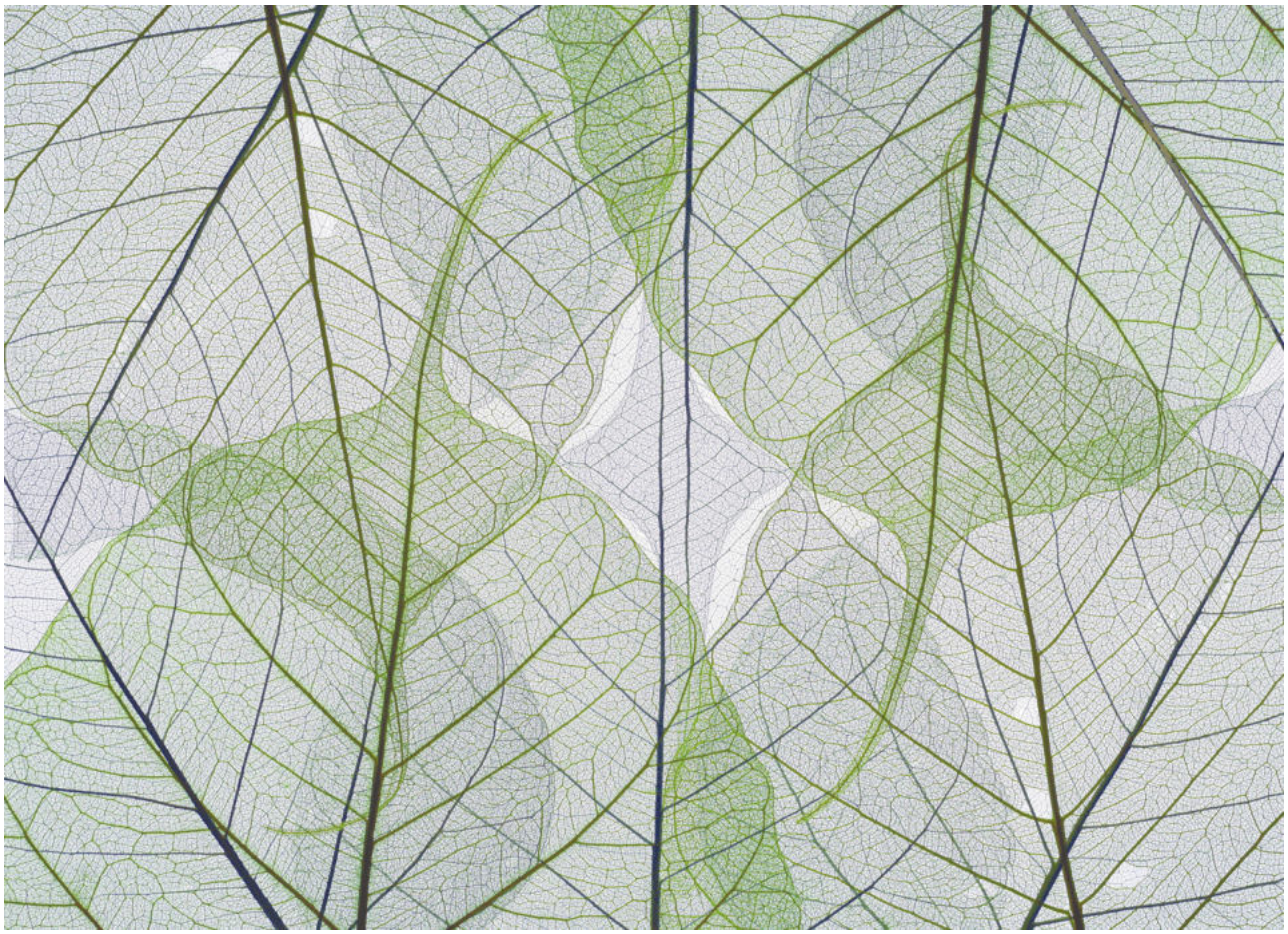


ScottishPower Renewables

Harestanes West Windfarm: Groundwater-Dependent Terrestrial Ecosystems Assessment

Technical Appendix 10.4

2760911-P10.4 (02)

NOVEMBER 2024

RSK

RSK GENERAL NOTES

Project No.: 2760911-P10.4(02)

Title: Harestanes West Windfarm Groundwater-Dependent Terrestrial Ecosystems Assessment

Client: ScottishPower Renewables

Date: November 2024

Office: Stirling

Status: Final

Author	Rhys Lithgow	**Technical reviewer**	Catherine Isherwood
Date:	06/11/2024	Date:	06/11/2024

Project manager	Giles Exley
Date:	06/11/2024

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

1.1 This report provides a Groundwater-Dependent Terrestrial Ecosystem (GWDTE) Assessment for Harestanes West Windfarm and associated development infrastructure (hereafter referred to as the 'proposed Development').

1.2 This report forms a Technical Appendix to the Environmental Impact Assessment Report (EIA Report) for the proposed Development and should be read in conjunction with this report. It has been produced in response to the request at Scoping stage to assess the effects of the proposed Development in areas with, or that have potential to affect, sensitive groundwater-dependent habitats raised by the Scottish Environment Protection Agency (SEPA) and Dumfries and Galloway Council (DGC).

1.3 GWDTE are protected under the *Water Environment and Water Services (Scotland) Act 2003* and are potentially sensitive receptors to the impacts of development. This report identifies the potentially groundwater-dependent habitats present within the study area and identifies and assesses the potential impacts of the proposed Development on these habitats. Design and mitigation methods to avoid or minimise these risks are set out, along with good construction practices that would be employed during all site works.

1.4 Within this Technical Appendix, the following definitions will be used: The 'access track to the turbine area' refers to the route leading from the A701 public road to the turbine area within the Site; 'Site' refers to the area within the Application Boundary within which the proposed Development lies. The 'Application Boundary' refers to the red line planning boundary comprising the Site and the access track; 'proposed Development' refers to the infrastructure part of the Application Boundary and not the land footprint. The 'study area' refers to the Site plus any additional area over which desk based or field assessments have been extended.

Site Location

1.5 The proposed Development is located north-west of the village of Ae, approximately 1.3 kilometres (km) from the Application Boundary and 2.2 km from the nearest proposed turbine, and approximately 13 km north of Dumfries. The Site is located wholly within the Dumfries and Galloway Council (DGC) administrative area. The turbine area lies to the west of the Water of Ae and the Windy Hill Burn runs through the centre of the turbine area from north-west to south-east. The Site is made up of undulating hills that form part of the upland plateau or range of hills between Annandale to the east and Nithsdale to the West.

Development Proposals

1.6 The proposed Development infrastructure would include:

- 12 wind turbines, six with a maximum height of 220 m and six with a maximum height of 200 m to blade tip;
- 12 No hardstanding areas at the base of each turbine, with an approximate total area of 3,856 m^2;

- transformer/switchgear housings located adjacent to turbines;
- site entrance from the A701, and 31.5 kilometres (km) of access track with associated watercourse crossings – of which 10.5 km are new access tracks and 21.0 km are upgrades to existing tracks;
- underground cabling linking the turbines with the substation;
- a permanent meteorological mast (PMM) and associated hardstanding area;
- an operations control building with parking and welfare facilities;
- a substation compound;
- a bellmouth and parking area adjacent to the A701;
- two temporary construction compound areas;
- extraction of material from up to three existing quarries owned and operated by Forestry and Land Scotland to provide suitable rock for access tracks, turbine bases and hardstanding;
- health & safety and other directional site signage; and
- additional development components to improve the overall ecological and environmental benefits accruing from the proposed Development in the form of peatland restoration, habitat improvement and native woodland planting.

1.7 Full details of the proposed Development design are provided in **Chapter 3: Proposed Development** of the EIA Report.

Aims

1.8 This report aims to undertake a review of relevant baseline information, including all habitat and vegetation data and hydrogeological details, in order to provide an assessment of the risk to GWDTE. Recommendations will be made for mitigation measures, including best practice measures, that should be implemented to minimise the risk of disturbance or damage to GWDTE during construction works and ongoing development operations.

Assessment Method

1.9 This assessment has involved the following stages:

- Desk study;
- Vegetation mapping;
- Hydrogeological assessment;
- Detailed assessment of sensitive habitats; and
- Identification of protection and mitigation measures.

2 DESK STUDY

Information Sources

2.1 The desk study involved a review of available relevant information sources on the ground conditions at the proposed Development. Information sources included:

- OS topographical mapping at 1:50,000 and 1:25,000 scales;
- British Geological Survey (BGS) geological mapping, superficial and bedrock;
- British Geological Survey online borehole records;
- Centre for Ecology and Hydrology Flood Estimation Handbook Web Service;
- Data provided by the applicant, including turbine foundation and track design specifications;
- Dumfries and Galloway Council private water supplies records;
- Scotland's Soils mapping, 1:250,000 scale; and
- Scottish Environment Protection Agency's *A functional wetland typology for Scotland*.

Climate and Topography

2.2 The proposed Development is in Dumfries and Galloway, located in the UK Meteorological (Met) Office's 'Western Scotland climatic area'. Western Scotland experiences a temperate maritime climate, characterised by substantial rainfall and strong westerly winds (Met Office, 2016).

2.3 Western Scotland is one of the wettest regions in the UK, with annual rainfall typically exceeding 1,500 mm. This is largely due to prevailing westerly winds from the Atlantic, resulting in frequent and substantial rainfall throughout the year (Met Office, 2023). Dumfries Crichton Royal No 2 (henceforth referred to as Dumfries Crichton Royal) climate monitoring station is approximately 20 km north of the proposed Development (Met Office, 2023). Rainfall data from this station is likely to provide a good representation of the Site and surrounding area.

2.4 Topography within the Application Boundary is variable, with elevations ranging from 108 m to 380 m AOD. The highest point on Site is towards the north-east of Holehouse Hill, situated within the eastern part of the access track, lying at 380 m AOD. Topography undulates across the Site with scattered peaks including: Auchengeith (299 m) in the south-west, Shiel Cleuch (300 m AOD) to the east, and Hound Knowe (340 m AOD) to the north.

2.5 The lowest point within the Site is to the south-east of the access track where it meets the A701, lying at 108 m AOD. Valleys caused by the incision of river systems account for several other areas of low elevation on Site, at roughly 200 m AOD.

Geology

2.6 Geological information is derived from the British Geological Survey (BGS) GeoIndex online geological mapping at a 1:50,000 scale and the BGS Lexicon of Named Rock Units (BGS, 2024a,b).

Bedrock Geology

2.7 The bedrock within the Site is predominantly greywacke sandstone, ranging from fine to very coarse grained and locally pebbly, with some bands of mudstone, siltstone and conglomerate in places. A minor area of breccia, a small intersection of mudstone, chert and smectite-claystone, and sandstone are present at the southern end of the Site Access.

Superficial Geology

2.8 Superficial geology mostly consists of diamicton till (BGS, 2024a), although much of the Site is without any mapped superficial geology. In the turbine area to the west of the Site, diamicton till is the most prominent, along with a few peat deposits. The largest of these peat deposits is located roughly 1 km north-east of Auchengeith Hill, the second between the peaks of Auchengeith Hill and Big Craig, and the last is 300 m north-west of Auchengeith Hill.

2.9 To the east of the Site, along the access track to the turbine area, the area is underlain by diamicton till, peat and alluvium (comprising silt, sand, and gravel). A single peat deposit is found where the access track intersects the Deer Burn.

Soils and Peat

2.10 The Soil Survey of Scotland (1981) digital soils mapping indicates that the soil coverage within the Application Boundary is predominantly peaty gleys, peat podzols and noncalcareous gleys (brown forest soils). Peat gleys are described as poorly drained acidic soils which support wet heathland and rough grassland communities. An area to the south of the turbine area has been identified as predominantly peaty podzols, which often have a thin iron-pan restricting the flow of water deeper into the soil.

2.11 A small section of the access track to the turbine area, at Deer Burn, has been identified as peat.

2.12 Peat depth surveys undertaken in the area confirm that peat is present in pockets across the Site but is largely absent from most of the access track to the turbine area. Details of the peat characteristics and coverage are provided in **Technical Appendices 10.1 and 10.2.**

2.13 NatureScot's Carbon and Peatland map (NatureScot, 2016) has been consulted to understand the carbon-rich soils, deep peat and priority peatland habitat within the Site. The map classifies soils into five carbon classes, as well as three classes for mineral soils, non-soils or unknown. Classes 1 and 2 are considered to be nationally important carbon-rich soils.

2.14 Within the Site, soils are predominantly Class 4 (unlikely to include carbon-rich soils). There are some areas of Class 5 (peat depth greater than 50 cm but currently lacking

peatland vegetation), distributed throughout the Site. Two small areas are identified as Class 3 (peaty soils that support some or mostly peat-forming vegetation) in the north western and south eastern corners of the Site. The remainder of the Site is Class 0 (mineral soils).

Hydrogeology

2.15 The bedrock within the Application Boundary is classified as a low-productivity aquifer of the Gala Group, comprising highly indurated greywackes with limited groundwater in the near-surface weathered zone and accompanied by secondary fractures (BGS, 2024a). Groundwater flow is predominantly through fractures and other discontinuities.

2.16 Three groundwater bodies are associated with the Application Boundary (SEPA, 2017b). The East Dumfriesshire groundwater body lies beneath most of the Site. The Dalveen Pass groundwater body lies beneath a western portion of the Site. The Lochmaben groundwater body lies beneath a southern portion of the access track. All groundwater bodies are in good condition.

Hydrology

2.17 The majority of the land within the Application Boundary lies within the Water of Ae (u/s Goukstane Burn) catchment, including the northern half of the turbine area and a large portion of the access track leading to the turbine area. The southern half of the turbine area primarily lies within the Goukstane Burn catchment, while a small area to the south west of the turbine area is drained by the Pennyland Burn catchment. The eastern section of the access track to the turbine area is drained by the Glenkiln Burn and Garrel Water catchments.

2.18 The Water of Ae, Goukstane Burn, Glenkiln Burn and Garrel Water are all tributaries to the River Annan. The Pennyland Burn is a tributary to the River Nith.

2.19 Watercourses within the Application Boundary appear to be modified, with a few larger watercourses in near-natural condition. The modification is likely a result of straightening and diverting of watercourses for the surrounding commercial forestry.

Water of Ae (u/s Goukstane Burn)

2.20 The Water of Ae (u/s Goukstane Burn) catchment has a total area of 72.68 ha and drains 52.0% of the land within the Application Boundary.

2.21 The Water of Ae is the largest fluvial system intersecting the Site and is in a near-natural condition. Many minor headwater tributaries contribute to the drainage of this catchment, including the Capel Water, Bran Burn, Clerk Grain, Deer Burn and Windyhill Burn. These tributaries have been artificially modified in places to accommodate the surrounding commercial forestry and associated infrastructure.

2.22 This Water of Ae catchment is located on undulating upland topography, with areas of steeply sloping ground. Commercial forestry covers a significant proportion of the southern area of catchment.

Goukstane Burn

2.23 The Goukstane Burn catchment has a total area of 11.43 ha and drains 29.2% of the land within the Application Boundary.

2.24 The Goukstane Burn is the second largest fluvial system on-site and ultimately drains into the Water of Ae. The Goukstane Burn is mostly in a near-natural condition due to its size; however, it has been artificially modified upstream to accommodate track infrastructure. Several unnamed minor tributaries drain into the Goukstane Burn. The majority of these have been artificially modified.

2.25 The Goukstane Burn catchment is located on undulating upland topography, with areas of steeply sloping ground. The catchment is used for commercial forestry and agriculture in lower lying areas.

Garrel Water

2.26 The Garrel Water catchment has a total area of 25.15 ha and drains 9.6% of the land within the Application Boundary.

2.27 The Garrel Water catchment drains into the Water of Ae a few kilometres downstream of the Site. Several minor watercourses drain into the Garrel Water, including the Mill Burn. These are likely to have been artificially modified.

2.28 The Garrel Water catchment is characterised by gently sloping lowland topography. The catchment is used mainly for agricultural practices.

Pennyland Burn

2.29 The Pennyland Burn catchment has a total area of 29.60 ha and drains 6.0% of the land within the Application Boundary.

2.30 The site drains into Duncow Burn (off-site to the West), a minor tributary of the Pennyland Burn. The Duncow Burn and Pennyland Burn has likely been artificially modified, due to their small size and proximity to commercial forestry. There are no other watercourses within the Application Boundary associated with this catchment.

2.31 The Pennyland Burn catchment is located on undulating upland topography, with areas of steeply sloping ground. The catchment is used for commercial forestry and agriculture in lower lying areas and encompasses the operational Dalswinton Windarm.

Glenkiln Burn

2.32 The Glenkiln Burn catchment has a total area of 15.12 and drains 3.1% of the land within the Application Boundary.

2.33 The Glenkiln Burn is a fluvial system similar in size and character to the Goukstane Burn and drains into the Water of Ae at the same confluence. It is likely parts of the Glenkiln Burn have been artificially modified in the headwaters but it is in a near-natural condition downstream. Several minor watercourses drain into the Glenkiln Burn, including the Lambfoot Linn. These have likely been artificially modified.

2.34 The Glenkiln Burn catchment is located on undulating upland topography, with areas of steeply sloping ground. The catchment is used for commercial forestry and agriculture in lower lying areas and encompasses the operational Minnygap Windfarm.

Catchment Statistics

2.35 The catchment wetness index for the catchment areas is between 0.60-0.64, indicating the Site is wet 60-64% of the time. The area has a base flow index (BFI HOST19) of between 0.32 and 0.55 indicating a moderate to low input of groundwater baseflow to surface watercourses. The standard percentage (SPR HOST) is 35-48%, which indicates that this percentage of rainfall on Site is converted into surface runoff from rainfall events. This represents a high runoff risk where soils have a limited capacity to store rainfall and/or a slow infiltration rate and would quickly saturate, leading to rapid runoff.

2.36 Catchment statistics derived from the Flood Estimation Handbook Web Service are provided in **Table 10.4.1** (CEH, 2022). Catchment statistics are provided for the five main catchments within the Application Boundary.

Table 10.4.1: Catchment statistics for the proposed Development

Catchment Name	Catchment Wetness Index (PROPWET)	Base Flow index (BFI HOST19)	Standard Percentage Runoff (SPR Host)	Area %*
Water of Ae (u/s Goukstane Burn)	0.63	0.32	48.12	52.0
Goukstane Burn	0.64	0.38	43.87	29.2
Pennyland Burn	0.64	0.55	35.34	6.0
Garrel Water	0.60	0.48	40.76	9.6
Glenkiln Burn	0.60	0.36	46.67	3.1

*The % area does not total 100% due to rounding.

Private Water Supplies

2.37 Data obtained from DGC regarding private water supplies (PWS) indicates that no PWS are present within the Application Boundary. There are no PWS identified within 2 km of the Application Boundary with a linkage to proposed infrastructure.

3 VEGETATION AND GROUNDWATER DEPENDENCY

3.1 GWDTE are defined by the UKTAG (2004) as:

> *"A terrestrial ecosystem of importance at Member State level that is directly dependent on the water level in or flow of water from a groundwater body (that is, in or from the saturated zone). Such an ecosystem may also be dependent on the concentration of substances (and potential pollutants) within that groundwater body, but there must be a direct hydraulic connection with the groundwater body."*

3.2 In line with the guidance provided in UKTAG (2004), a dual ecological and hydrogeological approach to identifying GWDTE has been used. This involves a detailed study of vegetation communities in order to determine the potential level of groundwater dependency, combined with a detailed hydrogeological study in order to identify locations where groundwater reaches the surface and is therefore able to provide a source of water to terrestrial ecosystems.

3.3 Determining groundwater dependency is complex as most water-dependent terrestrial ecosystems rely on a combination of groundwater, surface water and rainwater, and many vegetation communities will use whatever source of water is available. In some topographical and hydrogeological conditions, a particular ecosystem is surface water-dependent. Seasonal patterns of water availability influence water use, providing an additional level of complexity; groundwater reliance is typically greater in the summer when rainfall and surface water are less available (Isherwood, 2013).

Vegetation Mapping

3.4 Vegetation within the Application Boundary has been surveyed using a combined UK habitat classification and National Vegetation Classification (NVC) survey method and is reported in full in **Volume 2 Chapter 8 Ecology and Biodiversity**, with mapping provided in **Figure 8.3** of the EIA Report. The key findings relating to groundwater dependency are summarised below.

3.5 NVC communities identified by SEPA as likely to be highly or moderately groundwater dependent, depending on the hydrogeological setting, are listed in SEPA's publications "Planning advice on on-shore windfarm developments" (SEPA, 2017a) and "Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems" (SEPA, 2017b).

3.6 UKTAG Annex 1 differentiates communities by class, where Class 1 is potential high groundwater-dependency, Class 2 is potential moderate groundwater-dependency and Class 3 is potential low groundwater-dependency (UKTAG, 2009).

3.7 NVC survey mapping indicates that there are small pockets of NVC communities scattered throughout the Site and access; however, the majority of the Application Boundary is primarily without such communities as a result of the extensive commercial conifer plantations. The potentially groundwater-dependent NVC communities identified within the Application Boundary are found in **Table 10.4.2**.

Table 10.4.2: Potential groundwater dependency classification of identified NVC communities within the Application Boundary.

SEPA (2017b) groundwater dependency classification	NVC community	UKTAG (2009) groundwater dependency classification
High groundwater dependency	M6 *Carex echinata – Sphagnum recurvum/auriculatum* mire	1 (high)
	M23 *Juncus effusus/acutiflorus – Galium palustre* rush-pasture	2 (moderate)
Moderate groundwater dependency	M15 *Scirpus cespitosus – Erica tetralix* wet heath	2
	M27 *Filipendula ulmaria – Angelica sylvestris* mire	2
	M25 *Molinia caerulea – Potentilla erecta* mire	2 (UK) 3 (low, Scotland)

4 DETAILED ASSESSMENT

4.1 The study area has been reviewed to identify areas of NVC habitats that require assessment.

4.2 Detailed consideration is required for sensitive habitats that lie within 100 m of access tracks, which typically have excavations less than 1 m in depth, or within 250 m of excavations deeper than 1 m, such as turbine foundations and borrow pits (SEPA, 2017b). The combined infrastructure buffer is provided as a green dashed line in the figures provided, for reference purposes. An overview map of the proposed Development showing areas of potentially groundwater-dependent communities is provided in **Figure 10.4.1**.

Conceptual Site Model

4.3 Of the NVC communities identified in **Table 10.4.2**, SEPA (2017b) identifies M6 as *"... likely to be ... highly groundwater dependent ... depending on the hydrogeological setting"* and UKTAG (2009) identifies M6 as Class 1 (high) in both UK and Scottish settings.

4.4 Of the NVC communities identified in **Table 10.4.2**, SEPA (2017b) identifies M23 as *"... likely to be ... highly groundwater dependent ... depending on the hydrogeological setting"* and UKTAG (2009) identifies M23 as Class 1 (high) in UK setting and Class 2 (moderate) in Scottish settings.

4.5 Of the NVC communities identified in **Table 10.4.2**, SEPA (2017b) identifies M15 and M27 as *"... likely to be ... moderately groundwater dependent ... depending on the hydrogeological setting"* and UKTAG (2009) identifies both as Class 2 (moderate) in UK and Scottish settings.

4.6 Of the NVC communities identified in **Table 10.4.2**, SEPA (2017b) identifies M25 as *"... likely to be ... moderately groundwater dependent ... depending on the hydrogeological setting"* and UKTAG (2009) identifies M25 as Class 2 (moderate) in UK setting and Class 3 (low) in Scottish settings.

4.7 In this sense, M6 and M23 would be considered to be potentially more sensitive than M15, M25 and M27.

Habitats On Peat

4.8 A large part of the habitats identified as potentially highly groundwater-dependent are on areas of confirmed peat over 0.5 m in depth (habitats M6, M23 and M27). Although water flow through peat does occur, it is extremely slow and peat bodies are typically considered impermeable as a result. Water held within peat is not usually considered to form part of the groundwater body.

4.9 Blanket peat is generally considered to be ombrotrophic and receives all its nutrients from rainwater (JNCC, 2024). Localised flushing can occur adjacent to watercourses but is rarely extensive away from the watercourse channel. It is recognised that peat present within the Site has a wide range of depths; however, it remains likely that the dominant water source in the Site, irrelevant of peat depth, is rainwater with shallow through-flow within the uppermost vegetated layer.

4.10 The Phase 1 and 2 peat surveys noted that the base was predominantly firm or hard, indicating a high presence of clay or clayey material. Clay material would provide an impermeable barrier layer between the peat deposit and the bedrock, effectively preventing any existing groundwater from reaching the ground surface.

4.11 Bedrock in the Application Boundary are classed as low productivity aquifers; it is therefore unlikely that the small amount of potential groundwater present within the bedrock is accessible to surface habitats in much of the Site.

4.12 No springs or seepage features were identified within the Application Boundary. One spring is located at Windyhill, approximately 1.1 km east of Windyhill Rig and the proposed location for Turbine 3. Two wells and four further springs were identified within 2 km of the Application Boundary.

Habitats Not On Peat

4.13 Some of the identified habitats are located within areas with no identified peat. Small pockets are identified along the access track to the turbine area and elongated areas in the north and south of the turbine area. Although the identified habitat areas are small, the nature of the underlying substrate requires assessment.

4.14 The areas identified either lack superficial deposits or consist of diamicton till and fluvial deposits (alluvium), which are all naturally variable materials and may contain accessible groundwater. However, most of the proposed infrastructure is located on or near the top of hills and ridges and this means that it is less likely that they are able to access groundwater directly except at high water table levels in late spring, as a result of the very low groundwater storage capacity of the bedrock.

Potential Impacts

4.15 Potential impacts to identified potential GWDTE include direct and indirect impacts.

4.16 Direct impacts would arise as a result of habitat loss through construction activity and the associated requirement to excavate vegetation and soil material within the identified sensitive habitat area.

4.17 Indirect impacts would arise as a result of changes in the water supply to the sensitive habitat or of changes in the nutrient supply as a result of ‘flushing’. Most sensitive habitats are nutrient-poor and require continued supply of nutrient-poor water to retain their structure and vegetation community. Excavation works can provide a sudden influx of nutrient material arising from the soil disturbance, which can overwhelm such nutrient-poor communities causing temporary or permanent changes to the habitat as a result. Nutrient flushing is usually associated with changes to water supply pathways, and specifically with introduction of drainage from areas of active excavation that discharge into or upslope of such sensitive habitat areas.

Conclusions Relating to Groundwater Dependency

4.18 It is concluded that the occurrence of M6 and M23 habitats on peat preclude them from being groundwater-dependent as there is no groundwater source available to them. However, as noted there are areas where M6 and M23 habitats are listed without the presence of peat.

4.19 It is also concluded that none of the habitats within the study area not located on peat can truly be described as groundwater-dependent as there is no reliable source of shallow groundwater on which they can depend. These are likely to rely on a combination of rainfall and surface runoff, with some direct surface water in areas adjacent to watercourses and waterbodies.

4.20 Nevertheless, these habitats are considered to be sensitive, and a level of protection is required to minimise and, if necessary, mitigate any impacts that may occur. The areas of habitats identified above are within the combined infrastructure buffer and are discussed individually in the following sections.

Potential GWDTE Area 1

4.21 Area 1 covers part of the access track leading to the turbine area, from the A701, where the track heads north west, then south west, along mostly existing forestry track (**Figure** 10.4.1a).

Habitats present

4.22 Small pockets of M23 rush-pasture are identified along the access track.

Setting and infrastructure

4.23 Most of Area 1 is underlain by sedimentary bedrock of the Queensberry Formation, part of the Gala Group. The Queensberry Formation comprises sandstone, mudstone, siltstone and conglomerate. The southern section of the access track to the turbine area is underlain by sedimentary bedrock of the Selcoth Formation, part of the Ettrick Group.

4.24 Area 1 is underlain by superficial deposits of till, alluvium and isolated pockets of peat. There are parts of Area 1 where superficial deposits are not mapped.

4.25 The bedrock is described as a low productivity aquifer with a limited amount of groundwater present in the near-surface weathered zone, with flow virtually all occurring through secondary fractures and discontinuities.

4.26 Infrastructure development in Area 1 would involve upgrading of the existing track, areas of floating track, extension of an existing borrow pit and construction of a temporary construction compound.

4.27 The proposed floating track and track upgrade in Area 1 has some potential to affect the areas of M23.

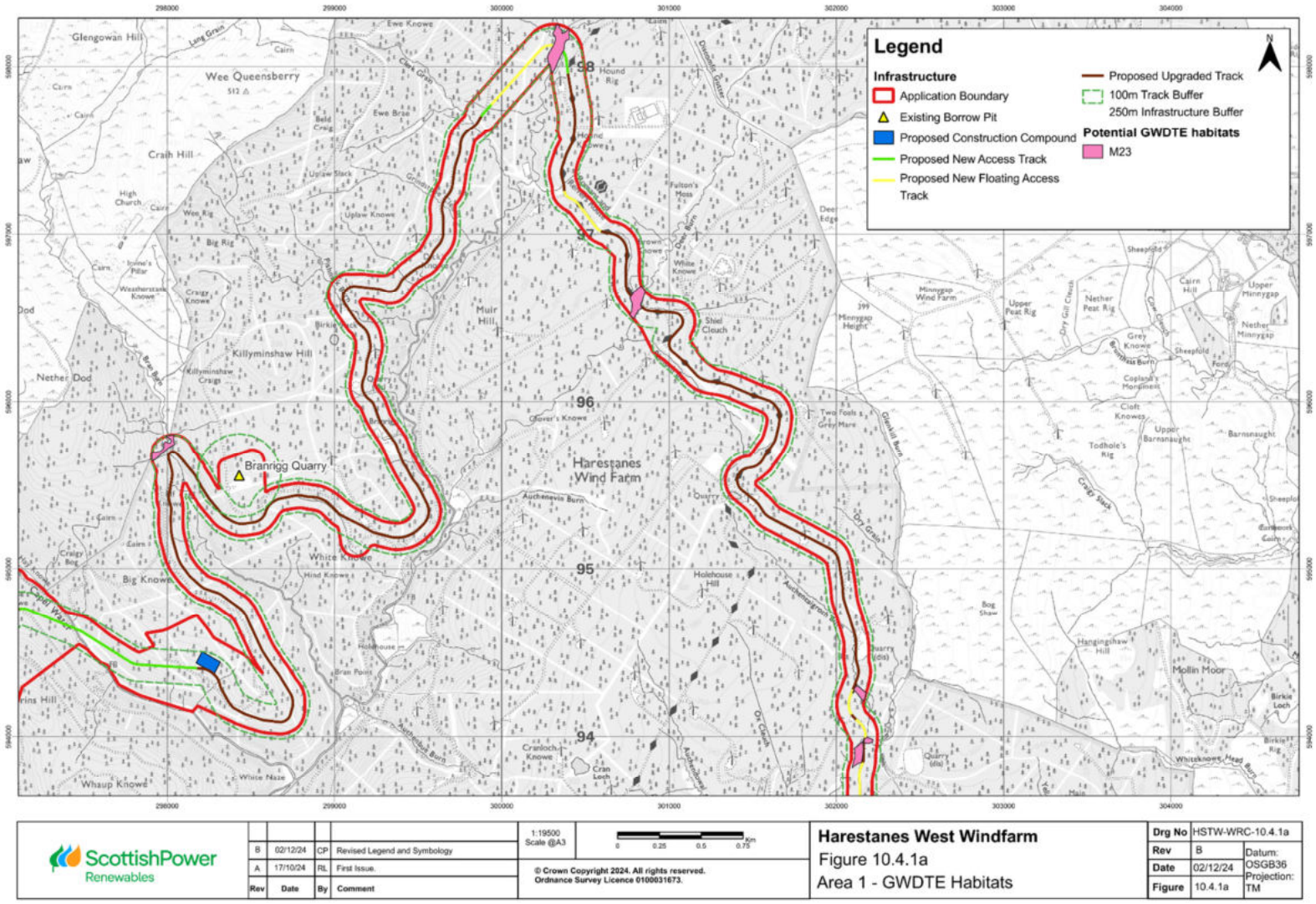


Figure 10.4.1a: Potential GWDTE habitats in Area 1

Assessment and mitigation

4.28 No indications of groundwater at surface were present in Area 1.

4.29 The areas of M23 are all associated with surface watercourses and surface water drainage paths and are therefore most likely to rely on surface water in these areas.

4.30 The areas furthest north and south correlate with pockets of relatively deep peat, further indication that the principal source of water in these areas is most likely to be surface water with rainwater contribution.

4.31 Direct impacts on the identified sensitive habitats include habitat loss from construction of sections of new and upgraded track.

4.32 Where possible, track widening works would be targeted away from identified areas of sensitive habitats, thereby avoiding direct impacts and minimising potential risk.

4.33 Where the new track crosses drainage pathways without distinct watercourses, suitable drainage would be installed below the track to provide continuity in flow across these areas. This would help to maintain the M23 habitat downslope of the track, as well as protecting the track from erosion and water damage.

4.34 Any required modified or additional trackside drainage would be minimised in terms of depth and length and would not discharge directly into or upslope of identified sensitive habitat areas, to minimise potential for water and nutrient flushing in these areas.

Potential GWDTE Area 2

4.35 Area 2 includes the northern part of the turbine area (

4.36 **Figure** 10.4.1b).

Habitats present

4.37 Further areas of M23 rush-pasture are present in Area 2. These include an elongated area along the northern Site boundary, mainly outwith the infrastructure buffer, and a smaller area along the existing track north-east of Turbine 1.

4.38 A small area of M25 mire is present in the north near the Site boundary and exists in conjunction with the M23 habitat, although this is outwith the 100 m and 250 m infrastructure buffers.

Setting and infrastructure

4.39 Area 2 is underlain by sedimentary bedrock of the Queensberry Formation, part of the Gala Group. The Queensberry Formation comprises sandstone, mudstone, siltsone and conglomerate. Where mapped, superficial deposits in Area 2 are mostly till, with smaller pockets of alluvium mostly associated with watercourses.

4.40 The bedrock is described as a low productivity aquifer with a limited amount of groundwater present in the near-surface weathered zone, with flow virtually all occurring through secondary fractures and discontinuities.

4.41 There are several watercourses in Area 2, mainly tributaries to the Water of Ae.

4.42 Infrastructure development in Area 2 includes sections of new and upgraded track, Turbines 1 and 2 and the main construction compound.

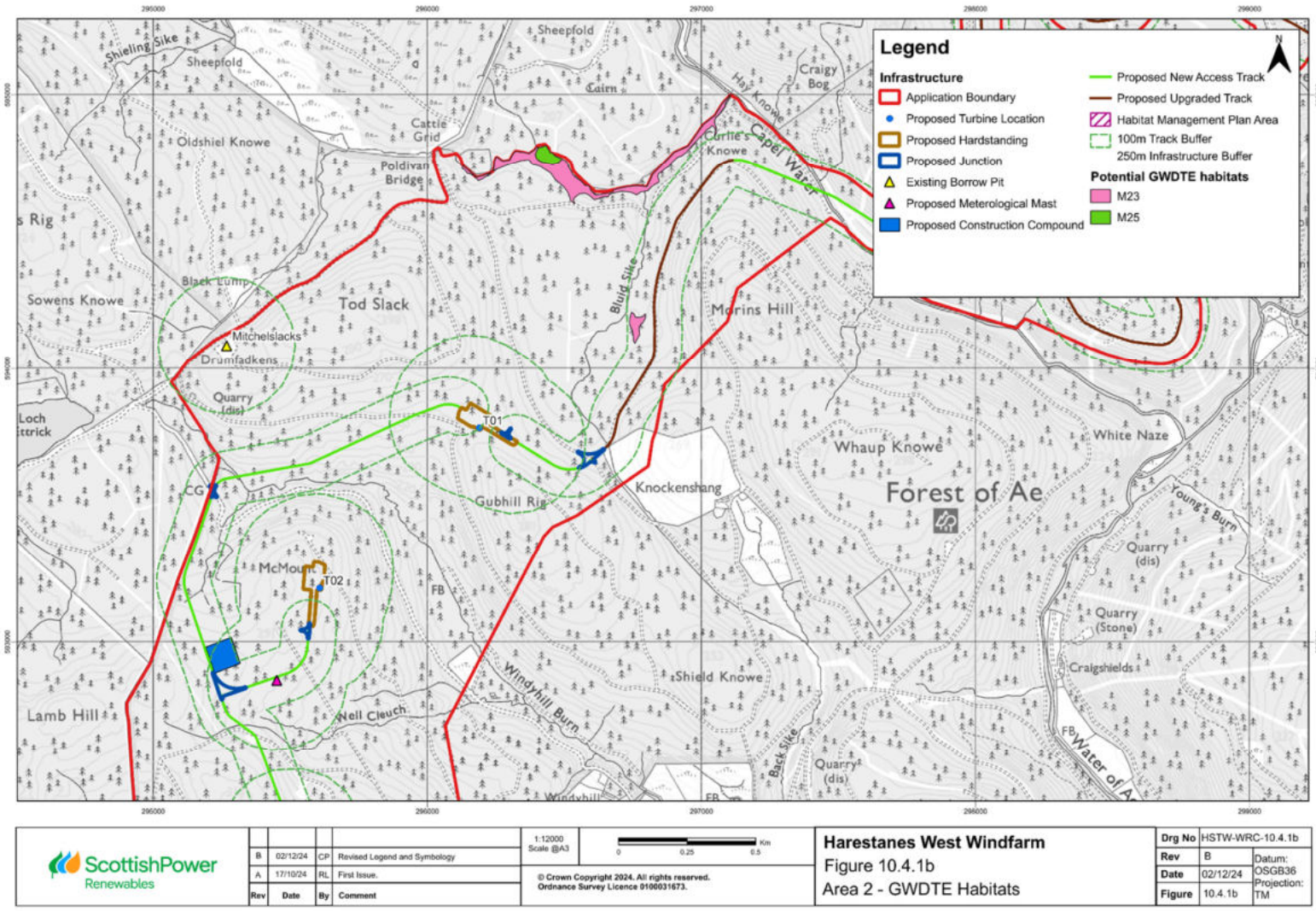


Figure 10.4.1b: Potential GWDTE habitats in Area 2

Assessment and mitigation

4.43 The M23 and M25 habitat in the north of Area 2 are both associated with surface watercourses or surface water flow channels, indicated by the elongated and sinuous form. This association indicates that the principal water source is most likely to be surface water.

4.44 The pocket of M23 in the central part of Area 2 is on the edge of an area relatively flat ground where surface water would naturally collect. This area recorded some very deep peat (>7 m) in the central section. The peat deposits in this area are therefore likely to be ombrotrophic, potentially with some surface water contribution, indicating that rainwater and surface water are the primary water sources.

4.45 Direct impacts on the identified sensitive habitats include habitat loss from construction of sections of new and upgraded track.

4.46 Where possible, track widening works would be targeted to the eastern side, away from and downslope of the identified areas of sensitive habitat, thereby avoiding direct impacts and minimising potential risk.

4.47 Any required modified or additional trackside and hardstanding drainage would be minimised in terms of depth and length and would not discharge directly into or upslope of identified sensitive habitat areas, to minimise potential for water and nutrient flushing in these areas.

Potential GWDTE Area 3

4.48 Area 3 covers the remainder of the turbine area and includes most of the major infrastructure for the proposed Development (**Figure 10.4.1c**).

Habitats present

4.49 Area 3 includes further pockets of M23 rush-pasture. Notable areas are along the proposed new track west and south of Turbine 4 and within the buffer zone of Turbine 8. Other areas are small and sporadic in nature. The area south of Turbine 8 has been identified as a potential Habitat Management Area. The degraded blanket bog in the area is proposed to be restored to a functional bog habitat.

4.50 Two areas of M15 wet heath are located in the central and south-eastern parts of Area 3. One elongated section lies between Turbines 6 and 8 and the other is located to the east of Turbine 10.

4.51 Small pockets of M27 mire are located beside the proposed new track west of Turbine 7.

4.52 Pockets of M6 mire are located north-west of Turbine 7 and within the buffer zones of Turbines 9 and 12.

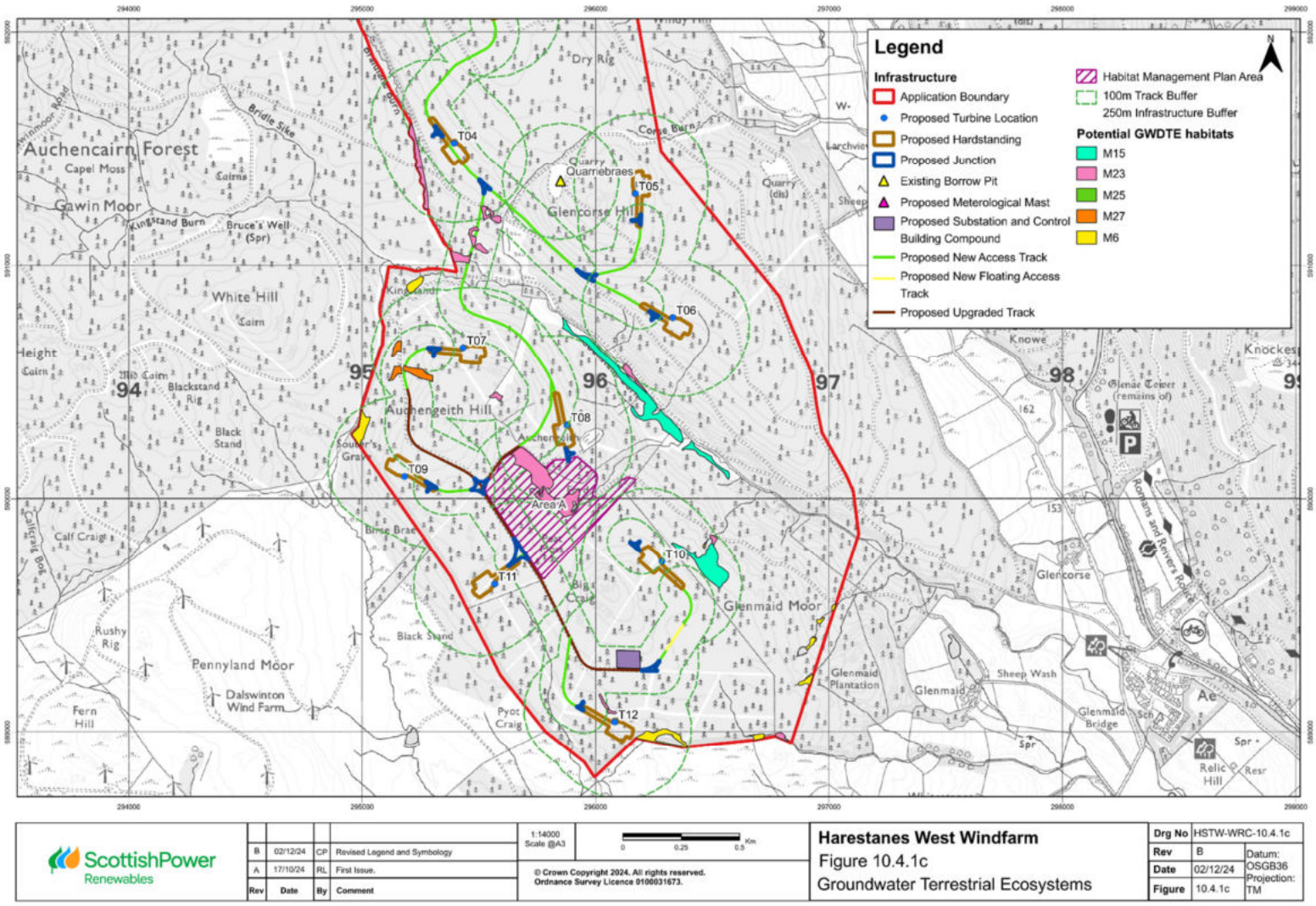


Figure 10.4.1c: Potential GWDTE habitats in Area 3

Setting and Infrastructure

4.53 Area 3 is underlain by sedimentary bedrock of the Queensberry Formation, part of the Gala Group. The Queensberry Formation comprises sandstone, mudstone, siltsone and conglomerate. Where mapped, the superficial deposits are mostly till with some pockets of peat.

4.54 The bedrock is described as a low productivity aquifer with a limited amount of groundwater present in the near-surface weathered zone, with flow virtually all occurring through secondary fractures and discontinuities.

4.55 There are several watercourses in Area 3, mostly tributaries and headwaters to the Water of Ae.

4.56 Proposed infrastructure in Area 3 includes sections of new and floated track and track to be upgraded, Turbines 3-12 and associated hardstandings, extension of existing borrow pits and construction of the substation and compound.

Assessment and Mitigation

4.57 The elongated section of M15 and small pocket of M23 between Turbines 6 and 8 are largely associated with the surface watercourse or surface water flow channels of the Goukstane Burn.

4.58 The area of M15 east of Turbine 10 is located on peat and does not appear to have the same association with surface drainage features. The habitat is a on a topographical flat area where surface water would naturally collect, leading to development of peat. This indicates that habitats in this area are most likely to depend on rainwater for their main water supply.

4.59 The larger areas of M23 around Turbines 4 and 8 are associated with surface watercourses or surface water flow channels. There are also peat deposits in these areas which further indicate the reliance on rainwater and surface water.

4.60 Areas of M27 west of Turbine 7 are associated with peat deposits where access to groundwater would be considerably restricted. Habitats on peat mainly rely on rainwater and shallow through-flow within the vegetated layer.

4.61 The two pockets of M6 to the north-west and south-west of Turbine 7 are associated with surface watercourses or surface water flow channels. The pocket of M6 south-east of Turbine 12 is associated with some deep peat deposits. This indicates that habitats in this area are most likely to depend on rainwater for their main water supply.

4.62 Direct impacts on the identified sensitive habitats include limited habitat loss from construction of sections of new and upgraded track and by the crane pad at Turbine 12, and to a lesser extent by the construction of Turbines 4, 6, 7, 8, 9 and 10.

4.63 Where possible, track widening works would be targeted to the side away from identified areas of sensitive habitats, thereby avoiding direct impacts and minimising potential risk.

4.64 Any required modified or additional trackside and hardstanding drainage would be minimised in terms of depth and length and would not discharge directly into or upslope of identified sensitive habitat areas, to minimise potential for water and nutrient flushing in these areas.

4.65 Where proposed infrastructure interacts with the margin of identified sensitive habitats, micrositing of groundworks should be considered to avoid direct habitat loss. This may be particularly effective for Turbine 12.

4.66 Deeper excavations required for the turbines and borrow pits would have perimeter drainage installed prior to start of excavations. The preferred method would be to use earth bunds, rather than installation of cut-off drains. Cut-off drains would not be used in areas of sensitive habitat unless there are no practical alternative options. All cut-off drains would be minimised in terms of length and depth, to minimise concentration of flows and unnecessary diversion of water. Water discharge from drainage systems would be spread across the ground in order to minimise changes to flow into downstream sensitive habitats.

4.67 Water collecting in excavations for the turbines and borrow pits would be directed into settlement ponds to allow for removal of sediment. Treated water would not be discharged directly into or upslope of identified sensitive habitats areas, to minimise potential for water and nutrient flushing into these areas. If necessary, water would be directed into trackside drainage to avoid potential impacts on sensitive habitat areas.

4.68 There may be options to improve or extend areas of M6, M15 and M23 and M27 habitats through vegetation management and/or drainage management within Area 3 as compensation for the unavoidable direct habitat loss. This would be discussed with the ECoW as part of the construction works mitigation.

5 PROTECTION AND MITIGATION

Design and Mitigation

5.1 The proposed Development design has taken account of identified sensitive habitats and has been designed to avoid these areas where possible, and to minimise incursion into these areas where avoidance is not possible.

5.2 For those areas where avoidance has not been possible, a number of best practice construction methods are available to minimise or mitigate the impacts.

5.3 Wetland habitats are known to be sensitive to changes in their water supply, whether this is from groundwater, surface water or rainwater. The following construction methods would be used for all development on or adjacent to wetland or bog areas:

- Where track sections cross wetland or bog areas, cross-drainage would be provided within the track construction to ensure continuity of flow. This may take the form of a drainage layer within the track, suitably closely-spaced drainage pipes, or both as appropriate. These would be determined on a case-by-case basis to suit each individual area.
- Removing protective layers of soil and superficial deposits makes groundwater vulnerable to pollution from leaks or spills from vehicles or equipment used during construction. Earthworks would be kept to a practical minimum within these areas, to reduce the area of wetland affected by the construction works.
- Trackside drainage would be kept to a practical minimum and would only be installed where required to protect the track from erosion.
- All works through and adjacent to wetland areas would be supervised by the ECoW.
- Location-specific mitigation, including drainage segregation to avoid 'flushing' from excavation works and micrositing to avoid specific higher sensitivity areas would be identified and established where appropriate.

Monitoring

5.4 Targeted monitoring would be put in place to provide a check on the identified wetland areas and to ensure that mitigation and protection measures are in place and effective.

5.5 All areas of sensitive habitat would be visited and assessed by the ECoW prior to any construction work. Assessment would include collection of representative photographs of the areas which are most likely to be affected by the works. Regular assessment visits would be undertaken throughout the construction period and for a minimum of 12 months after reinstatement to ensure that habitat protection is effective, and any restoration and recovery works become established.

5.6 Surface water monitoring would be established within the existing watercourse network. Details are provided in the EIA Report **Chapter 10: Hydrology, Hydrogeology, Geology and Soils**.

5.7 Proposed habitat monitoring would begin at least 6 months prior to construction work, would continue throughout the construction period and for at least 12 months following reinstatement.

6 CONCLUSIONS

6.1 A detailed assessment of the interactions between the proposed works for the proposed Development and any potentially groundwater-dependent terrestrial ecosystems has been undertaken.

6.2 The potentially groundwater-dependent NVC communities identified within the Application Boundary are:

- M6 mire;
- M15 wet heath;
- M23 rush-pasture;
- M25 mire; and
- M27 mire.

6.3 M6 mire has potentially high groundwater dependency in a Scottish setting. M15 wet heath, M23 rush pasture and M27 mire have potentially moderate groundwater dependency in a Scottish setting. M25 mire has potentially moderate to low groundwater dependency in a Scottish setting.

6.4 Owing to the distribution of habitats within the Application Boundary, identified habitats have been assessed in smaller sub-areas. These include the site access to turbine areas, the northern area of the Site and the southern area of the Site.

6.5 The potentially groundwater-dependent habitats have been assessed specifically within the context of the proposed Development, considering the local bedrock and superficial geology, peat distribution and site observations.

6.6 Superficial deposits within the study area consist mainly of till, peat deposits and alluvium. Peat deposits would act to insulate the groundwater in the bedrock from the ground surface in areas where they are present, leading to reliance on rainwater and surface water flow. Although till and alluvium may contain groundwater in some quantities, their extent at the Site is relatively limited and till deposits are noted to include a high proportion of clay material which would prevent groundwater flow. It is likely that the main water supply for all sensitive habitats is a combination of rainwater and surface water.

6.7 Impacts to sensitive habitats would arise from direct habitat loss as a result of construction activity; and indirect habitat loss or modifications arising from changes to water or nutrient supply to the habitats resulting from upslope construction works and installation of drainage structures such as ditches and earth bunds.

6.8 Impacts to wetland habitats and watercourses would be kept to a practical minimum through use of best practice construction and mitigation measures. Specific mitigation measures, to avoid changes to the wetland hydrochemistry through ‘flushing’ of excavated material in surface runoff, have been set out and would be adhered to during all site works. Careful construction to ensure suitable continuity of flow across site tracks would help to minimise any potential impacts to the wetland habitats present within the Application Boundary.

7 REFERENCES

BGS (2024a). GeoIndex online geological mapping. British Geological Survey. Available at: http://mapapps2.bgs.ac.uk/geoindex/home.html, accessed 09/2024.

BGS (2024b). BGS Lexicon of Named Rock Units. Available at: https://www.bgs.ac.uk/technologies/the-bgs-lexicon-of-named-rock-units/, accessed 09/2024.

CEH (2024). Flood Estimation Handbook Web Service. Centre for Ecology and Hydrology. Available at: https://fehweb.ceh.ac.uk/ (subscription service), accessed 09/2024.

Isherwood, C.E. (2013). Wetland Types and Groundwater Dependence. Unpublished MSc Dissertation, School of Civil Engineering and Geoscience, Newcastle University.

JNCC (2024). 7130 Blanket Bogs: Raised bogs and mires and fens. Available at: https://sac.jncc.gov.uk/habitat/H7130/, accessed 09/2024.

Met Office (2024) UK climate averages, Dumfries, Crichton Royal No 2. Available at: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcv3mcrf9, accessed 09/2024.

Met Office (2016) Western Scotland: climate. Available at: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/uk-past-events/regional-climates/western-scotland_-climate---met-office.pdf, accessed 09/2024.

NatureScot (2016). Scotland's Soils, Carbon and Peatland 2016 Map. Available at: https://soils.environment.gov.scot/maps/thematic-maps/carbon-and-peatland-2016-map/, accessed 09/2024.

SEPA (2017a). Planning guidance on onshore windfarm developments. Scottish Environment Protection Agency, Land Use Planning System Guidance Note 4 (LUPS-GU4). Available at: https://www.sepa.org.uk/media/136117/planning-guidance-on-on-shore-windfarms-developments.pdf, accessed 09/2024.

SEPA (2017b). Guidance on assessing the impacts of development proposals on groundwater abstractions and groundwater dependent terrestrial ecosystems. Scottish Environment Protection Agency, Land Use Planning System Guidance Note 31 (LUPS-GU31). Available at: https://www.sepa.org.uk/media/144266/lups-gu31-guidance-on-assessing-the-impacts-of-development-proposals-on-groundwater-abstractions-and-groundwater-dependent-terrestrial-ecosystems.pdf, accessed 09/2024.

Soil Survey of Scotland (1981). Soil maps of Scotland at a scale of 1:250,000. Macaulay Institute for Soil Research, Aberdeen. Available at: https://soils.environment.gov.scot/maps/soil-maps/national-soil-map-of-scotland/, accessed 09/2024.

UKTAG (2004). Guidance on the identification and risk assessment of groundwater dependent terrestrial ecosystems. UK Technical Advisory Group on the Water Framework Directive. Available at: http://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Risk%20assessment%20of%20terrestrial%20ecosystems%20groundwater_Draft_210104.pdfhttp://www.wfduk.org/resources%20/risk-assessment-groundwater-dependent-terrestrial-ecosystems, accessed 09/2024.

UKTAG (2009). Annex 1: NVC plant communities and dependency on groundwater. Annex 1 to UKTAG (2004). Available at: http://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environme

nt/UKTAG%20guidance%205%20ab%20ANNEX%201%20updated%205%20October%202009.pdf, accessed 09/2024.

296000 300000 304000 308000

596000 592000

Legend

N

Infrastructure

- Application Boundary
- Proposed Turbine Location
- Proposed Hardstanding
- Proposed Junction
- Existing Borrow Pit
- Proposed Meterological Mast
- Proposed Substation and Control Building Compound
- Proposed Construction Compound
- Proposed Parking Area
- Proposed New Access Track
- Proposed New Floating Access Track
- Proposed Upgraded Track
- Habitat Management Plan Area
- 100m Track Buffer
- 250m Infrastructure Buffer

Potential GWDTE habitats

- M15
- M23
- M25
- M27
- M6

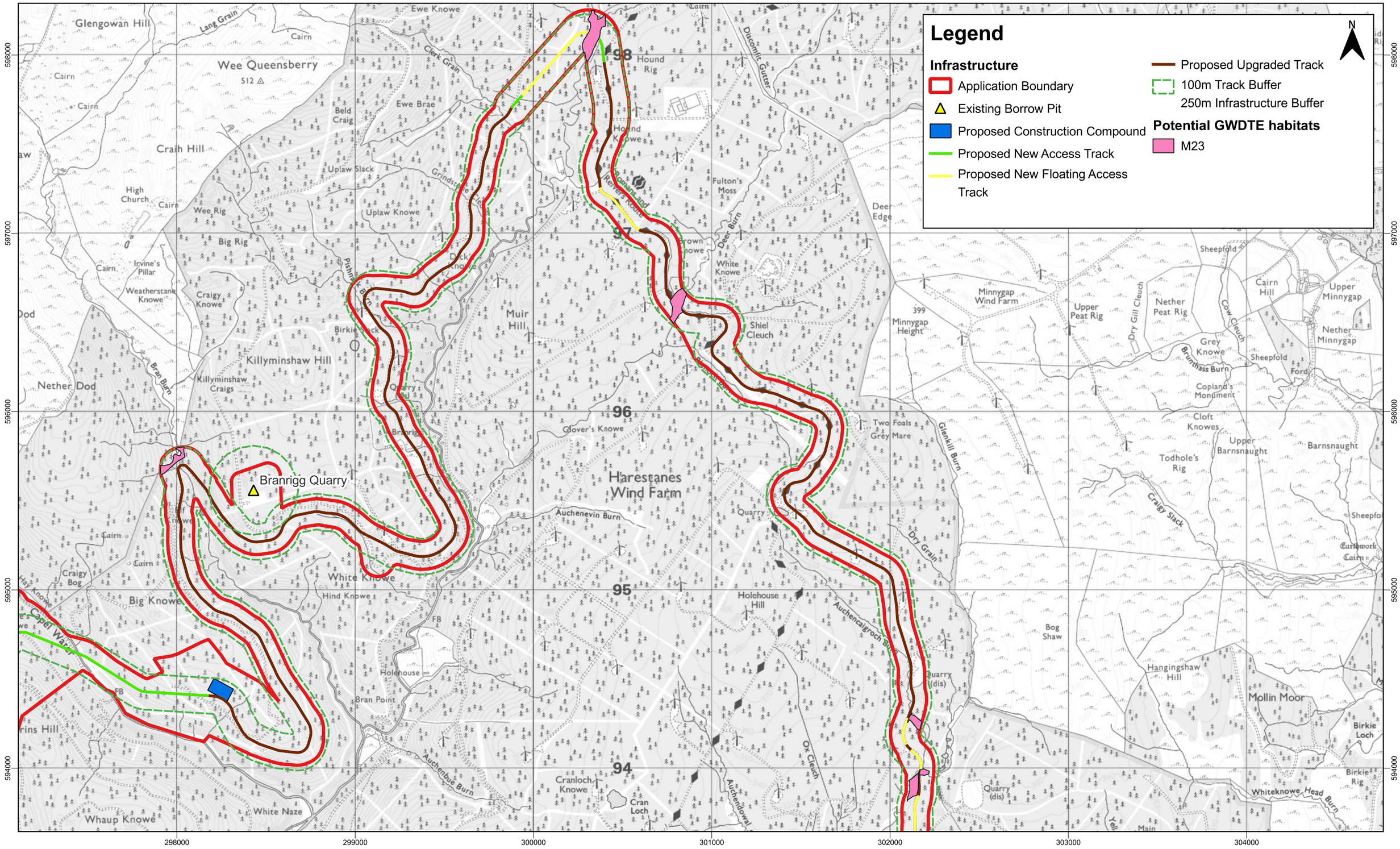
Branrigg Quarry
Mitchelslacks
T01
T02
T03
T04
Quarriebraes
T05
T06
T07
T08
T09
Area A
T10
T11
T12
Area B
Harestanes Wind Farm
Forest of Ae
Auchencairn Forest

296000 300000 304000 308000

ScottishPower Renewables				1:41000 Scale @A3	0 0.75 1.5 Km
	B	02/12/24	CP	Revised Legend and Symbology	
	A	17/10/24	RL	First Issue.	
	Rev	Date	By	Comment	

Harestanes West Windfarm
Figure 10.4.1
Groundwater Terrestrial Ecosystems

Drg No	HSTW-WRC-10.4.1	
Rev	B	Datum: OSGB36 Projection: TM
Date	02/12/24	
Figure	10.4.1	



B	02/12/24	CP	Revised Legend and Symbology
A	17/10/24	RL	First Issue.
Rev	**Date**	**By**	**Comment**

1:19500 Scale @A3

0 0.25 0.5 0.75 Km

Harestanes West Windfarm

Figure 10.4.1a

Area 1 - GWDTE Habitats

Drg No	HSTW-WRC-10.4.1a		
Rev	B	Datum: OSGB36 Projection: TM	
Date	02/12/24		
Figure	10.4.1a		

Legend

Infrastructure

- Application Boundary
- Proposed Turbine Location
- Proposed Hardstanding
- Proposed Junction
- Existing Borrow Pit
- Proposed Meterological Mast
- Proposed Construction Compound
- Proposed New Access Track
- Proposed Upgraded Track
- Habitat Management Plan Area
- 100m Track Buffer
- 250m Infrastructure Buffer

Potential GWDTE habitats

- M23
- M25

N

T01

T02

295000 296000 297000 298000 299000

595000 594000 593000

Rev	Date	By	Comment
B	02/12/24	CP	Revised Legend and Symbology
A	17/10/24	RL	First Issue.

1:12000 Scale @A3

0 0.25 0.5 Km

Harestanes West Windfarm

Figure 10.4.1b

Area 2 - GWDTE Habitats

Drg No	HSTW-WRC-10.4.1b
Rev	B
Date	02/12/24
Figure	10.4.1b

Datum: OSGB36
Projection: TM

294000 295000 296000 297000 298000 299000

592000 591000 590000 589000

Legend

N

Infrastructure

- Application Boundary
- Proposed Turbine Location
- Proposed Hardstanding
- Proposed Junction
- Existing Borrow Pit
- Proposed Meterological Mast
- Proposed Substation and Control Building Compound
- Proposed New Access Track
- Proposed New Floating Access Track
- Proposed Upgraded Track
- Habitat Management Plan Area
- 100m Track Buffer
- 250m Infrastructure Buffer

Potential GWDTE habitats

- M15
- M23
- M25
- M27
- M6

T04 T05 T06 T07 T08 T09 T10 T11 T12

Area A

Auchencairn Forest · Capel Moss · Gawin Moor · Kingstand Burn · Bruce's Well (Spr) · Bridle Sike · Braunie Burn · Dry Rig · Corse Burn · Quarry Quarriebraes · Glencorse Hill · Quarry (dis) · Larchview · Sheep · White Hill · Cairn · Height Cairn · Mid Cairn · Blackstand Rig · Black Stand · Souter's Grave · Auchengeith Hill · Auchengeith · Birse Brae · Peat Hags · Big Craig · Calf Craig · Calfcraig Bog · Rushy Rig · Pennyland Moor · Dalswinton Wind Farm · Fern Hill · Pyot Craig · Glenmaid Moor · Glencorse · Glenmaid Plantation · Glenmaid · Sheep Wash · Glenmaid Bridge · Knowe · Glenae Tower (remains of) · Romans and Reivers Route · Relic Hill · Resr · Spr

B	02/12/24	CP	Revised Legend and Symbology	
A	17/10/24	RL	First Issue.	
Rev	**Date**	**By**	**Comment**	

1:14000 Scale @A3

0 0.25 0.5 Km

Harestanes West Windfarm

Figure 10.4.1c

Groundwater Terrestrial Ecosystems

Drg No	HSTW-WRC-10.4.1c	Datum: OSGB36 Projection: TM	
Rev	B		
Date	02/12/24		
Figure	10.4.1c		