orkney Windfarm: Flood Risk and Drainage Assessment, Incorporating an Outline Drainage Strategy

Supporting Study 3

2760759-P8.3(04)

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1 INTRODUCTION

1.1 This report provides a Flood Risk and Drainage Assessment, incorporating an Outline Drainage Strategy, for West of Orkney Windfarm and associated onshore Project infrastructure (hereafter referred to as the onshore Project) and associated development infrastructure. A final Drainage Strategy and Flood Risk Plan will be developed post consent and provided within the final Construction Environmental Management Plan (CEMP).

1.2 The report forms a supporting study to the Onshore Environmental Impact Assessment (EIA) Report for the onshore Project and should be read in conjunction with this document. It has been produced to address the requirement for new drainage infrastructure for the onshore Project.

1.3 For the purposes of this document, the onshore study area is considered to be the onshore Project area plus a buffer zone of 2 km (Figure 3.1). Areas downstream to the Caithness coast are also considered as, in some instances, effects can be transmitted downstream for greater distances than 2 km. The onshore export cables will be buried as construction progresses and therefore are not anticipated to impact drainage in a significant way, as all temporary drainage infrastructure required during construction will be fully reinstated at the end of the construction stage.

1.4 This document primarily focuses on the onshore substation search area as this constitutes the only long-term proposed flood-sensitive infrastructure. However, drainage issues related to the construction stage of the onshore export cables, and the risks from coastal flooding to the landfall locations during the construction stage, are also considered in this report.

Flood risk assessment

1.5 Certain elements of the onshore Project have potential to be affected by flooding. Notable flood risk is present at the proposed landfall locations and associated with various watercourses within the onshore Project area. Long-term flood risk will require to be considered in relation to the onshore substation and its detailed design.

Drainage impact assessment

1.6 This document assesses how the onshore substation may affect the existing drainage system within the onshore substation search area, from both a water quality and water quantity perspective. This assessment identifies any potential drainage issues, as well as appropriate mitigation measures to address these issues. This will ensure that drainage infrastructure is suitable for the onshore substation development and keep changes to the natural drainage to a practical minimum.

1.7 Considerations that need to be taken into account for installation of construction-stage drainage for the onshore export cables will also be outlined, to ensure that drainage is

managed appropriately to minimise risks to construction and potential flood risk in areas downstream.

Regulatory background

1.8 Under the terms of the *Water Environment (Controlled Activities) (Scotland) Regulations 2011* as amended (known as CAR), it is an offence to undertake the following activities without an appropriate authorisation in place:

- Discharge to any wetland, surface water or groundwater;
- Disposal of waste water or effluent to land;
- Abstraction from any wetland, surface water or groundwater;
- Impoundment (dam or weir) of any river, loch, wetland or transitional water; and
- Engineering works in any inland water or wetland.

1.9 With respect to drainage infrastructure, any formal discharge to water or to land may require authorisation. The developer has a duty to manage water within the onshore study area and discharge water outwith the onshore study area in a compliant manner. The drainage strategy provided here will establish the design requirements in order to manage construction stage and post-construction water flows within and deriving from the onshore substation and the wider onshore Project.

1.10 This report is produced in compliance with the requirements of The Highland Council (THC) in their document 'Supplementary Guidance: Flood Risk and Drainage Impact Assessment' (2013) and the Sustainable Urban Drainage Scottish Working Party's 'Water Assessment and Drainage Assessment Guide' (SUDSWP, 2016) and is in line with current best practice.

Development proposals

1.11 The onshore Project infrastructure will include:

- Landfall – the locations at Greeny Geo and Crosskirk where the offshore export cables will be brought ashore. One or both options may be utilised. The temporary working area for the construction compound at each landfall is expected to be 22,500 m^2.
- Onshore export cables – five onshore export cables will be buried underground in separate trenches, with each onshore export cable comprising of three separate power cables and a one fibre optic communications cable. Each onshore export cable will be up to 33 km across a working corridor width of up to 100 m. The total working corridor area is 3,300,000 m^2. Temporary laydown compounds of 100 m x 100 m will be placed along the route every 2 km.
- Onshore substation – contains the electrical components for transforming the power supplied from the Project via the export cables to meet the export requirements. The full size of development area (including substation screening, Sustainable Drainage Systems (SuDS) and bunding) is 239,200 m^2. During construction, the temporary construction compound (22,500 m^2), site office and car park (40,000 m^2) will total 62,500 m^2.
- Temporary access tracks (not including haul roads) up to 3,300 m in length at the landfall, the entry and exit points of the horizontal directional drilling (HDD) points and the onshore substation. Lengths are indicative only.

- It is anticipated that up to six new permanent access tracks will be required for HDD sites and one permanent access track will be required at the onshore substation. This consists of approximately 5 km in length of permanent access tracks. 24% (1.2 km) are existing tracks, 44% (2.21 km) are existing tracks that require improvements and 33% (1.67 km) will be newly installed tracks.

1.12 Full details of the onshore Project design are provided in chapter 5: Project description of the Onshore EIA Report. As detailed in Figure 3.1, buffers around the onshore Project area appropriate to individual effects are used to assess impact. The onshore study area for geology and hydrology is the onshore Project area plus a buffer zone of 2 km (Figure 3.1). The onshore study area for GWDTE is the onshore Project area plus a buffer zone of 250 m (Figure 3.1). The onshore study area for considering potential effects on water resources, including Private Water Supplies (PWS) and waterbodies is the onshore Project area plus a buffer zone of 5 km (Figure 3.1).

1.13 The final onshore export cable route and onshore substation location will be defined during the detailed design stage, post-consent.

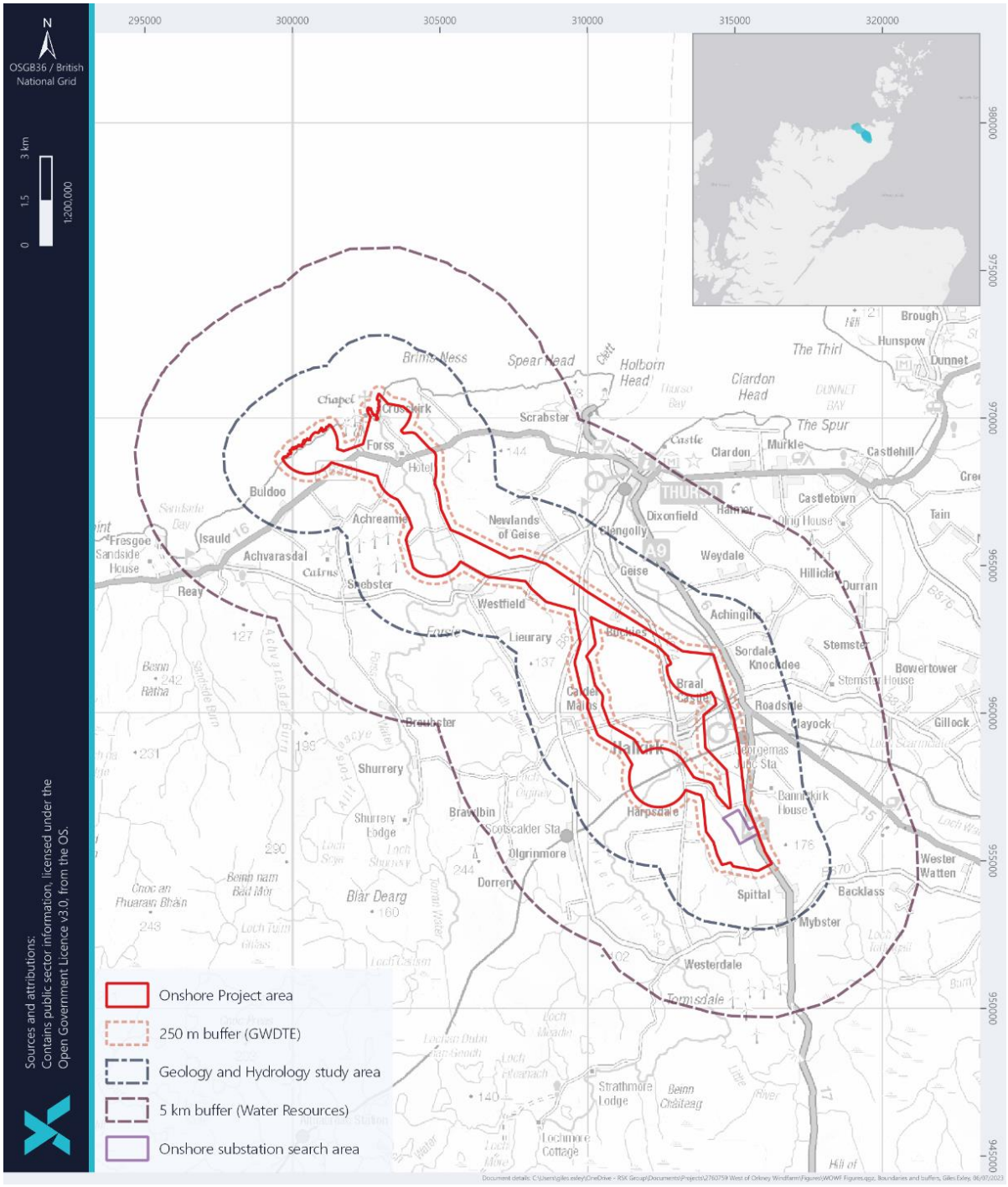

Figure 3.1 Onshore Project area and buffers for study areas

2 DRAINAGE CHARACTERISTICS

2.1 This section of the document outlines the existing drainage characteristics of the onshore Project area, and the wider onshore study area in order to determine a baseline against which to assess changes to the drainage regime. Natural drainage characteristics are determined by topography, existing drainage features and natural catchment areas, rainfall characteristics, current land use and any existing drainage infrastructure within the onshore study area and wider onshore Project.

Site topography

2.2 The onshore Project area lies on relatively low ground, with elevations ranging from sea level to around 115 m above Ordnance Datum (AOD). The lowest point within the onshore Project area is at the eastern landfall near Crosskirk, where Forss Water meets the sea. The highest point within the onshore Project area is to the west of Spittal Hill, at the southern extent of the onshore export cable corridor.

2.3 The two landfall locations are both characterised by rocky shorelines and low cliffs of around 10-20 m in height. Inland, the topography is characterised by low-lying rolling hills and valleys. Steeper slopes are present within the Forss Water valley, on both sides of the river, and in the eastern part of the onshore export cable corridor along the side of Buckies Hill. The southern part of the onshore export cable corridor, near and to the south of Halkirk, is nearly flat in nature.

2.4 The onshore substation search area of search has an elevation that ranges from around 60 m to 95 m AOD. The elevation of the indicative substation location ranges from 65 m AOD to 85 m AOD. The slope aspect of the site is predominantly north-west, sloping down to the Burn of Achanarras.

2.5 The onshore substation search area is bounded by Spittal Hill (176 m AOD) to the south-east, and Achanarras Hill (115 m AOD) to the south-west. North of the onshore substation area, the surrounding landscape is flat or gently sloping along the Burn of Achanarras and Burn of Halkirk valleys.

Existing drainage and natural catchments

2.6 The onshore Project area lies within five catchments: the River Thurso, the Forss Water, the Burn of Brims, Thurso Coastal between Forss Water and Dounreay Burn, and Thurso Coastal between Burnside Burn and Forss Water. Catchments are shown on Figure 3.2 and details are provided in Table 3.1.

2.7 The onshore substation search area is entirely within one catchment, the River Thurso (CEH, 2022).

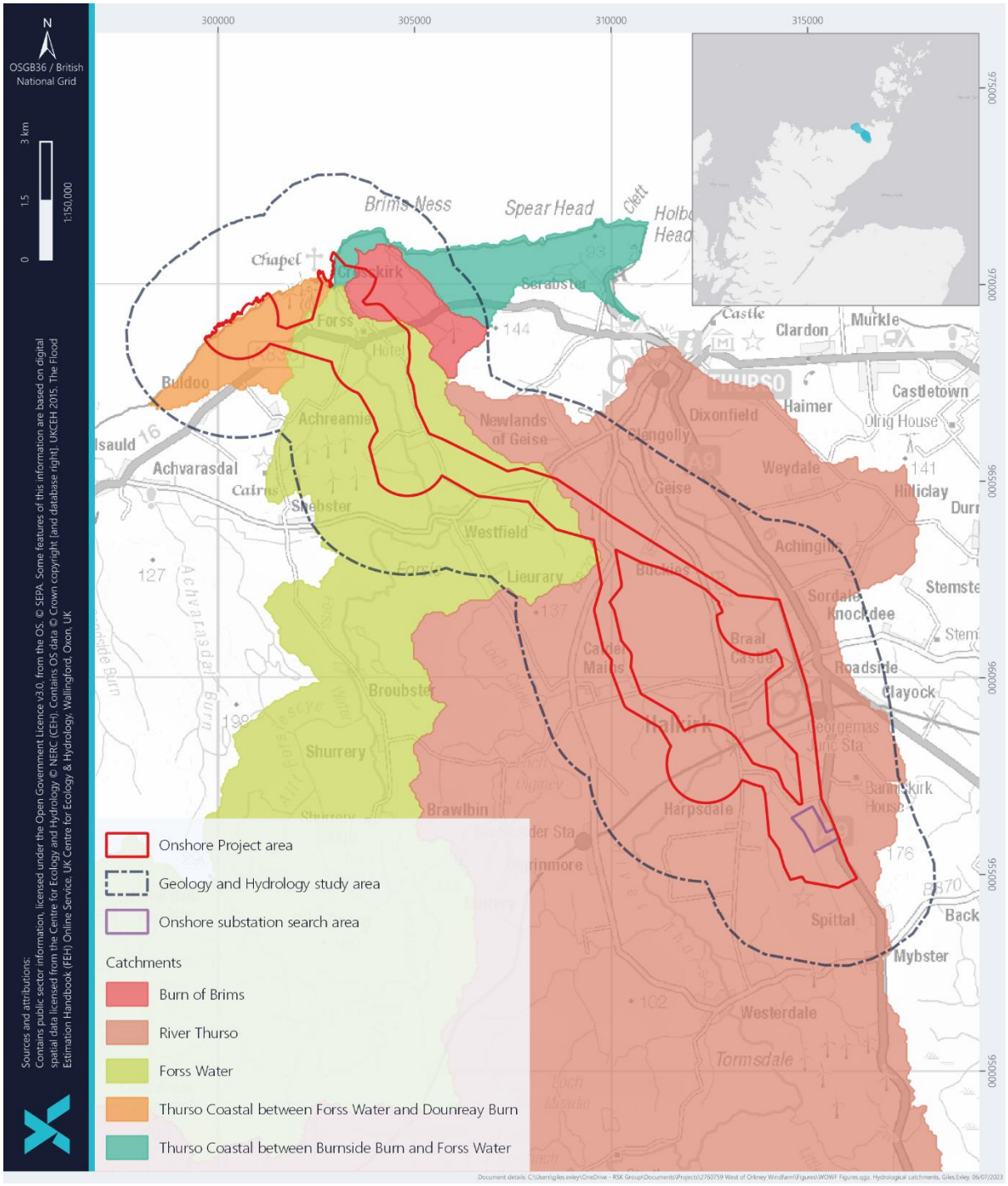

Figure 3.2 Hydrological catchments in the vicinity of the onshore Project area (CEH, 2022)

Table 3.1 Overview of watercourse catchment areas within the onshore Project area (CEH, 2022)

Catchment name	PROPWET	BFI HOST19	SPR HOST	% of onshore Project area
River Thurso	0.56	0.317	52.85%	53.5
Forss Water	0.54	0.319	51.46%	36.3
Burn of Brims	0.50	0.339	39.21%	2.4
Thurso Coastal between Forss Water and Dounreay Burn	N/A[1]			6.8
Thurso Coastal between Burnside Burn and Forss Water	N/A[2]			1.0

Rainfall characteristics

2.8 A review of the watercourse catchment and rainfall characteristics was undertaken using data from the Flood Estimation Handbook (FEH) web service (CEH, 2022). Catchment statistics have been provided for the River Thurso catchment.

2.9 Standard average annual rainfall (SAAR) for the River Thurso catchment is 1,040 mm. This value is considered to be representative of the entire onshore substation area and therefore will be used for calculations in Section 3 below.

Catchment land use

2.10 Land use in the River Thurso catchment is predominantly rural land. Rural land uses include improved grassland, shrub and coniferous woodland. The upper catchment around Halkirk is mainly sheep farming.

2.11 The Scottish Hydro Electric Transmission Limited (SHET-L) substation at Spittal is located immediately south-east of the onshore substation search area. This substation has involved considerable groundworks to form a flat platform area, and includes a settlement and attenuation pond plus area of rough grassland between the substation platform and the Burn of Achanarras.

[1] This information is not publicly available because the watercourse is too small to model with sufficient accuracy for the data to be useful.

[2] *Ibid*

Existing drainage infrastructure

Waste water

2.12 There is no existing waste water infrastructure, either foul drainage or surface water drainage, present within the onshore substation search area.

Surface water

2.13 The onshore Project area currently drains naturally via overland flow and natural channels to the existing watercourses in and around the area, principally the River Thurso and the Forss Water and their tributaries.

2.14 Modification to the natural drainage systems is widespread and there is evidence that several natural watercourse channels have been modified and straightened to improve drainage. In addition, a considerable network of artificial drainage ditches have been installed, primarily to provide drainage for agriculture and, in some cases, for forestry.

2.15 Some artificial surface drainage infrastructure is also associated with the existing roads, tracks and railway throughout the onshore Project area. This drainage infrastructure includes ditches beside tracks and along field boundaries, bridges across larger watercourses, culverts at minor watercourses and field drains. The drainage infrastructure is largely in good condition.

2.16 The onshore substation search area is bounded to the south-west by the Burn of Achanarras, a tributary to the River Thurso. Within the area of search, a number of drainage ditches and field drains are indicated, mainly along field boundaries, and forming an irregular grid pattern. Principal drainage directions are to the north-west and to the south-west.

Water resources

Drinking water protected areas

2.17 The onshore Project area passes through a surface water Drinking Water Protected Area (DWPA), which comprises part of the catchment of the River Thurso and the river itself (Figure 3.3).

2.18 A small area of both Loch Calder and the Loch Calder catchment surface water DWPAs are in the onshore study area, however, these protected areas are located upstream from the onshore Project area and would be unaffected by the development (Figure 3.3).

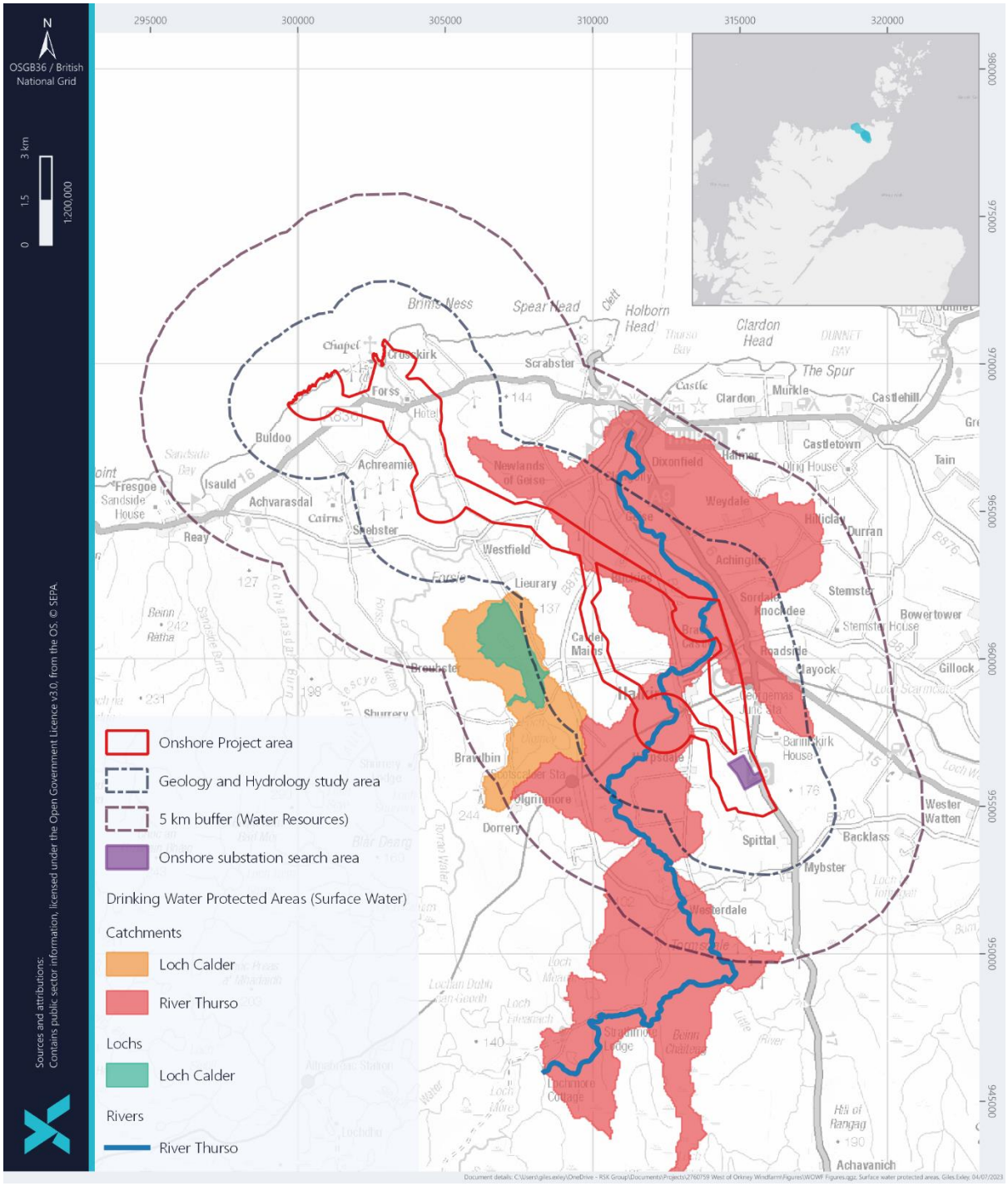

Figure 3.3 Surface water Drinking Water Protected Areas in the vicinity of the onshore study area (Scottish Government, 2014)

2.19 The onshore study area is primarily located in the Caithness groundwater DWPA, with the exception of the landfall at Greeny Geo, which is located in the Dounreay groundwater DWPA (Figure 3.4).

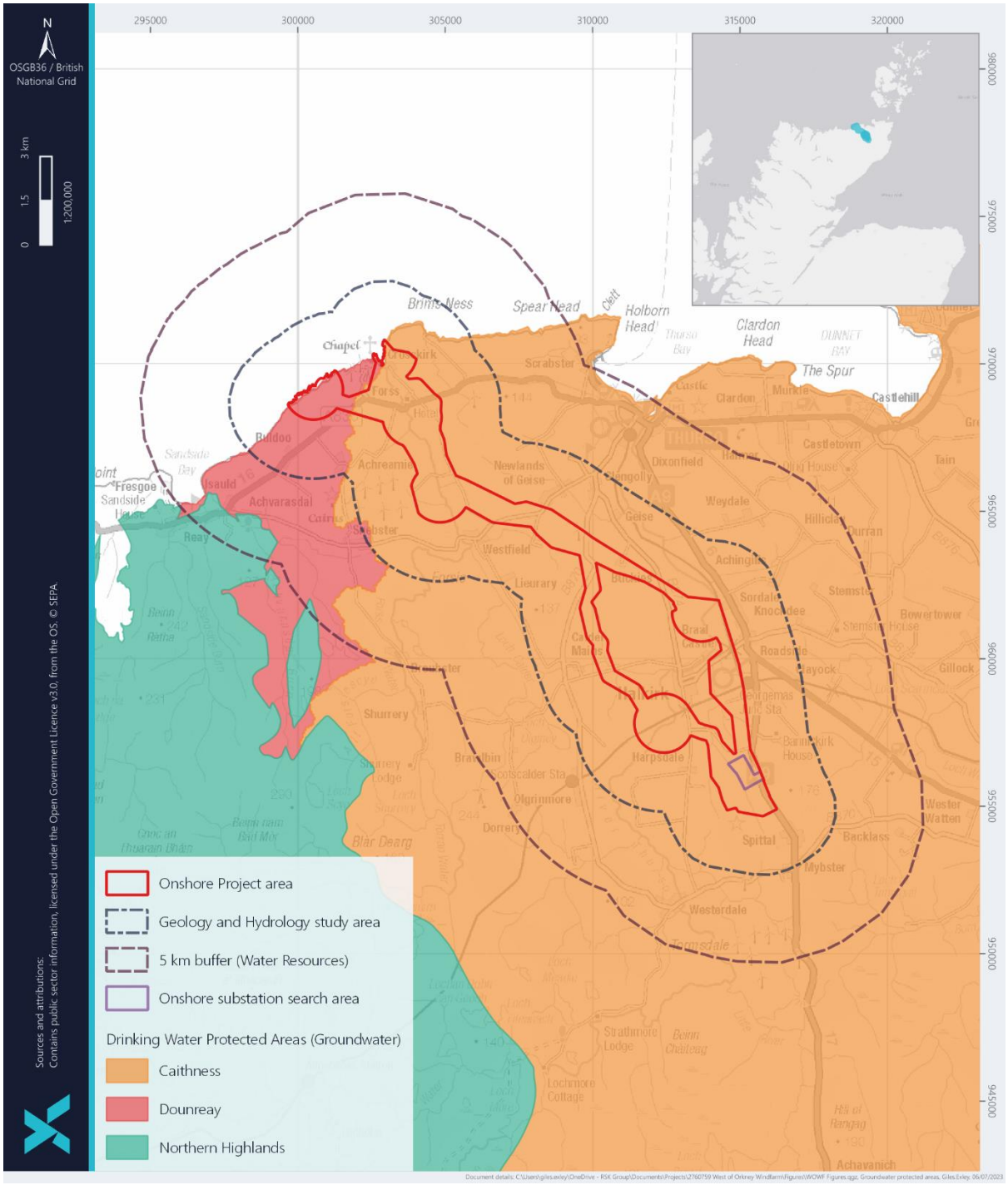

Figure 3.4 Groundwater water Drinking Water Protected Areas in the vicinity of the onshore study area (Scottish Government, 2014)

Private water supplies

2.20 A number of PWS have been identified within and surrounding the onshore Project area (Figure 3.5). Information in this section has been provided by THC; their records confirm that there are two PWS within the onshore Project area and 12 registered PWS within 5 km of the onshore Project area.

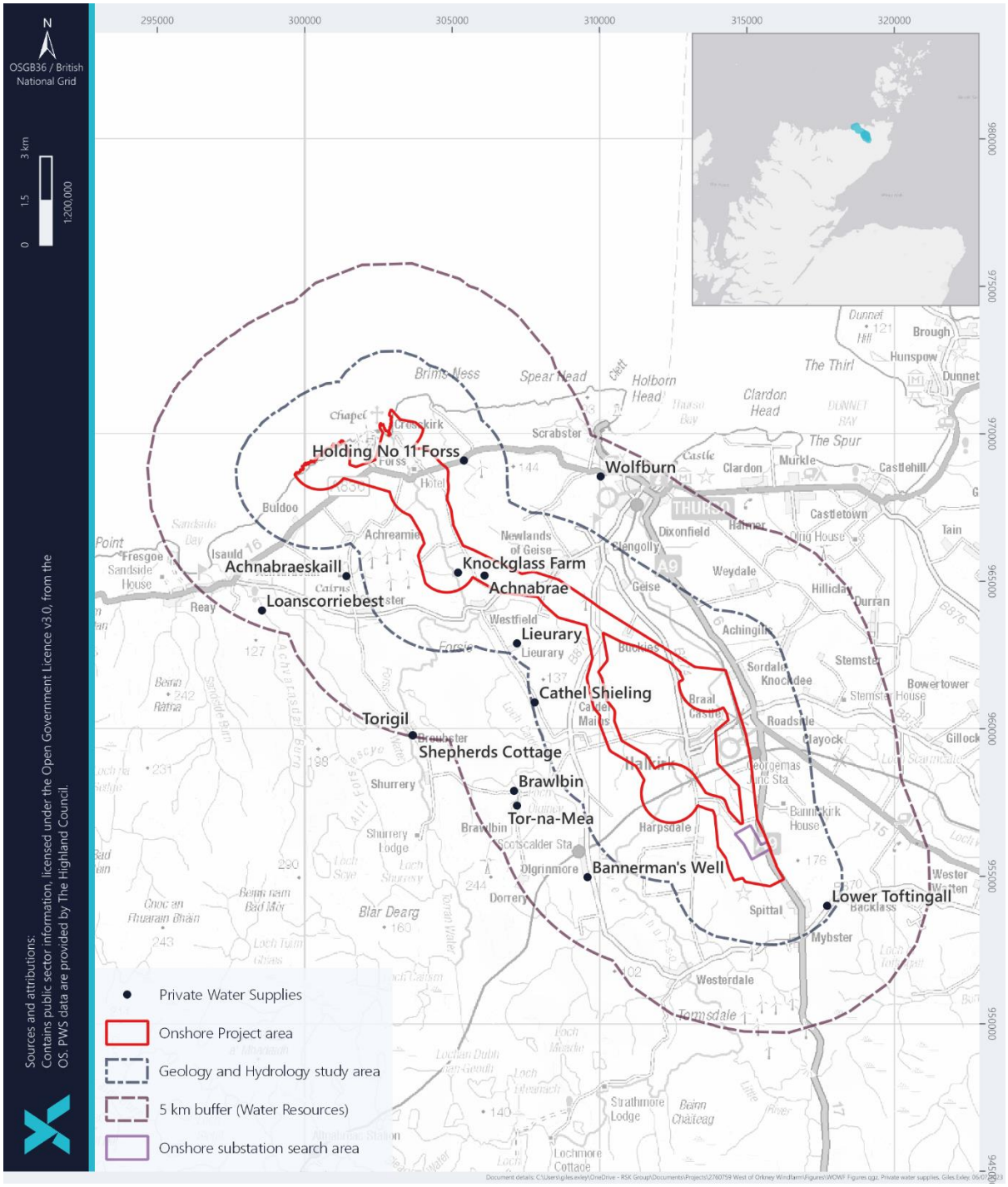

Figure 3.5 Private water supplies in the vicinity of onshore study area (THC, 2023)

2.21 Information provided by local landowners confirms that two PWS are present within the onshore Project area: Achnabrae at National Grid Reference (NGR) 306100 965200 and Knockglass Farm at NGR 305200 965300.

2.22 No PWS are known to be present within the onshore substation search area, or within a 5 km buffer.

2.23 BGS GeoIndex (BGS, 2023) identifies three boreholes (Achanarras and Georgemas Station 1 and 2) within 2 km of the onshore substation search area, and a further four boreholes (all at Braal Bridge) within 5 km downstream of the onshore substation search area. These boreholes were drilled for ground investigation purposes and have not been used for water abstraction.

2.24 Additionally, Ordnance Survey mapping identifies one well within the onshore substation search area at NGR 315369 955780. A further three springs and 27 wells are present within 2 km of the onshore substation search area.

3 FLOOD RISK MANAGEMENT

Onshore substation search area

3.1 The indicative onshore substation design has taken into account the flood risk zone alongside the Burn of Achanarras (Figure 3.6), as electricity substations are considered to be critical infrastructure in a flood risk situation.

3.2 The onshore substation search area has an elevation that ranges from around 60 m to 95 m AOD. The elevation of the indicative substation location is 70 m AOD.

3.3 Within the onshore substation search area, the Burn of Achanarras is located between approximately 57 m and 77 m AOD. The identified flood risk zone runs along the main watercourse channel, extending eastwards by approximately 60 m to 85 m, becoming wider to the north as the topography opens out towards the Moss of Halkirk (SEPA, 2022b).

3.4 All of the flood-sensitive infrastructure will be located outwith the flood risk area. The detailed design will include assessment of flood levels and the required platform height to ensure sufficient freeboard, including an appropriate allowance for climate change, and this will be confirmed with the Scottish Environment Protection Agency (SEPA) and THC as part of the detailed design process. A buffer zone is proposed between the flood risk zone and the main substation infrastructure, and this will allow space for inclusion of sustainable drainage systems, likely to include settlement and storage ponds to manage and treat drainage from the main substation area. Details of the final drainage system will form part of the detailed design.

3.5 Construction works within the flood risk area will be restricted to those required to connect the settlement ponds with the burn and, if required, for the cable route crossing of the burn.

3.6 No vehicles or plant will be left within the flood risk zone outwith working hours.

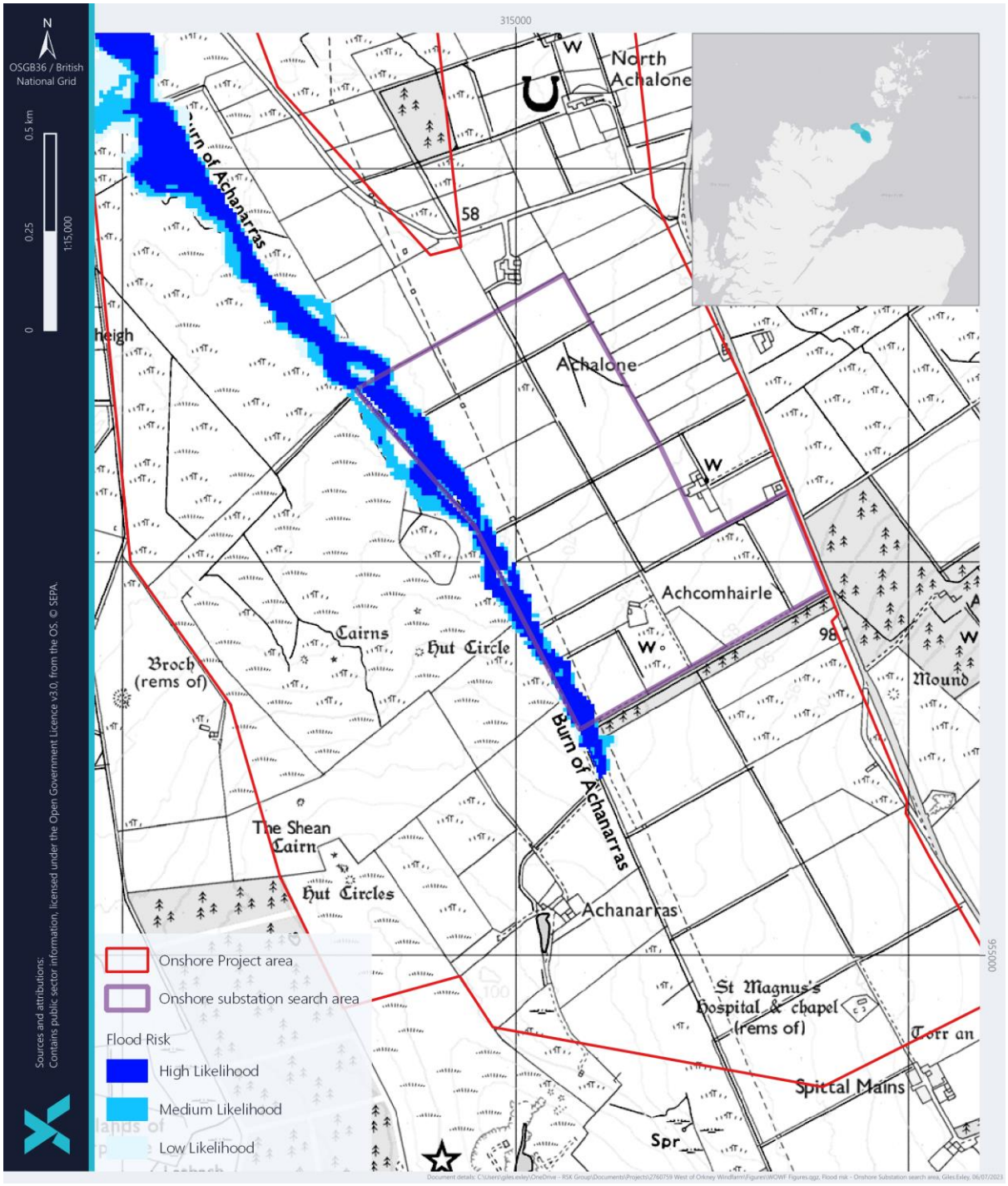

Figure 3.6 River flood risk at the onshore substation search area (SEPA, 2022b)

Onshore cable corridor

3.7 The onshore cable corridor will not require installation of long-term drainage infrastructure as, once buried and reinstated, the cables themselves are considered to be flood-resilient infrastructure. However, some parts of the onshore cable corridor will require works within identified flood risk areas as discussed in the sections below.

Landfall areas

3.8 SEPA and THC have identified that the cable landfalls will be required to cross the coastal flood risk zone at both locations (Figure 3.7).

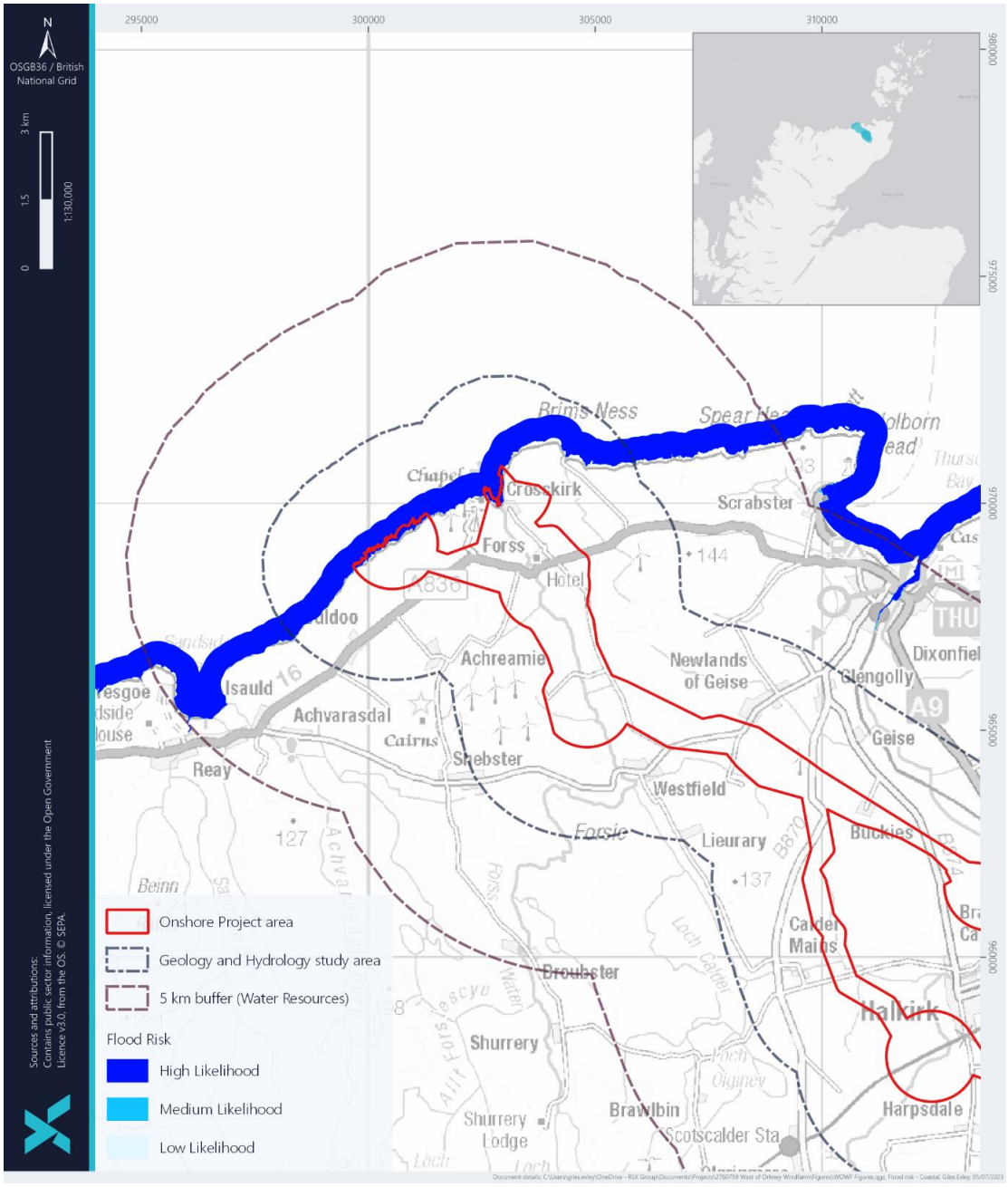

Figure 3.7 Coastal flood risk for the onshore Project area (SEPA, 2022b)

3.9 The cable landfall will be installed via HDD from a location or locations above the shoreline cliffs. Cliffs at both landfall locations are 10-15 m high and HDD operations will be managed from locations above and set back from these cliffs.

3.10 Although not directly at risk from coastal flooding as a result of their elevation, it is possible that the HDD platforms may be affected during stormy weather, as storm surges may cause large waves and significant spray to be carried inland from the coast. This risk can be effectively managed by maintaining a watching brief on weather forecasts, particularly if work is proposed for the winter months when storms are more likely. Should storms be forecast, operations will be paused where possible and any sensitive equipment, plant and all personnel relocated to a safe area outwith any potential danger zone.

3.11 The landfall locations will only be active during the construction stage and will be reinstated upon completion of the construction. Any remaining infrastructure, such as clifftop joint bays, will be constructed to be flood-resilient in the event of future storm events leading to waves and spray above the cliff level.

River crossings

3.12 Proposed crossings of the River Thurso (Figure 3.8 and Figure 3.9) and, if necessary, the Forss Water (Figure 3.10) will be undertaken using HDD. Both rivers are substantial watercourses and open-cut crossings are not considered appropriate. In addition, the River Thurso is considered to be highly sensitive to changes in water quality and additional care is required for operations in proximity to the river. Both rivers have flood risk zones associated with the main channels. The preferred approach will be for the HDD platforms to be located outwith these flood risk zones to either side of the river, to minimise potential flood risk to plant and personnel during the HDD process.

3.13 If this is not possible for any reason, any works taking place within the flood risk zones will require a watching brief on weather forecasts to check for incoming storms or significant periods of rainfall. Should any concerns be raised, operations within the flood zone will be paused where possible and any sensitive equipment, plant and all personnel relocated to a safe area outwith any potential danger zone.

3.14 For any other construction work within flood risk zones, particularly associated with smaller watercourses such as the Burn of Achanarras, a similar process will be employed to ensure that all personnel and flood-sensitive equipment are removed from the risk area in advance of incoming bad weather. Where possible, any works in flood risk areas should be planned outwith the winter months, to minimise the risk of flood conditions occurring during the construction activities.

3.15 A flooding evacuation 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 or period of significant rainfall from any of the potential flood risk locations.

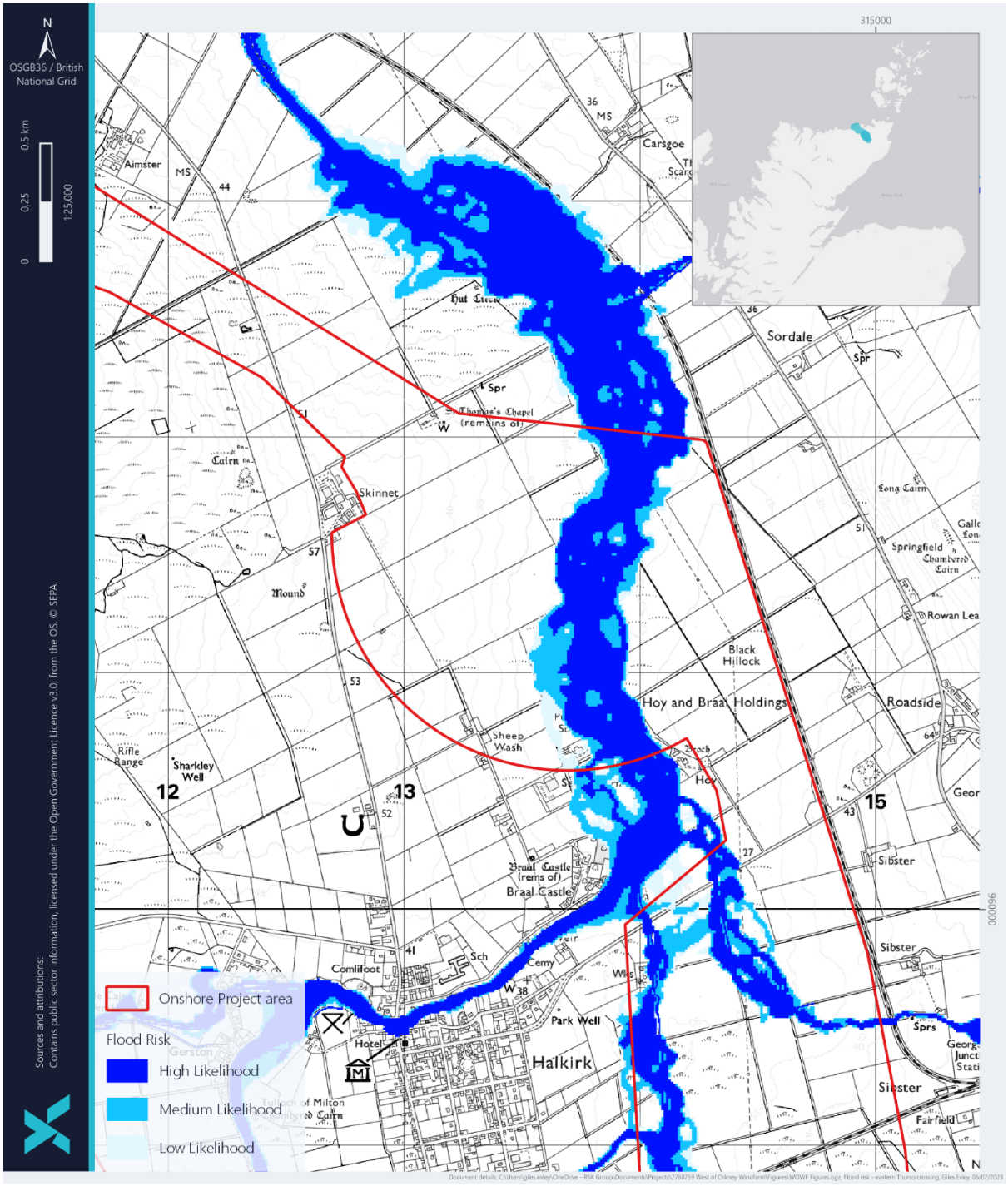

Figure 3.8 River flood risk at the east of Halkirk river crossing (SEPA, 2022b)

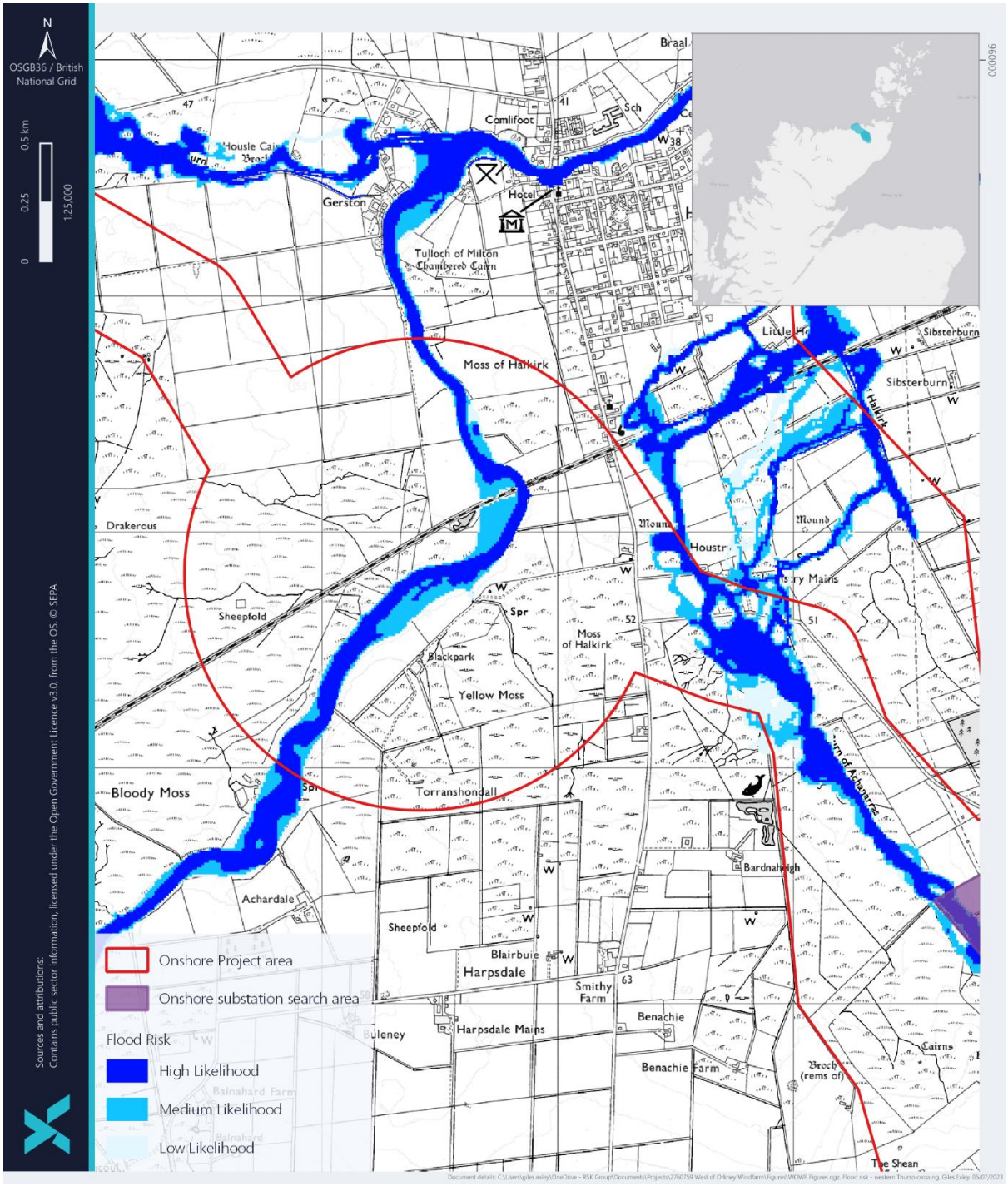

Figure 3.9 River flood risk at the west of Halkirk river crossing (SEPA, 2022b)

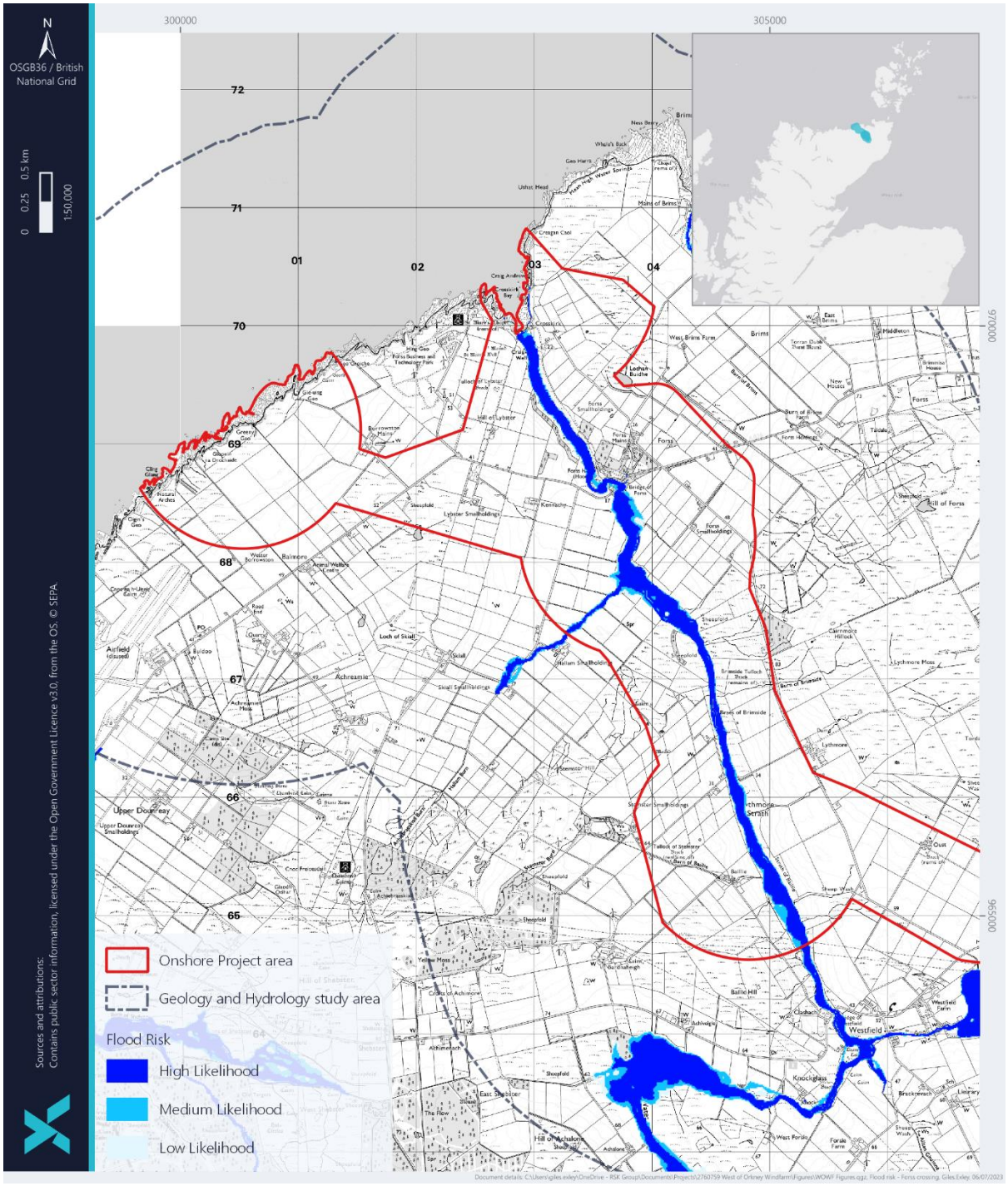

Figure 3.10 River flood risk in the vicinity of Forss Water (SEPA, 2022b)

4 OUTLINE DRAINAGE STRATEGY

Introduction

4.1 This section provides an outline drainage strategy for the onshore substation search area. The objective is to maintain site runoff within the natural catchment areas, and to maintain drainage to the onshore substation area and wider onshore study area watercourses following treatment and attenuation in order to mimic natural flow as closely as possible.

Waste water drainage

4.2 Foul drainage will be required for the onshore substation welfare facilities. It is anticipated that waste water will be disposed of through use of temporary facilities during the construction stage and installation of a septic tank or package plant for longer-term use. The final Drainage Strategy and Flood Risk Plan will be agreed upon with statutory consultees including Scottish Water and detailed within the CEMP.

4.3 Temporary facilities are likely to include a suitably sized holding tank with waste water removed by tanker for offsite disposal at a licensed facility.

Surface water drainage

4.4 The surface water drainage network for the onshore substation will be designed taking into account THC's Supplementary Guidance: Flood Risk and Drainage Impact Assessment (THC, 2013), SUDSWP's Water Assessment and Drainage Assessment Guide (SUDSWP, 2016) and CIRIA Publication C753 – the SuDS Manual (CIRIA, 2015).

4.5 The following sections describe the requirements that lead to determination of the proposed outline drainage strategy and which inform sustainable drainage systems (SuDS) provision recommendations. Implementation of these drainage requirements will prevent the onshore substation infrastructure from increasing flood risk to areas downstream.

Allowable discharge

4.6 Surface water flows from the onshore substation search area will be directed, following appropriate treatment and attenuation, to the existing watercourses in order to maintain pre-development water quality characteristics and flow rate.

4.7 In line with THC's supplementary guidance (THC, 2013), it is anticipated that the allowable discharge from the site will match that of the existing 1-in-2 year greenfield runoff rate. This is discussed in the following sections.

Post-development discharge criteria

4.8 Post-development surface water flows will be restricted to the discharge levels set out in THC's supplementary guidance (THC, 2013) and will be in line with best practice. The development proposals recognise THC's requirements, within which three key design principles are noted:

- The post-development runoff rate and volume do not exceed the greenfield runoff rate for previously undeveloped sites. However, if infiltration to ground is not feasible, the additional runoff generated should be discharged from the site at flow rates below 2 litres per second per hectare (l/s/ha).
- Formal on-site storage should be provided up to the 1-in-30 year return period event (3.33% annual exceedance probability) and attenuation measures should be designed such that SuDS features will not surcharge during a 1-in-30 year return period rainfall event.
- The 1-in-200 year event (0.5% annual exceedance probability) should be contained on site, unless it can be demonstrated that the 1-in-200 year event could be managed appropriately without causing increased flood risk elsewhere.

Greenfield runoff assessment

4.9 A review of the catchment characteristics relating to the proposed onshore substation was undertaken using the FEH Web Service (CEH, 2022). Catchment statistics for the River Thurso catchment are considered to be representative, as the onshore substation will lie within this catchment. The following catchment statistics have been used to determine the Greenfield Runoff Rate that corresponds to the existing characteristics within the onshore substation search area:

- SAAR of 1,040 mm for the study area; and
- Standard percentage runoff (SPR) of 52.85%.

4.10 The Greenfield Runoff Rate has been calculated using the online Greenfield Runoff Estimation for Sites tool (HR Wallingford, 2022), which gives the IH124 model[3] results for the study area.

4.11 The 1-in-2 year Greenfield Runoff Rate has been calculated to be **594 l/s** based on a total drained area of 61 ha.

4.12 The output from the Greenfield Runoff Estimation for Sites tool is provided in Annex A.

4.13 It should be noted that the above calculations are based on an indicative substation layout. The Greenfield Runoff Rate will be reviewed at the detailed design stage in order to ensure compliance with the requirements as specified within SEPA's documents.

Attenuation

4.14 THC's supplementary guidance requires that formal on-site storage is provided up to the 1-in-30 year return period event and attenuation measures should be designed such that SuDS features will not surcharge during a storm of this magnitude (THC, 2013).

4.15 The site drainage strategy aims to promote attenuation within the SuDS proposals to mitigate any additional surface water runoff generated as a result of the proposed onshore substation. Attenuation volumes will be reviewed at the detailed design stage in order to ensure compliance with the 1-in-30 year and 1-in-200 year requirements as specified within THC's Supplementary Guidance: Flood Risk and Drainage Impact Assessment (THC, 2013).

[3] The IH124 model provides a method for estimation of flow characteristics and flooding for small, ungauged catchments, derived by the institute of Hydrology (now Centre for Ecology and Hydrology). Details can be found in Marshall & Bayliss (1994).

4.16 Approximate attenuation and storage volumes have been calculated as follows, using guidance provided in the SuDS Manual (CIRIA, 2015) and SEPA's Climate change allowances for flood risk assessment in land use planning document (SEPA, 2022a):

- For a 1-in-30 year return period event plus climate change allowance, storage of approximately **3,566 m^3** is required.
- For a 1-in-200 year return period event plus climate change allowance, storage of approximately **5,503 m^3** is required.

4.17 It should be noted that the above calculations are based on an indicative substation layout. Attenuation volumes will be reviewed at the detailed design stage in order to ensure compliance with the 1-in-30 year and 1-in-200 year requirements as specified within THC's supplementary guidance.

Sustainable drainage systems

4.18 The onshore substation drainage strategy seeks to implement a design that will match the pre-development site characteristics. The drainage design is intended therefore to provide an appropriate degree of treatment and attenuation such that runoff discharge is no greater than pre-development greenfield runoff for the area and that runoff quality will not risk any reduction in the water quality of the receiving waterbody. Drainage design has been determined based on the greenfield runoff rates and attenuation storage volumes calculated above.

4.19 Drainage design is indicative at this stage, and the final detailed drainage design will be completed at a future date following planning permission in principle and contractor appointment.

Quality of receiving waterbodies

4.20 SEPA's Water Environment (SEPA, 2021a) and Water Classification Hubs (SEPA, 2021b) have been consulted to determine the existing baseline water quality for the main watercourses and waterbodies within the onshore substation area.

Surface waterbodies

4.21 The Burn of Achanarras, classified by SEPA as part of the Halkirk Burn catchment[4], provides the main drainage for the onshore substation area and is located 120 m to the west of the indicative substation location (Figure 3.11). The burn was classified by SEPA in 2021 as having 'Moderate' ecological potential (SEPA, 2021a). It was designated by SEPA in 2020 as being 'Moderate' for biology (fish), 'High' for water quality, and 'Bad' for hydromorphology (SEPA, 2021b).

Receiving waterbodies

4.22 The Burn of Achanarras/Halkirk Burn drains north into the River Thurso (Figure 3.11). This waterbody was classified by SEPA in 2020 as having 'Good' overall ecological status

[4] The Burn of Achanarras is an important water feature with relevance to the onshore Project, but forms part of the Halkirk Burn catchment in SEPA's terminology. This document refers principally to the Burn of Achanarras.

(SEPA, 2021a). The River Thurso was designated by SEPA in 2021 as being ‘Good’ for biology (fish), ‘Good’ for water quality, and ‘Good’ for hydromorphology (SEPA, 2021b).

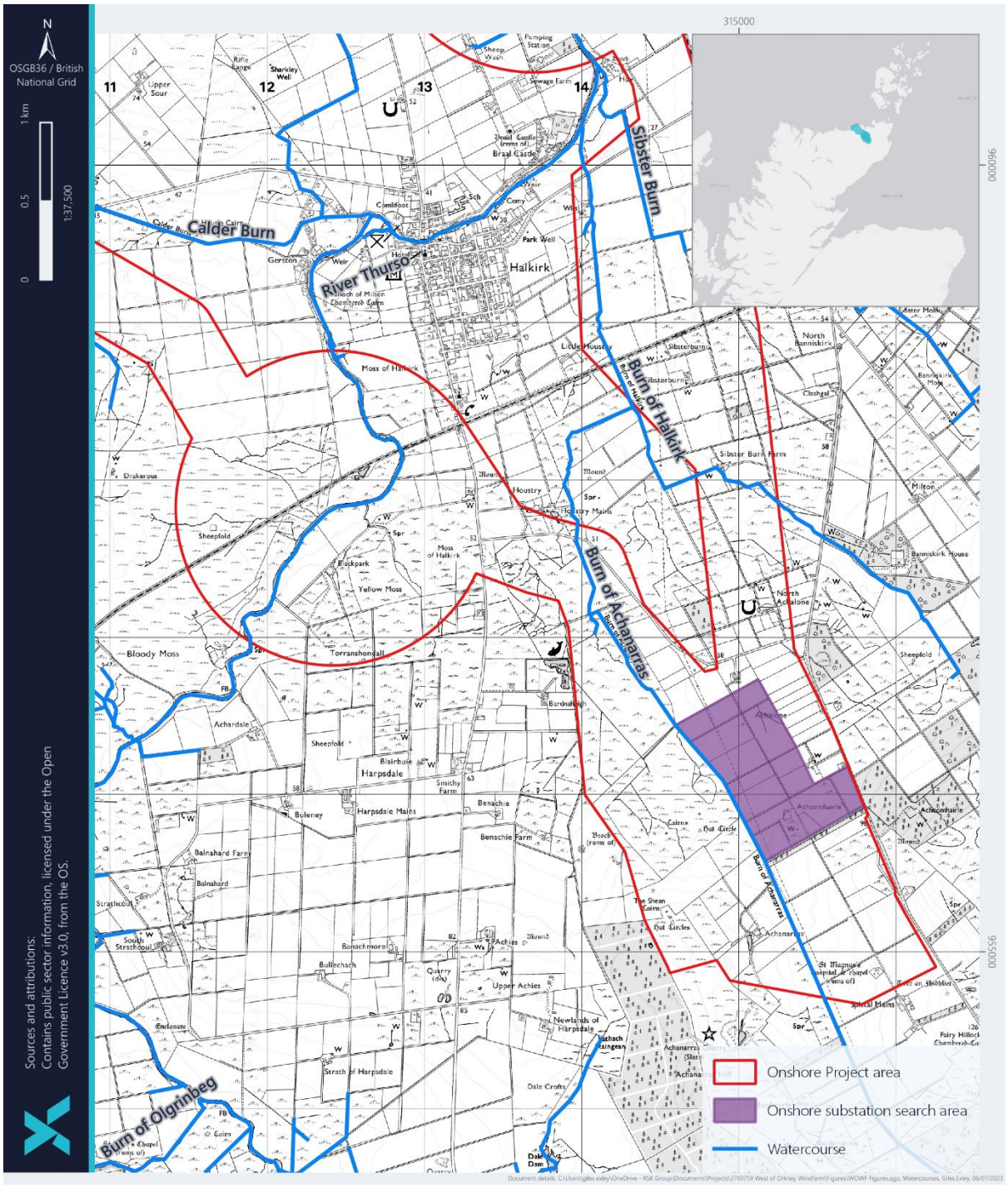

Figure 3.11 Map showing key surface waterbodies and receiving waterbodies in the onshore substation search area (Ordnance Survey, 2023)

4.23 The River Thurso is a Special Area of Conservation (SAC) designated for populations of Atlantic salmon (*Salmo salar*) (NatureScot, 2022). The northerly location of the river, and cooler water temperatures, result in slower-growing juveniles which smolt at an older age. The River Thurso also supports grilse (a salmon that has returned to fresh water after a single winter at sea), meaning that the river supports the full range of salmon life-history types (JNCC, 2023). The River Thurso is therefore considered to be highly sensitive to changes in water quality.

Levels of treatment

4.24 Surface water treatment systems should be based on catchment characteristics and the sensitivity of the receiving watercourse (CIRIA, 2015). Treatment will be required during the entire lifetime of a development, from construction through to decommissioning. Much of the construction phase surface water treatment could provide suitable water treatment for the operational phase.

4.25 SEPA (2010) states that 'Each individual type of SuDS feature, such as a filter drain, detention basin, permeable paving or swale, provides one level of treatment.'

4.26 All activities at the onshore substation area during construction and decommissioning will require at least two levels of treatment prior to discharge, as a result of the sensitivity of the receiving waterbodies and the high potential for generating loose sediment associated with construction and excavation works. Parts of the onshore substation area with a higher pollution risk, notably any areas used for plant maintenance and refuelling, will require three levels of treatment.

4.27 During operation of the substation, one level of treatment, such as swales or filter drains, should be sufficient for most of the onshore substation area, apart from any areas where potentially polluting materials such as fuel, oils and lubricants, are used or stored. These areas will require at least two levels of treatment as a result of their higher pollution risk.

4.28 During the construction phase, temporary water control measures will be implemented as necessary adjacent to areas of excavation. These will include the onshore substation search area and all sections of cable trench. These measures may include various SuDS components such as filter drains and temporary settlement ponds as detailed below.

4.29 Specific details of these measures will be provided within the CEMP and suitability will be determined following appropriate on-site soil tests.

SuDS components

4.30 The following SuDS features should be considered for inclusion within certain sections of the onshore substation's drainage infrastructure in order to control, manage and treat surface water runoff during construction, operation and decommissioning of the onshore substation.

Swales and filter strips

4.31 Swales are shallow, broad, and linear vegetated drainage features that can be designed to store and/or convey surface runoff as well as providing water treatment. Where soil and groundwater conditions allow, swales can also promote infiltration. Vegetation within

swales varies but typically comprises grass or dense vegetation that can act to slow down flow rates and trap particulate pollutants in the water.

4.32 Filter strips are gently sloping vegetated strips of land that provide off-the-edge diffuse drainage. They provide some flow attenuation and treatment, but little or no water storage.

Filter drains

4.33 Filter drains are also linear features, but rather than incorporating vegetation they include coarse graded rock which provides good drain stability whilst also providing water storage and conveyance. Filter drains have a narrower footprint than swales and can be used in areas where space constraints prevent wider swales from being used. Filter drains provide some limited water treatment.

Check dams

4.34 For either swales or filter drains that cross slopes, check dams provide a valuable means of attenuating water flow. These are typically placed across the swale or drain at intervals of 10-20 m. The design is such that the toe of the upstream dam is level with the crest of the next downstream dam. A small opening or pipe is placed at or near the base of each dam to allow limited flow to pass through rather than over the dam, in order to maintain low flow conveyance.

4.35 Check dams should be built into the sides of the swale or filter drain, to ensure that water flow cannot bypass the dam.

4.36 When made of soil (as opposed to rock), check dams are often called bunds or berms.

Silt fences and straw bales

4.37 Silt fences, constructed from a closely woven synthetic geotextile material, and straw bales both provide temporary flow attenuation and excellent particulate filtration treatment for surface water runoff. These are particularly valuable for sediment management in runoff during construction works, as silt fences and pegged straw bales can be positioned along the main runoff routes to capture, slow and treat runoff. They can also provide temporary check dams if required in short-term drainage infrastructure.

Settlement or detention ponds

4.38 Settlement ponds provide storage for site runoff and are a highly effective method of treatment and attenuation of surface water. They are particularly useful for developments where bulk earthworks form a significant part of the works.

Sumps

4.39 Sumps are essentially small settlement ponds, located in areas where there are space restrictions preventing use of a larger pond, or where large volumes of water or sediment are not anticipated. Water can either discharge naturally from a sump or can be pumped out to an alternative location for discharge or further treatment.

Permeable paving

4.40 Permeable paving forms part of the operational drainage infrastructure by allowing surface water infiltration through the paving and either into the subsurface or into buried collector drains. Particularly valuable in areas with good infiltration potential, permeable paving can play an important role in managing downstream flood risk by slowing the runoff rate and broadening the flood peak.

Outline drainage strategy

Onshore substation

4.41 Construction of the substation will require temporary drainage infrastructure (including temporary bunding and cut-off drains around onshore substation search area) to be established on a running basis ahead of excavation works. Where possible, trackside drainage will be laid up to 100 m ahead of track construction works on a running basis.

4.42 Onshore substation excavations will be designed and constructed with a slight gradient to encourage drainage into settlement ponds, to allow infiltration into vegetated areas and as shallow through-flow into soils where appropriate.

4.43 Trackside drainage will be no longer or deeper than necessary to provide required track drainage. Cross-drains under tracks will be installed at an appropriate frequency to mimic natural drainage patterns and to minimise concentration of flows.

4.44 The onshore substation will also require long-term drainage to ensure that the substation infrastructure is protected from surface water and flooding through its operational lifetime. It is anticipated that perimeter drains will be required around the substation area to collect and transport the surface water away from the substation area. Depending on detailed design, these may take the form of swales or filter drains as appropriate.

4.45 The perimeter drainage will need a connection to additional storage, particularly if filter drains are proposed. Additional storage will be best provided by one or more settlement and attenuation ponds. These should be located between the substation area and the nearby Burn of Achanarras, as shown on the indicative substation layout. Treated water from the settlement ponds should be permitted to discharge into the Burn of Achanarras, to maintain flow levels downstream. It is expected that the discharge will require formal authorisation under CAR.

4.46 It may be practical to employ permeable paving within the main substation area as a means to control surface water runoff and promote infiltration to ground. This will be confirmed during the detailed design stage.

4.47 Any areas within the substation where potentially polluting materials will be stored or used are likely to require additional treatment to ensure that spills and leaks do not gain direct access into the groundwater or surface water environments. Such additional treatment is likely to include oil separators, or provision of a self-contained drainage network which is entirely separate from the surface water drainage system. Again, this will be confirmed during the detailed design stage (post-consent).

4.48 Where possible, proposed long-term drainage infrastructure should be incorporated into the construction drainage. This will include the proposed settlement ponds as these will

form valuable settlement and attenuation features throughout construction as well as during operation. These should be installed as early in the construction process as possible, to ensure that suitable treatment is provided prior to discharge.

4.49 The long-term drainage infrastructure should also be retained for as long as possible during decommissioning, to ensure that the water treatment process can continue to operate effectively.

4.50 Long-term drainage infrastructure around onshore substation will have a monitoring and maintenance programme established, to include regular visual inspection of drainage infrastructure to check for blockages, debris or damage that may impede flow. Remediation will be undertaken immediately. Routine maintenance will be scheduled where possible for dry weather.

Onshore cable corridor

4.51 Surface water and sediment management will be required during the construction stage for the onshore cable corridor. It is anticipated that temporary infrastructure will be installed as necessary along the onshore cable corridor, on the upslope side in areas with a cross-slope and along both sides in flatter areas. Such temporary infrastructure will include:

- Soil bunds to divert clean water away from excavations and stripped ground;
- Temporary cut-off ditches or blind catch-ditches which may be rock-filled for stability;
- Deployment of silt fencing to trap and hold suspended sediment;
- Use of settlement ponds and sumps as necessary to provide water settlement and storage;
- Use of geotextile silt matting to cover and protect bare soils, especially on sloping ground, to minimise mobilisation of sediment; and
- Use of seeding on soil stockpiles if they need to be left in situ for more than a few days.

4.52 All water and sediment management infrastructure will be removed and fully reinstated at the end of the construction process.

4.53 All water management infrastructure will be established in such a way as to minimise concentration of flows and transmission of surface water between hydrological catchment areas. This can best be achieved by use of regular cross-drainage to transfer surface water from the upslope side of construction works to the downslope side, where it can be treated and permitted to discharge slowly to ground in a controlled manner. Details of the temporary drainage will form part of the detailed design.

Landfall

4.54 In terms of construction activities at the landfall such as HDD and installation of the TJBs, where appropriate, the drainage principles outlined above will also apply. Nonetheless, in terms of longer-term drainage any above-ground hard infrastructure would be sufficiently small not to have an impact on the local drainage and as such it is not anticipated that any long-term drainage strategy for the operation and maintenance stage for the infrastructure at the landfall will be required.

Vulnerable receptors

4.55 To mitigate impacts on vulnerable receptors, including PWS, watercourses and GWDTE within the onshore study area, the following embedded mitigation measures will be put in place:

- Installation of a soil bund downslope of excavation works to capture and divert runoff away from PWS;
- At least two lines of silt fencing downslope of the bund, to ensure that runoff from the bund does not lead to sediment transfer towards PWS;
- Regular monitoring of the PWS source for the duration of construction works upslope of source. As requested by SEPA, monitoring will begin 6 months prior to construction works taking place within 250 m of the PWS and will continue throughout period of groundworks in this area. Monitoring of the source will be undertaken daily while construction works are active within 250 m of the source.
- Monitoring upstream and downstream of any proposed major watercourse crossings will take place for a minimum of 6 months prior to commencement of works in order to establish a baseline and will continue for duration of groundworks in these areas, in line with established best practice.
- Placement of clay bunds or alternative impermeable barrier periodically within the cable trench, to minimise in-trench groundwater flow;
- All works through and adjacent to wetland areas will be supervised by the Environmental Clerk of Works.

4.56 A more detailed assessment of GWDTE in the onshore study area is provided in Supporting Study (SS) 2: West of Orkney Windfarm: Groundwater-Dependent Terrestrial Ecosystems Assessment.

Authorisation

4.57 Where proposals have potential to affect the water environment, the design of any works required to mitigate these effects must take into account the onshore Project characteristics and existing drainage conditions. Treatment and discharge of surface water to the water environment is regulated under CAR and forms an additional requirement to planning consent. Any formal authorisations under CAR that are needed for the drainage strategy will be put in place prior to work beginning on-site.

5 CONCLUSIONS

5.1 This report has assessed the relevant aspects of drainage associated with the onshore substation area. Recognising the requirements of THC and taking into account current best practice guidance, it suggests SuDS components which could be utilised to provide surface water treatment for the site. Once the infrastructure layout is confirmed, an onshore Project-specific drainage strategy will be produced.

5.2 The onshore substation search area and wider onshore Project area currently drain via natural overland flow, natural channels, drainage ditches, modified channels and culverts to the existing watercourses in and around the area.

5.3 A detailed drainage strategy will be produced once the infrastructure layout for the onshore Project is confirmed. This will follow the principles set out in this outline strategy. The drainage strategy will promote maintenance of natural runoff characteristics where possible, and drainage infrastructure to mimic the natural characteristics of the landscape where required. Runoff attenuation and treatment proposals will be designed to prevent any detrimental effects to the water quality or quantity of existing waterbodies. The drainage strategy will make use of SuDS features within the detailed engineering design to mimic the existing runoff characteristics.

5.4 Proposed SuDS to be incorporated in the drainage strategy include use of settlement ponds, swales, filter strips, check dams/berms, sumps and silt fences/straw bales at different stages of the proposed onshore substation and cable installation. Different levels of treatment will be required during the construction, operation and decommissioning stages of the onshore Project. Different levels and types of treatment will also be required for the onshore substation and other features of the onshore Project such as onshore export cables and landfall.

5.5 Flood risk during the cable installation process will be limited to areas where the construction works are located within or immediately adjacent to flood risk zones. Methods for managing the flood risk are set out and will be updated when the detailed design is available to ensure they are site-specific. Once the cables have been installed and reinstated, they are not considered to be at risk from flooding.

5.6 All necessary authorisations under CAR will be put in place prior to any site works taking place.

5.7 Flood risk to the onshore Project, and potentially increased flood risk arising from the onshore Project infrastructure, can be managed appropriately by implementation of the strategies set out in this document. Installation of suitable surface water treatment infrastructure and drainage management will prevent any increase to downstream flood risk as a result of the onshore Project.

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7 ANNEX A

HR Wallingford
Working with water

Greenfield runoff rate estimation for sites

www.uksuds.com | Greenfield runoff tool

Calculated by:	Lucy McCulloch
Site name:	West of Orkney Windfarm
Site location:	Caithness

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.

Site Details

Latitude:	58.48611° N
Longitude:	3.45608° W
Reference:	2827377829
Date:	Jan 20 2023 16:21

Runoff estimation approach IH124

Site characteristics

Total site area (ha): 61

Methodology

Q_{BAR} estimation method:	Calculate from SPR and SAAR
SPR estimation method:	Specify SPR manually

Soil characteristics	Default	Edited
SOIL type:	4	4
HOST class:	N/A	N/A
SPR/SPRHOST:	0.47	0.53

Hydrological characteristics	Default	Edited
SAAR (mm):	945	1040
Hydrological region:	1	1
Growth curve factor 1 year:	0.85	0.85
Growth curve factor 30 years:	1.95	1.95
Growth curve factor 100 years:	2.48	2.48
Growth curve factor 200 years:	2.84	2.84

Notes

(1) Is Q_{BAR} < 2.0 l/s/ha?

When Q_{BAR} is < 2.0 l/s/ha then limiting discharge rates are set at 2.0 l/s/ha.

(2) Are flow rates < 5.0 l/s?

Where flow rates are less than 5.0 l/s consent for discharge is usually set at 5.0 l/s if blockage from vegetation and other materials is possible. Lower consent flow rates may be set where the blockage risk is addressed by using appropriate drainage elements.

(3) Is SPR/SPRHOST ≤ 0.3?

Where groundwater levels are low enough the use of soakaways to avoid discharge offsite would normally be preferred for disposal of surface water runoff.

Greenfield runoff rates	Default	Edited
Q_{BAR} (l/s):	409.33	594.26
1 in 1 year (l/s):	347.93	505.12
1 in 30 years (l/s):	798.2	1158.8
1 in 100 year (l/s):	1015.14	1473.76
1 in 200 years (l/s):	1162.5	1687.69

This report was produced using the greenfield runoff tool developed by HR Wallingford and available at 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 www.uksuds.com/terms-and-conditions.htm. The outputs from this tool are estimates of 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, CEH, Hydrosolutions or any other organisation for the use of this data in the design or operational characteristics of any drainage scheme.

8 ABBREVIATIONS AND ACRONYMS

Acronym	Definition
AOD	Above ordnance datum
BFI HOST19	Baseflow index derived from the Hydrology of Soil Types
BGS	British Geological Survey
CAR	Controlled Activities Regulations, a short form of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 as amended.
CEH	Centre for Ecology and Hydrology
CEMP	Construction Environment Management Plan
CIRIA	Construction Industry Research and Information Association
DWPA	Drinking water protected area
EIA	Environmental impact assessment
FEH	Flood Estimation Handbook
GWDTE	Groundwater-dependent terrestrial ecosystem
HDD	Horizontal directional drilling
JNCC	Joint Nature Conservation Committee
NGR	National grid reference
PROPWET	Catchment wetness index
PWS	Private water supply
SAAR	Standard average annual rainfall
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SHETL	Scottish Hydro Electric Transmission Limited
SPR HOST	Standard percentage runoff derived from the Hydrology of Soil Types
SS	Supporting Study
SuDS	Sustainable Drainage Systems, also known as Sustainable Urban Drainage Systems
SUDSWP	Sustainable Urban Drainage Scottish Working Party
THC	The Highland Council