Technical Appendix 6.5: Groundwater Dependent Terrestrial Ecosystems

This page is intentionally blank.

Technical Appendix 6.5: Groundwater Dependent Terrestrial Ecosystems

Contents

Technical Appendix 6.5: Groundwater Dependent Terrestrial Ecosystems

Introduction

Groundwater Dependent Terrestrial Ecosystems (GWDTEs) are types of wetlands that are specifically protected under the Water Framework Directive. GWDTEs should be considered in terms of their hydrology and their ecology. This Appendix has been provided to 'bridge the gap' between the two disciplines of Ecology and Hydrology by providing information from both disciplines to complete the assessment of potential effects of the proposed Appin Wind Farm (hereafter referred to as the Proposed Development) on GWDTEs.

This Appendix should be read in conjunction with **Chapter 6: Geology, Hydrology and Peat**, **Chapter 7: Ecology** and **Appendix 7.1: Habitats and Vegetation** of the EIA Report. The assessment draws together detailed information from both chapters, summarising where applicable.

The assessment methodology follows the methods in **Chapter 6: Geology, Hydrology and Peat** of the EIA Report to determine the sensitivity of the receptor, the magnitude of effect and therefore the significance of the effect as set out in **Tables 6.2, 6.3** and **6.4**.

The Scottish Environmental Protection Agency (SEPA) has produced detailed guidance on how to assess impacts of proposed developments on GWDTEs and the following assessment is based on the SEPA guidance (SEPA, 2024).

Identification of GWDTE

The following is an excerpt from the EU GWDTE Technical Report (European Commission, 2012) which defines a GWDTE in the context of the Water Framework Directive:

'In order for terrestrial ecosystems to be considered as part of the classification for groundwater bodies (GWBs), they need to be 'directly dependent' on the groundwater body (GWB). This means that the GWB should provide quantity (flow, level) or quality of water needed to sustain the ecosystems which are the reasons for the significance of the GWDTE. This critical dependence upon a GWB is most likely where groundwater supplies the GWDTE for a significant part or a significant time period of the year.'

Therefore, for a habitat to be designated as a GWDTE, there must be significant hydrogeologic connectivity between the groundwater body and the habitat.

Potential GWDTEs were initially identified during Phase 1 habitat and National Vegetation Classification (NVC) surveys (see below). Potential GWDTEs were then visited by the hydrologists to characterise the hydrogeological connectivity of each habitat unit and to determine the level of groundwater dependency. The results of the GWDTE assessment are described below.

Habitat and Vegetation Surveys

Phase 1 habitat and NVC surveys were undertaken on the 30th July 2021 and 2nd and 3rd August 2021 (with a habitat 'validation' survey undertaken on 8th October 2024 to check habitats on-site were consistent with the original surveys in 2021). The survey extent and results are described in **Appendix 7.1: Habitats and Vegetation**. Where Phase 1 habitat types had potential to support GWDTE vegetation communities, further investigation was undertaken. Phase 1 habitat types that have potential to support GWDTE communities include:

- B2.1 Unimproved neutral grassland;
- B5 Marshy Grassland;
- B1.1 Unimproved acid grassland (in damper areas); and
- A1.1.1 Broadleaved semi-natural woodland.

Where appropriate, within habitats coded as above, the NVC method (Rodwell, J.S. 1991-2000) was used to identify potential GWDTE communities. However, to avoid unnecessary extensive botanical study, where Phase 1 habitat types were obviously attributable to surface water movement, rather than groundwater movement, no NVC was completed. This included stands of marshy grassland in hollows on steep slopes, and obvious ombrogenous (rainwater fed) bogs etc.

However, where water influence was less clear, NVC was completed. As above, NVC data was also considered in light of wider influencing factors. Upon determining the NVC community, a decision tool was used to establish the level of dependency of each community on groundwater. **Table 1** below shows the decision-making tool used in determining GWDTE presence.

When assessing potential effects to a GWDTE, the ecological importance of a GWDTE receptor is assessed in accordance with SEPA guidance (2024) on factors such as designated sites, conservation status (e.g. Scottish

Biodiversity List), connectivity, extent within Scotland, and supporting notable or particularly sensitive species. Where the ecological importance of a GWDTE is assessed to be lower than the groundwater-dependency status of the receptor, a lower sensitivity may be selected and presented with the corresponding rationale.

Table 1 - GWDTE Decision Tool (European Commission, 2012)

Criteria	Yes	No
A. Is the GWDTE vegetation evidently influenced by groundwater? (i.e. base-enriched (M10, M11, M37 and/or M38) and/or discharging from an evident point source such as a spring head (M31, M32, M33).		
If the answer to A is 'Yes' then field assessment ends at this stage and the GWDTE is treated as 'high', as per the guidance. If 'No', continue to B.		
B. Is the GWDTE polygon associated with an evident surface water feature? i.e. is the vegetation located within one of the following topographic locations:		
Watershed/ridge		
Watercourse		
Floodplain		
Ponding location, pond, loch, etc (localised depression)		
Surface water conveyance (drain, gully, rill, etc.)		
If the answer to B is 'Yes' then the GWDTE polygon is no more than 'moderate' and very likely to be 'low'. Additional floristic and environmental data should be collected, including photographs to allow for further, desk-based determination of the groundwater dependency. If 'No', continue to C.		
C. Is the GWDTE polygon associated with an ombrogenous system? i.e. with blanket bog or wet heath habitat. This is especially relevant to M6:		
Presence/persistence of distinctive bog habitat, species and/or associations.		
Deep peat not confined to depressions/valleys (>0.5 m visible in drains or hagged areas).		
If the answer to C is 'Yes' then the GWDTE is no more than 'moderate' and very likely to be 'low'. Additional floristic and environmental data should be collected, including photographs to allow for further, desk-based determination of the groundwater dependency.		

GWDTE Baseline

Figure 7.3a of **Chapter 7: Ecology** presents the Phase 1 habitat survey results and **Figure 7.4** of **Chapter 7** presents the NVC survey results. The habitat survey results are discussed in detail in **Appendix 7.1: Habitats and Vegetation** and are not repeated here.

Based on the SEPA guidance (SEPA, 2024), NVC class MG9 and M23 have the potential to have a dependency on groundwater.

It should be noted that polygons mapped as *potential* GWDTEs based on ecology data may comprise a mosaic of NVC communities, for example M23a might only cover 20% of a polygon, with the remaining 80% being some other non-GWDTE communities. To be conservative, the entire polygon was considered as *potentially* groundwater dependent derived from **Figure 7.4.** A number of potentially groundwater dependent habitats were identified within the Site. These areas typically had at least some components of M23 habitat. These areas are associated with surface water features when it occurs close to watercourses. Otherwise, it can occur as larger expanses on wet level ground.

Within the Site, these areas are constrained to saturated valley bottoms such as that of the Appin Burn and its tributaries. Specifically, the entire valley base and upper headwater area of the Appin Burn was identified as being a mosaiced habitat of M23/MG9 communities. Elsewhere, tributaries close to Conrick Hass and Shiel Cleuch were found to consist of solely M23 and mosaiced M23/U20, respectively. The M23 sub-community found within the Site is M23a (*Juncus acutiflorus*) and generally reflects damp and peaty conditions, with nothing of note floristically to indicate an input of nutrients. Based on hydrogeological setting, the M23a habitats within the Appin Burn valley base, near Conrick Hass and near Shiel Cleuch are considered majority surface-water fed with, at most, low groundwater dependency and are not considered further.

Ecological surveys of the western access track show that this part of the Site is comprised almost entirely of Sitka spruce forested / previously forested habitats, with some areas of marshy grassland. No groundwater dependent habitats were identified along the entire western access track route and so this area is not considered further.

During surveys undertaken by the hydrology team and following the steps outlined in **Table 1**, it was identified that there is one GWDTE area within the Site with potential to have a dependency on groundwater. This area, associated with a groundwater spring/flush around the upper headwaters of the Appin Burn, is associated with a mix of the MG9 and M23 NVC habitats.

A GWDTE assessment survey was undertaken by the hydrology team in June 2022 to visit the all the *potential* GWDTE locations to establish the level of groundwater dependency. The upper headwater portion of the Appin Burn, consisting of mosaiced M23/MG9 communities was ground-truthed as moderately dependent based on hydrogeological setting and groundwater analysis during survey. This GWDTE, designated GWDTE 1, is shown in **Photo 1**. None of the other *potential* GWDTEs were assessed as groundwater dependent and are not GWDTE.

Photo 1 - GWDTE 1 – Flush line visible on the southern valley flank of the Appin Valley headwater area

Based on the results of the surveys by hydrologists and ecologists and the desk-based assessment, a number of adjustments were made to the turbine locations to consider the presence of the GWDTE. However, given the location of the confirmed GWDTE, it was not possible to meet the recommended 250 m buffer for siting turbines or the 100 m buffer for siting tracks and trenches, as per SEPA guidance (SEPA, 2024). The access tracks and turbines were placed as sympathetically as possible with respect to the GWDTE, within the confines of other constraints. **Chapter 3: Site Selection and Design Evolution** of the EIA Report, provides more detail on why it was not possible to achieve the 100 m and 250 m buffers.

A summary of the confirmed GWDTE is provided in **Table 2**.

Table 2 - Details of the GWDTE within 100 m of excavations <1 m deep and 250 m from excavations >1 m deep

Potential GWDTE	Phase 1	NVC	Potential groundwater dependency based on NVC class (Rodwell, J.S. 1991-2000)	Hydrogeological setting	Actual groundwater dependency based on site surveys	Distance from infrastructure
GWDTE 1	M23/MG9 springs and flushes	MG9 *Holcus lanatus–Deschampsia cespitosa* grassland M23a *Juncus acutiflorus* Rush-pasture	Moderate to High	Located at south-east of Colt Hill within the upper headwaters of the Appin Burn. Clear vegetation change along flush line. Running water observed. Spring/flush head was too vegetated to confirm that groundwater was the only source. Likely combination of surface	Moderate, based on the association with evident surface water features such as artificial peat drains cut into the upgradient slope and a lack of clear/definitive	GWDTE extent is at closest: 50 m from T3 hardstanding 90 from T3 base 65 m from proposed new access track for T3 40 m from proposed new

Potential GWDTE	Phase 1	NVC	Potential groundwater dependency based on NVC class (Rodwell, J.S. 1991-2000)	Hydrogeological setting	Actual groundwater dependency based on site surveys	Distance from infrastructure
				and groundwater contributions to the flow.	discharge points.	access track leading to T2 140 m from T2 hardstanding 150 m from T2 base 120 m from proposed new access track leading to T1

Effects Assessment

Following ecological identification of *potential* groundwater dependent habitats and an assessment of the levels of groundwater dependency of the specific habitats, this section provides an assessment of the potential effects of the Proposed Development upon groundwater flow to GWDTE 1 (described in **Table 2**). All other *potential* GWDTEs were considered to have at most a low dependency on groundwater and are not GWDTE and therefore not considered further.

A site-specific qualitative risk assessment of GWDTE 1 was carried out based on the available data on local geology, hydrology, ecology and hydrogeological regime.

There is no available data on sub-surface flows and in the absence of data, it is considered that the movement of sub-surface water is primarily driven by topography. Flow routing analysis was carried out in QGIS software using 50 m-resolution Ordnance Survey Terrain data. In the absence of data on ground water levels and flow paths, analysis of topography and surface water flows paths was used to infer hydrological and hydrogeological connectivity to the Proposed Development infrastructure.

The assessment of impact on a groundwater flow path is made with reference to distance, slope, aspect, typical water table levels and features such as watercourses. This assessment is made with imperfect knowledge of the exact extent that a particular impact may have and imperfect knowledge of specific sub-surface flow paths. As such, it takes a precautionary approach using the available information.

Two specific aspects are considered in the assessment. One is the likelihood of an impact upon a flow path feeding an area of groundwater. The second aspect is the likelihood that an area of groundwater may be drained at an un-naturally fast rate following the introduction of drainage for infrastructure / access tracks / tower bases.

The SEPA guidance (SEPA, 2024) for assessing impacts of development on GWDTEs recommends a 250 m buffer zone from all excavations deeper than 1 m and a 100 m buffer for excavations less than 1 m deep. The two buffers are shown on **Figure 6.3** in the EIA Report. Based on the Proposed Development description and construction methods outlined in **Chapter 4: Description of Proposed Development** of the EIA Report, excavations for the turbine foundations and borrow pits will be deeper than 1 m, while access tracks and other infrastructure (compounds and substation) will be less than 1 m.

GWDTE 1

The proposed new access track leading to T1, T2 and T3 falls within the 250 m buffer to the south, west and north of GWDTE 1. The new track also crosses into the 100 m buffer to the west of the GWDTE. The hardstanding for T3 straddles the 100 m buffer boundary to the south of the GWDTE, while T3 itself lies just within the 100 m buffer. T2 and the associated hardstanding lies within the 250 m buffer. Based on Site surveys (see **Table 2**), the GWDTE here is considered to be moderately dependent on groundwater, but it is likely that there is both a surface water and groundwater contribution to the flow. The location of the GWDTE Polygon is shown on **Image 1** below and described in context with available geological, peat and hydrological information.

Ecologically, the mosaic of M23/MG9 M23 was fairly species-poor for this community and the importance of the habitat was assessed to be of Low importance. Based on the moderate dependency on groundwater and low ecological importance, the sensitivity of the receptor is **low**.

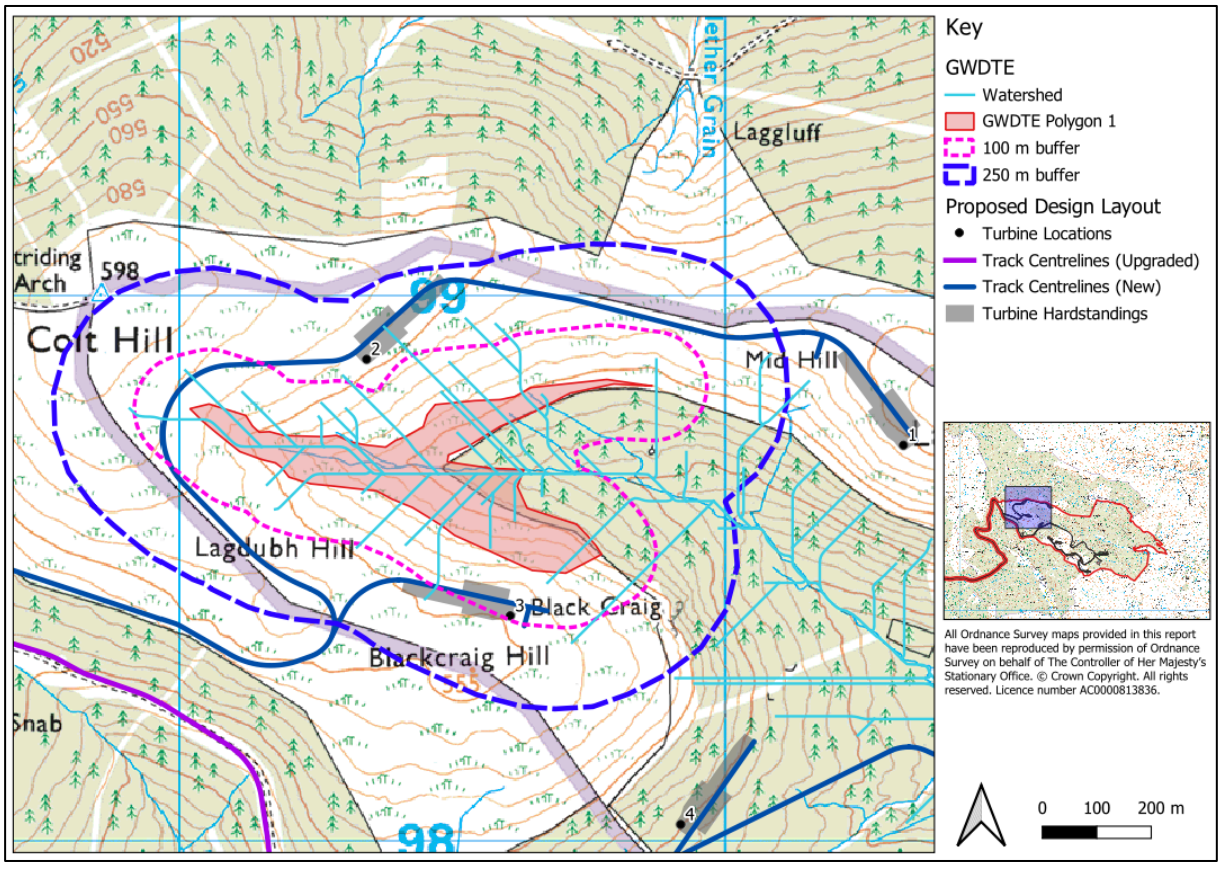
British Geological Survey (BGS) 1:50K bedrock geology maps indicate that the geology around GWDTE 1 comprises of Wacke sedimentary rock of the Portpatrick Formation (**Figure 6.4** of the EIAR Report). This formation is part of a low to very low productivity greywacke aquifer body. Flow is fracture-based, with negligible intergranular permeability.

BGS 1:50K superficial geology maps indicate that the superficial drift geology at the GWDTE comprises of sedimentary glacial till deposits (**Figure 6.4** of the EIAR Report).

The NatureScot Carbon and Peatlands Map 2016 (**Figure 6.6** of the EIAR Report) shows that GWDTE lies within a mosaic of Class 3, Class 4, Class 5 and a small portion of Class 1 peatland. However, the peat depth survey (**Figure 6.7** of the EIA Report) undertaken for the EIA Report indicates some areas of peat between 50 cm – 100 cm in depth at the GWDTEs, with the majority of the Polygon consisting of depths of less than 30 cm.

GWDTE 1 lies across the upper headwater area of the Appin Burn, which originates south-east of Colt Hill and runs through the middle of the Polygon from west to east. Surface water flow path analysis of 50 cm OS LiDAR Digital Terrain Model (DTM) indicates that the GWDTE drains to the Appin Burn, with flow paths controlled by the steep sides of the Appin Burn valley. The surface water catchment to the GWDTE is estimated to measure roughly 0.4 km^2, comprising drainage from peatland areas from the surrounding hilltops to the south, west and north.

Image 1 - Effects Assessment - GWDTE 1 and Proposed Infrastructure



Excluding a small section of new access track leading to T1 to the north-east of the GWDTE Polygon, which drains to an area further east, surface water from all infrastructure within the 250 m and 100 m buffers drains towards the GWDTE. Excavations at T2 and T3 could have a potential effect on the GWDTE.

However as both T2 and T3 lie 32 m and 7 m higher than the GWDTE, respectively it is not considered likely that the groundwater table at the GWDTE will be dewatered by excavations for the turbines, However, it is possible that there may be temporary effects to upgradient groundwater supply due to excavations at T2 and T3. There is also a risk that runoff from the access tracks could result in increased sediment/pollution draining towards the GWDTE and that the access track could potentially block sub-surface flow paths to the GWDTE.

Based on the above, it is considered that the Proposed Development may have a temporary effect on groundwater quality at the GWDTE. Given that there is a moderate groundwater dependence of the GWDTE (as it

is partly sourced by surface/sub-surface water draining the upslope peat), the effect on the GWDTE prior to additional mitigation is considered to be of temporary and minor magnitude, resulting in an effect of **minor to negligible significance** during the construction phase. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

Embedded mitigation measures (e.g. SuDS, silt fences and best practise construction techniques) will minimise the risk of pollution/sediment to the GWDTE. Best practice construction techniques as set out in the guidance document "Good Practice during Wind Farm Construction" (Scottish Renewables, 2024) will be employed to ensure that the infrastructure does not affect groundwater flow or chemistry to sensitive receptors.

Additional mitigation measures will be put in place during construction to maintain the baseline subsurface flows towards the GWDTEs and to ensure that any proposed track drainage does not alter the natural drainage conditions of the site. The track drainage will be designed with appropriate drainage features to avoid blocking subsurface and surface flow pathways. Additional SuDS and fences will be employed on the downslope side of all access tracks sloping down towards the GWDTE, the north (downslope) side of T3 and the south/southeast side of T2 to eliminate potential pollutants effecting groundwater quality which could recharge the GWDTE. Specific measures will be implemented on a case-by-case basis as directed by the Ecological Clerk of Works (ECoW) during construction.

Monitoring will be put in place to assess the quantitative and chemical effect of the infrastructure to determine that the groundwater flow and quality to the GWDTEs are not statistically significantly changed post-construction. Monitoring will be carried out based on SEPA guidance (SEPA, 2024) and will comprise groundwater monitoring at flush line. Pre-construction monitoring will commence 12 months before construction commences. Monitoring reports will be prepared, and remedial actions identified if statistically significant changes to the groundwater flow or chemistries to sensitive receptors are identified.

Additional mitigation and monitoring will reduce the magnitude of effects on the GWDTE to negligible and the significance of the residual effect is considered to be **negligible.**

Summary

GWDTE locations were considered early in the design process for the Proposed Development.

However, there is one GWDTE where infrastructure is proposed within SEPA's recommended buffers. This has been assessed in detail and reported herein. Based on the GWDTE Decision Tool (**Table 1**) the GWDTE has been assessed to have a moderate dependence on groundwater and is considered to be of low ecological importance, based on habitat surveys.

The effects of the Proposed Development on the GWDTE location (assuming embedded mitigation measures, such as construction SUDS, are in place) are summarised in **Table 3** below. Additional mitigation measures at each location are summarised in the second last column of the table.

Table 3- Summary of Assessment of GWDTE within 100 m of excavations < 1 m deep and 250 m from excavations > 1 m deep

GWDTE	Groundwater dependency based and ecological importance based on site surveys	Distance from infrastructure	Significance before additional mitigation (including embedded mitigation measures)	Additional Mitigation	Significance after additional mitigation
GWDTE 1	Moderate dependency and low ecological importance Low sensitivity	GWDTE polygon is at closest: 50 m from T3 hardstanding 90 from T3 base 65 m from proposed new access track for T3 40 m from proposed new access track leading to T2 140 m from T2 hardstanding 150 m from T2 base	Minor to Negligible	Access track will be designed to enable subsurface flows to be maintained. Additional silt fences, silt traps and SuDS will be emplaced on the downslope side of infrastructure and utilised during construction Pre- and post-construction monitoring.	Negligible

GWDTE	Groundwater dependency based and ecological importance based on site surveys	Distance from infrastructure	Significance before additional mitigation (including embedded mitigation measures)	Additional Mitigation	Significance after additional mitigation
		120 m from proposed new access track leading to T1			

References

Botanaeco (2018) GWDTE Decision Tool. Available online at: https://botanaeco.co.uk/gwdte

European Commission, Directorate-General for Environment, Technical report on groundwater dependent terrestrial ecosystems. Technical report. No 6, Publications Office, 2012, https://data.europa.eu/doi/10.2779/93018

Rodwell, J.S. 1991-2000. British plant communities. 5 Volumes. Cambridge University Press

Scottish Renewables, NatureScot, SEPA & Forestry Commission (2024) Good Practice during Windfarm Construction.

SEPA (2024) Guidance on Assessing the Impacts of Development on Groundwater Dependent Terrestrial Ecosystems.