



Technical Appendix 6.3

Groundwater Dependent Terrestrial Ecosystems

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1.1 Introduction

1. This report provides additional information to **Chapter 6: Hydrology, Hydrogeology, Geology and Soils** and should be read with reference to this chapter and associated figures. **Figure 6.6 Groundwater Dependent Terrestrial Ecosystems Overview** is of particular relevance as it shows the Groundwater Dependent Terrestrial Ecosystems (GWDTE) units.
2. The information within this appendix is for habitats categorised via the National Vegetation Classification (NVC) Surveys, with full details provided in **Chapter 7: Ecology and Biodiversity** and **Appendix 7.2 NVC Report**. These habitats were identified as low GWDTE. This report presents a hydrological assessment of the GWDTE identified by the Ecology Team.
3. The following assessment considers the following additional information derived from desktop studies and information gathered from site visits:
 - hydrogeological setting;
 - topography; and
 - drainage or local features that may alter groundwater levels.
4. From this information, the individual areas of habitat have been assessed, providing a revised groundwater dependency classification.
5. As per Land Use Planning System SEPA Guidance Note 31 (LUPS-GU31) (SEPA, 2017), the potential 'High' and 'Moderate' dependency GWDTE assessed (shown on **Figure 6.6 Groundwater Dependent Terrestrial Ecosystems Overview**) include those:
 - within 100m radius of all excavations less than 1m in depth; and
 - within 250m of all excavations deeper than 1m.

1.2 Baseline

6. In **Table 6.3.1**, the 'High' initial groundwater dependency class represents vegetation that was dominant within the survey area, which is potentially of high groundwater dependency. The 'Moderate' status represents vegetation that was dominant within the survey area, which is potentially of moderate groundwater dependency.
7. Following review all areas were considered to have 'Low' groundwater dependency and are not considered sensitive to groundwater alterations as a result of the Proposed Development.
8. The vegetation within the Site Boundary is a matrix of species including those which are identified as potentially GWDTE, including NVC M5, M6, M9, M15, M23, MG9, MG10, U6 and W7. Further details of each community are detailed below.

- M5 *Carex rostrata-Sphagnum squarrosum* mire is widespread but scarce in both upland and lowland parts of northern and western Great Britain. This is a community of loch-sides, pools and fens where there is mild base enrichment, either from the underlying rock or from irrigating water. It occurs where the pH is a little higher than in the *Carex rostrata-Sphagnum fallax* mire, but where conditions are not as base-rich as they are in the *Carex-Calliergonella* mire (JNCC, 2004).
- M6 *Carex echinate-Sphagnum fallax/denticulatum* mire and M6c sub-community dominated by *J. effusus* are common throughout the uplands from Cornwall north to Shetland. They are the most widespread soligenous mires in the British uplands. These mires appear in wet hollows, gullies and along streams (JNCC, 2004).
- M9 *Carex rostrata-Calliergonella cuspidata/Calliergon giganteum* mire is widespread but scarce in the British uplands. This community is confined to places where base-rich water seeps through deep, wet peat. It occurs in hollows and seepage lines in blanket bogs, in calcareous fens, in topogenous mires, and around lochans, springs and raised mires (JNCC, 2004).
- M15 *Trichophorum-Erica* wet heath is widespread in the north and west of Great Britain. It is most common in the western Highlands. It is a community of shallow, wet or intermittently waterlogged, acid peat or peaty mineral soils on hillsides, over moraines, and within tracts of blanket mire (JNCC, 2004).
- M23 *Juncus effuses / acutiflorus-Galium palustre* rush-pasture community occurs over a variety of moist, moderately acid to neutral, peaty and mineral soils in the cool and rainy lowlands of western Britain. It is a community of gently-sloping ground around the margins of soligenous flushes, as a zone around topogenous mires and wet heaths, and especially widespread in ill-drained, comparatively unimproved or reverted pasture (JNCC, 2001).
- MG9 *Holcus lanatus - Deschampsia cespitosa* grasslands is characteristic of permanently moist and periodically inundated soils throughout the British lowlands (JNCC, 2014).
- MG10 *Holcus lanatus-Juncus effusus* rush-pasture is a vegetation type of damp acid to neutral soils on level to gently sloping ground in enclosed pastures, and in neglected situations such as ditches, pond sides and roadside verges. This community is widespread in lowland Great Britain, and it also occurs at low altitudes in most upland areas (JNCC, 2004).
- U6 *Juncus squarrosus-Festuca ovina* grassland is a vegetation type of damp peaty soils or gleyed podsols on flat or gently sloping ground. The soils are moist and can be waterlogged. The community is generally indifferent to underlying geology. It occurs throughout the north and west of Great Britain (JNCC, 2004).
- W7 *Alnus glutinosa-Fraxinus excelsior-Lysimachia nemorum* are woodlands of flushed slopes, valleys and streamsides throughout the upland fringes. These communities are widespread and common at low altitudes throughout the British uplands with outliers in the lowlands of southern England. It is scarce in the far north of Scotland (JNCC, 2004).

9. Based on SEPA Guidance Note 31 (2017), the following NVC communities are considered to be Highly groundwater dependent: M5, M6, M9, M23 and W7. M15, MG9, MG10 and U6 are considered to be Moderately groundwater dependent.

1.3 Conclusion

10. Taking account of **Table 6.3.1**, with revised groundwater dependency values based on local characteristics and the adoption of mitigation measures, the residual impact of the Proposed Development on GWDTE is considered to be not significant.

GWDTE Area	Area (km ²)	NVC Classes	Initial Groundwater Dependency	Location Relative to Proposed Infrastructure	Baseline	Potential Effects
1	0.002	M6 M15 MG9 MG10	Highly Dominant / Moderately Dominant / Moderately Sub-dominant	<p>Area 1 is located on slopes adjacent to Turbine 5, and associated infrastructure.</p> <p>The operational Harestanes Windfarm access track, to be upgraded, crosses these habitats.</p> <p>(See Figure 6.6b).</p>	<p>Area 1 is a region composed of narrow mire and mesotrophic grassland habitats in the southern extent of Area 1. Peat records are held within these communities, with peat depths recorded locally ranging from 0.1m to 0.9m. Slope angles range from gentle to moderate; 2° to 10°.</p> <p>The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation superficial deposits at the southern part of Area 1, with no superficial deposits encountered at the northern part of Area 1.</p> <p>These habitats are immediately adjacent to the existing track and forestry rides.</p> <p>There is a close association with artificial forestry drainage and surface water flowing downslope from Whitefauld Hill and Pumro Fell, forming two tributaries of the Garrel Water, including Cat Cleuch.</p> <p>Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.</p>	<p>Habitats within Area 1 will be impacted by a combination of direct and indirect effects.</p> <p>The habitats within Area 1 are located partially within the operational Harestanes existing track to be upgraded, as a result a small proportion of the area will be directly lost under the upgrade works.</p> <p>The majority of the habitats within Area 1 are located downslope of the proposed Turbine 5 and associated infrastructure. The proposed infrastructure will involve earthworks and associated drainage, as a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns.</p> <p>A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils, are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.</p>

GWDTE Area	Area (km ²)	NVC Classes	Initial Groundwater Dependency	Location Relative to Proposed Infrastructure	Baseline	Potential Effects
2	0.03	M15 M23 M23a M23b MG9 MG10 W7	Highly Dominant / Moderately Dominant / Moderately Sub-dominant	Area 2 is located on slopes adjacent to Turbines 5 and 6, and associated infrastructure. New access tracks to Turbine 6 crosses these habitats. (See Figure 6.6b).	Area 2 is a region composed of mosaic mire habitats in the southern extent. Peat records are held within these communities, with peat depths recorded locally ranging from 0.0m to 1.2m. Slope angles range from gentle to steep; 2° to 25°. The steepest slopes are recorded at the mires adjacent to the deep valley of the Garrel Water tributary. The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation superficial deposits at the eastern extent, with no superficial deposits encountered at the western extent. The type of geology (highly indurated greywackes with limited groundwater in near surface weathered zone and secondary fractures) and steep slopes indicate the habitat is unlikely to be critically dependent on groundwater. A fault is recorded running from north east to south west upslope of the habitats. These habitats are located within the disused quarry and the clear-felled area. There is a close association with surface water flowing downslope from the Whitefauld Hill, including runoff from the disused quarry, to form two unnamed tributaries of the Garrel Water. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 2 will be impacted by a combination of direct and indirect effects. The habitats within Area 2 are located partially within the forestry road to be upgraded to the proposed Turbine 6 and operational Harestanes existing track to be upgraded, as a result a small proportion of the area will be directly lost under the upgrade works. Approximately half of the habitats within Area 2 are located downslope of the proposed access tracks to be upgraded. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.
3	0.13	M5 M6c M15 M23 M23a MG10 W7	Highly Dominant / Highly Sub-dominant / Moderately Dominant / Moderately Sub-dominant	Area 3 is located downslope of Turbines 6, 7 and 8, and associated infrastructure. New access tracks to Turbine 8 and forestry track to be upgraded cross these habitats. (See Figure 6.6b).	Area 3 is a region composed of narrow mire, mesotrophic grassland and woodland habitats. Peat records are held within these communities, with peat depths recorded locally ranging from 0.0m to 1.5m. Slope angles range from gentle to steep; 2° to 35°. The steepest slopes are recorded on the mires adjacent to the deep valley of tributary of the Garrel Water. The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation, and two small pockets of Peat and Kirkbean Sand and Gravel Superficial deposits on the western extents. These habitats are immediately adjacent to the local watercourse channels, existing track and forestry rides. There is a close association with surface water and artificial forestry and track drainage flowing downslope from Main Rig and Whitefauld Hill, to form two tributaries of the Garrel Water, including Yellowtree Grain. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 3 will be impacted by a combination of direct and indirect effects. The habitats within Area 3 are located partially below the proposed Turbine 8 hardstanding and the forestry track to be upgraded. As a result, a small proportion of the area will be directly lost under the upgrade works. The majority of the habitats within Area 3 are located downslope of the proposed Turbines 6, 7 and 8, and associated infrastructure. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.

GWDTE Area	Area (km ²)	NVC Classes	Initial Groundwater Dependency	Location Relative to Proposed Infrastructure	Baseline	Potential Effects
4	0.05	M6 M6c M15 M23 M23a M23b MG9 W7	Highly Dominant / Highly Sub-dominant / Moderately Dominant / Moderately Sub- dominant	Area 4 is located downslope of Borrow Pit (BP) 01, Turbine 7, and associated infrastructure. BP01, new access track to Turbine 7 and forestry track to be upgraded cross these habitats. (See Figure 6.6b).	Area 4 is a region of mire and mesotrophic grassland habitat confined to the slopes of the existing quarry on the eastern extents. Peat records are held within these communities, with peat depths recorded locally ranging from 0.0m to 1.1m. Slope angles range from level to steep; 0° to 25°. The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation, and two small pockets of Alluvium and Kirkbean Sand and Gravel Superficial deposits on the western extents. These habitats are located within the slopes of the existing quarry in an area with deep peat deposits recorded on the top of the hill. The topography and the presence of M6 in association with M15 and M19 communities may indicate the habitats are associated with a rain-fed (ombrogenous) system. These communities are closely associated with direct rainfall to the blanket bog and surface water flowing downslope. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 4 will be impacted by a combination of direct and indirect effects. A narrow mire at the top of the hill within Area 4 is crossed by Turbine 7 access track, and one small patch of grassland falls within BP01. As a result, a small proportion of the area will be directly lost under the scheme footprint. The remainder of these habitats are located downslope of the proposed Turbine 7 and BP01. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows altering the natural drainage patterns. Note that BP01 may not require to be opened (for further details refer to Appendix 6.5), this location has been assumed to be required within this process. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.
5	0.22	M6 M15 M23 M23a M23b MG9 MG10 U6	Highly Dominant / Moderately Dominant / Moderately Sub- dominant	Area 5 is located downslope of the control building, Turbine 4, and associated infrastructure. New access tracks to Turbine 4, operational Harestanes Windfarm access and forestry tracks to be upgraded cross these habitats. (See Figure 6.6a and b).	Area 5 is a large area composed of extensive mire and mesotrophic grassland habitats within a clear-felled area. Peat records are held within these communities, with peat depths recorded locally ranging from 0.0m to 3.0m. Slope angles range from gentle to steep; 2° to 40°. The steepest slopes are recorded on the mires adjacent to the deeply incised valley of the Glenkiln Burn. The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation, and Alluvium Superficial deposits in the immediate vicinity to the Glenkiln Burn. These habitats are located within an extensive clear-felled area and immediately adjacent to the Glenkiln Burn. These habitats are closely associated with surface water and artificial forestry and track drainage channels flowing downslope from Whitefauld Hill, to then join the Glenkiln Burn. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 5 will be impacted by a combination of direct and indirect effects. The habitats within Area 5 are located partially below the proposed Turbine 4 and associated infrastructure, control building and operational Harestanes Windfarm and forestry tracks to be upgraded, as a result a small proportion of the area will be directly lost under the upgrade works. A proportion of the habitats within Area 5 are located downslope of the proposed Turbine 4 and associated infrastructure. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.

GWDTE Area	Area (km ²)	NVC Classes	Initial Groundwater Dependency	Location Relative to Proposed Infrastructure	Baseline	Potential Effects
6	0.03	M15 M23 M23b MG10 W7	Highly Dominant / Highly Sub-dominant / Moderately Dominant	Area 6 is located downslope of BP02, Turbine 3 and associated infrastructure. Turbine 3 hardstanding is within Area 6. (See Figure 6.6a).	Area 6 is a small area composed of narrow woodland and mire habitats in the southern extents of the Site. Peat records are held within these communities, with peat depths recorded locally ranging from 0.0m to 0.43m. Slope angles range from gentle to steep; 1° to 45°. The steepest slopes are recorded on the woodland and mires adjacent to the deeply incised valley of the Glenkiln Burn. The geology consists of the Selcoth Formation (sandstone, mudstone and siltstone) bedrock (low productivity aquifer), overlain by the Langholm Till Formation, and Alluvium Superficial deposits in the immediate vicinity to the Glenkiln Burn. These habitats are constrained to the valleys of Glenkiln Burn, Castlerough Burn and forestry rides. These communities are closely associated with surface water flowing downslope from Pumro Fell and forming or joining surface water channels. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 6 will be impacted by a combination of direct and indirect effects. The habitats within Area 6 are located partially below the proposed Turbine 3 hardstanding, as a result a small proportion of the area will be directly lost under the scheme footprint. A proportion of the habitats within Area 6 are located downslope of the proposed BP02, Turbine 3, and associated infrastructure. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to the subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns. Note that BP02 may not require to be opened (for further details refer to Appendix 6.5), this location has been assumed to be required within this process. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.
7	0.13	M5 M6 M6c M9 M15 M23 M23a MG9 MG10 U6 W7	Highly Dominant / Highly Sub-dominant / Moderately Dominant /	Area 7 is located downslope of BP03, Turbines 1, 2, and associated infrastructure. Turbines 1 and 2, and associated infrastructure are within Area 6. (See Figure 6.6a).	Area 7 is a region composed of narrow woodland and mire habitats in the western extents of the Site. Peat records are held within these communities, with peat depth recorded locally ranging from 0.1m to 1.1m. Slope angles range from gentle to steep; 1° to 35°. The steepest slopes are recorded on the woodland and mires adjacent to the deeply incised valleys of the Clachanbirnie Burn and an unnamed tributary of the Glenkiln Burn. The geology consists of the Queensberry Formation (sandstone, mudstone, siltstone and conglomerate) bedrock (low productivity aquifer), with no superficial deposits to the north and the Langholm Till Formation deposits overlain to the south. These habitats are restricted to the valleys of Clachanbirnie Burn, an unnamed tributary of the Glenkiln Burn and forestry rides. These communities are closely associated with surface water flowing downslope from the local hills to eventually form or join surface water channels. Surface water and precipitation are likely to be the primary water sources. As a result, the revised groundwater dependency of this area is deemed to be Low with equivalent level of sensitivity.	Habitats within Area 7 will be impacted by a combination of direct and indirect effects. The habitats within Area 7 are located partially below proposed Turbines 1 and 2 and associated infrastructure. As a result, a small proportion of the area will be directly lost under the scheme footprint. A proportion of the habitats within Area 7 are located downslope of the proposed BP03, Turbines 1 and 2, and associated infrastructure. The proposed infrastructure will involve earthworks and associated drainage. As a result, some changes to subsurface flows and groundwater levels are expected. The proposed infrastructure may act as a partial barrier to these flows, altering the natural drainage patterns. Note that BP03 may not require to be opened (for further details refer to Appendix 6.5), this location has been assumed to be required within this process. A number of embedded mitigation measures, as listed in Chapter 6: Hydrology, Hydrogeology, Geology and Soils , are proposed to reduce potential alterations to sub-surface flows and groundwater levels by the works.

Table 6.3.1: GWDTE Assessment

1.4 References

JNCC (2001). National Vegetation Classification: Field guide to mires and heaths. [online]. Available at: http://jncc.defra.gov.uk/PDF/Mires_Heaths.pdf [Accessed September 2020]

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Harestanes South Windfarm Extension Project Team

ScottishPower Renewables
9th Floor ScottishPower Headquarters
320 St Vincent Street
Glasgow
G2 5AD

HarestanesSouthWindfarm@scottishpower.com

