Appendix 7.5: Ground Water Dependent Terrestrial Ecosystem (GWDTE) Assessment

Appendix A

Groundwater Dependent Terrestrial Ecosystem Assessment

Introduction

A.1 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 An Càrr Dubh Wind Farm (hereafter referred to as the Proposed Development) on GWDTEs.

A.2 This Appendix should be read in conjunction with **Chapter 7: Geology, Hydrology, Hydrogeology and Peat**, **Chapter 8: Ecology** and **Appendix 8.2: Habitats and Vegetation Survey Report** of the EIA Report. The assessment draws together detailed information from both chapters, summarising where applicable.

A.3 The Scottish Environmental Protection Agency (SEPA) has produced detailed guidance[1] on how to assess impacts of proposed development on GWDTEs and the following assessment is based on the SEPA guidance.

Identification of GWDTE

A.4 The following is an excerpt from the EU GWDTE Technical Report[2] 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"*.

A.5 Therefore, for a habitat to be designated as a GWDTE, there must be significant hydrogeologic connectivity between the groundwater body and the habitat.

A.6 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

A.7 Phase 1 habitat and NVC surveys were undertaken during the spring and summer of 2021 and 2022. The survey extent and results are described in **Appendix 8.2**. 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:

- E2.1 Acid Flush;
- E2.2 Basic Flush;
- E2.3 Bryophyte-dominated Spring;
- B5 Marshy Grassland;
- D1-D6 Heathland;
- E1-D4 Bog; and
- F1-F2 Swamp.

A.8 Where appropriate, within habitats coded as above, the NVC method[3] 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, obviously ombrogenous bogs etc.

A.9 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.

Table A.1: GWDTE decision tool[4]

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 topographical 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 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 and M25: ■ Presence/persistence of distinctive bog habitat, species and/or associations. ■ Deep peat not confirmed to depressions/valley (>0.5m 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, desk0based determination of the groundwater dependency.		

GWDTE Baseline

A.10 Figure 8.3 of **Chapter 8: Ecology** presents the Phase 1 habitat survey results, **Figure 8.4** of **Chapter 8** presents the NVC survey results, and **Figure 8.5** of **Chapter 8** presents the potential GWDTEs identified. The habitat survey results are discussed in detail in **Appendix 8.2** and are not repeated here. The GWDTE baseline is presented below.

[1] SEPA (2017) Land Use Planning System SEPA Guidance Note 31 – Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems
[2] European Commission (2011) Common Implementation Strategy for the Water Framework Directive (2000/60/EC) – Technical Report No. 6: Technical Report on Groundwater Dependent Terrestrial Ecosystems [online]. Available at: https://op.europa.eu/en/publication-detail/-/publication/f7bd5cf8-c62c-41f6-8138-fe922a1f6410
[3] Rodwell, J. S. (1991-2000) British plant communities (5 Volumes)
[4] Botanaeco (2018) Groundwater Dependent Terrestrial Ecosystems (GWDTE) [online]. Available at: https://botanaeco.co.uk/gwdte [Accessed August 2022]

A.11 During surveys undertaken by the ecology team and following the steps outlined in **Table 1**, it was identified that there are a number of GWDTE Target Notes (TNs) located across the Site with potential to have a high dependency on groundwater. These are point locations associated with the following habitats:

- M6 *Carex echinata-Sphagnum fallax/denticulatum* mire;
- M10 *Carex dioica-Pinguicula vulgaris* mire;
- M11 *Carex demissa-Saxifraga aizoides* mire; and
- M32 *Philonotis fontana-Saxifraga stellaris* spring.

A.12 A specific survey was undertaken by the hydrology team in October 2021 to visit the TN locations to establish the level of groundwater dependency associated with each one.

A.13 Other habitats that have the potential to be groundwater dependent were mapped by the ecology team as follows:

- M15 *Trichophorum germanicum-Erica tetralix* wet heath;
- M23 *Juncus effusus/acutiflorus-Galium palustre* rush-pasture;
- M25 *Molinia caerulea-Potentilla erecta* mire;
- U6 *Juncus squarrosus-Festuca ovina* grassland; and
- W4 *Betula pubescens-Molinia caerulea* woodland.

A.14 Based on the SEPA guidance, NVC classes M15, M25 and U6 have the potential to have a moderate dependency on groundwater and M23 and W4 have the potential to have a high dependency on groundwater. Areas of habitat that have the potential to be groundwater dependent are widespread across the Site (see **Figure 8.5**). However, it is noted that the areas shown in Figure 8.4 often comprise a mosaic of NVC communities, for example M15 might only cover 20% of a polygon, with the remaining 80% being some other non-GWDTE communities (e.g. likely bog communities associated with the peat bog). To be conservative, the entire polygon was mapped as potentially groundwater dependent on **Figure 8.5**.

A.15 Most of the moderate potential habitats within the Site are M15. Based on their hydrogeological setting – an upland blanket peat bog – the M15 sub-communities are generally reflective of wet, peaty conditions. It is considered that if the M15 area contains a confirmed GWDTE TN, then there could be some groundwater influence on the M15 habitat. Elsewhere (where it occurs over large extents in mosaic with bog habitats) the M15 community is considered to have, at-most, low dependency and is not considered further. If they are associated with the TNs (e.g. association with true springs/flushes) the M15 polygon as a whole is regarded as a moderate potential GWDTE.

A.16 U6 acid grassland, with moderate potential, was also noted throughout the Site. It often occurred on drier, grazed areas in mosaic with wet or dry heath communities or appearing to have replaced blanket bog habitats where grazing levels were high. Floristically, it did not exhibit signs of nutrient input. In the context of the Site this community is generally reflective of wet, peaty conditions, and is created and maintained by grazing. The U6 community is considered to have, at-most, low dependency and is not considered further.

A.17 There are several smaller areas of M23 habitat within the Site. These are often associated with surface water features when it occurs close to watercourses. Otherwise it can occur as larger expanses on wet level ground. At the Site, the M23 habitats are located either close to watercourses or on hillsides in the east of the Site, as small patches of rushes within shallow peat on the damp hillside. The sub-community found on the Site is M23b, which is dominated by soft rush Juncus effusus and generally reflects damp and peaty conditions, with nothing of note floristically to indicate an input of nutrients. Based on the hydrogeological setting, the area of M23 habitat south of T11 is a localised area of rushes at the confluence of two watercourses and is not considered to be groundwater dependent. The M23 habitats further east close to the access track are on the side of a damp hillside and are considered to have, at-most, low groundwater dependency and are not considered further.

A.18 There is an area of M25 within the afforested area in the east of the Site at the top of the existing track and a small area ~350 south of T10, adjacent to a small watercourse. The M25 within and close to the afforested area is associated with modified wet heath or bog and the small area south of T10 is associated with the surface water feature. Both are considered to have, at-most, low dependency and are not considered further.

A.19 The only extent of W4 woodland is within the afforested area in the east of the Site, adjacent to an extent of M25 grassland and a small, mapped watercourse. It comprises self-seeded birch trees along a wayleave on the edge of a block of conifer forestry. As such, it is considered to reflect the damp and peaty conditions. Based on the hydrogeological setting, this community is not considered to be groundwater dependent and is not considered further.

A.20 Based on the results of the TN survey by hydrologists and ecologists and the desk-based assessment, a number of adjustments were made to the turbine locations to consider the presence of GWDTEs. Where possible, the 250m buffer has been avoided for siting turbines and borrow pits, and 100m buffer has been avoided for siting roads, tracks and trenches, as per SEPA guidance. However, it has not been possible to avoid these in all locations. GWDTEs within 100m of the access tracks (<1m excavation) and within 250m of proposed turbines and borrow pits (>1m excavation) are described in **Table 2**. **Chapter 3: Site Selection and Design Strategy** of the EIA Report provides more detail on why it was not possible to avoid the 100m and 250m buffer areas, largely due to the presence of other constraints on the site.

Table A.2: Details of GWDTEs within 100m of excavations <1m deep and 250m from excavation >1m deep

Potential GWDTE Polygon (P) or Target Note (TN)	Phase 1	NVC	Potential Groundwater Dependency based on NVC Class	Hydrological Setting	Actual Groundwater Dependency based on Site Survey	Distance from Infrastructure
TN1, TN2 and TN3 (LUC19, LUC18 and LUC17)	E2.1 Acid flush/ neutral flush/Spring	M6 *Carex chinate-Sphagnum-fallax/denticulatum* mire	High	Located on south side of watercourse on gently sloping ground. Noted small seep coming out of hillside ~3m higher than watercourse. Large peat filled depression south of TNs, however it is likely that there is both surface water and groundwater contributions to the flow.	Moderate, based on the association with evident surface water features such as the large local depression to the south and no clear and definitive discharge points.	TN1, TN2 and TN3 are 160m, 173m and 180m south-east of borrow pit, respectively. TN1 is 30m west of track. TN2 is 40m east of track. TN3 is 71m east of track.
TN4 (LUC0)	E1.6.1 Blanket bog	M6 *Carex chinate-Sphagnum-fallax/denticulatum* mire	High	Very wet area. No springs noted and located within a low-lying area of wet bog on gentle slopes. Could be a minor flush. Peat depth >0.5m.	Low to Moderate	140m north-west of T12. 120m north-west of track.
TN5 (LUC2)	E2.3 Brophyte-dominated spring	M32 *Philonotis fontana-Saxifraga stellaris* spring	High	On the northern side of a small rocky outcrop. A small but noticeable flow, with very small surface water catchment and change in topographic slope. Given hydrogeological setting, flow was	High	66m west of track that connects T5 and T6.

Potential GWDTE Polygon (P) or Target Note (TN)	Phase 1	NVC	Potential Groundwater Dependency based on NVC Class	Hydrological Setting	Actual Groundwater Dependency based on Site Survey	Distance from Infrastructure
				determined to be likely to come from ground water.		
TN6 (LUC3)	E2.3 Brophyte-dominated spring	M32 *Philonotis fontana-Saxifraga stellaris* spring with *Dicranella palustris* (moss)	High	Base of rocky ridge. 40m south of large surface water body. Spring observed by ecologists.	High	215m north-west of T8.
TN7 (LUC10)	E2.2 Basic flush E2.3 Brophyte-dominated spring	M32 *Philonotis fontana-Saxifraga stellaris* M11 *Carex viridula* ssp. *Oedocarpa-Saxifraga aizoides* mire	High	Sprig noted, with substantial amount of water and an obvious channel.	High	90m south of temporary construction compound.
TN8 (LUC28), TN9, TN10 and TN11 (LUC29, LUC30 and LUC31)	E2.2 Basic flush E2.3 Brophyte-dominated spring	M11 *Carex viridula* ssp. *Oedocarpa-Saxifraga aizoides* mire M32 *Philonotis fontana-Saxifraga stellaris* spring M10a *Carex dioica-Pinguicula vulgaris* mire	High	TNs are located nearby or directly at the north-facing foot of a large scree slope. A sequence of springs and flushes were found around this locality. The hill above the scree slope, known as 'Garbh Achadh' is geologically different to most of the surrounding area and is composed of intrusive igneous felsite and quartz porphyry units. Peat depths were noted to be very shallow (<.01m) depth around the spring discharge points.	High	TN8 is ~100m north of proposed access track. TN9, TN10 and TN11 are further north, located outside the 100m buffer, but within the same spring sequence. There are several other springs further north, located well outside of the 100m buffer.
P1	D6 Wet heath/acid grassland	M15 *Trichophorum germanicum-Erica tetralix* wet heath	Moderate	Contains TN8 and series of springs to the north.	Moderate	Access track passes through M15 habitat area but the confirmed GWDTE TN is ~100m north of access track.
P2	D6 Wet heath/acid grassland	M15 *Trichophorum germanicum-Erica tetralix* wet heath	Moderate	Contains several confirmed GWDTE TNs in northern part of the habitat polygon.	Moderate	Access track passes through M15 habitat area but the confirmed GWDTE TN is outside the 100m buffer, ~127m north of track.

Effects Assessment

A.21 Following ecological identification of 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 each of the identified areas of GWDTE described in **Table 2**.

A.22 A site-specific qualitative risk assessment of each GWDTE was carried out based on the available data on local geology, hydrology, ecology and hydrogeological regime at each location. 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.

A.23 Flow routing analysis was carried out in QGIS software using 5m-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 project infrastructure.

A.24 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.

A.25 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.

A.26 The SEPA Guidance for assessing impacts of development on GWDTEs recommends a 250m buffer zone from all excavations deeper than 1m and a 100m buffer for excavations less than 1m deep. The two buffers are shown on **Figure 7.3** in the EIA report.

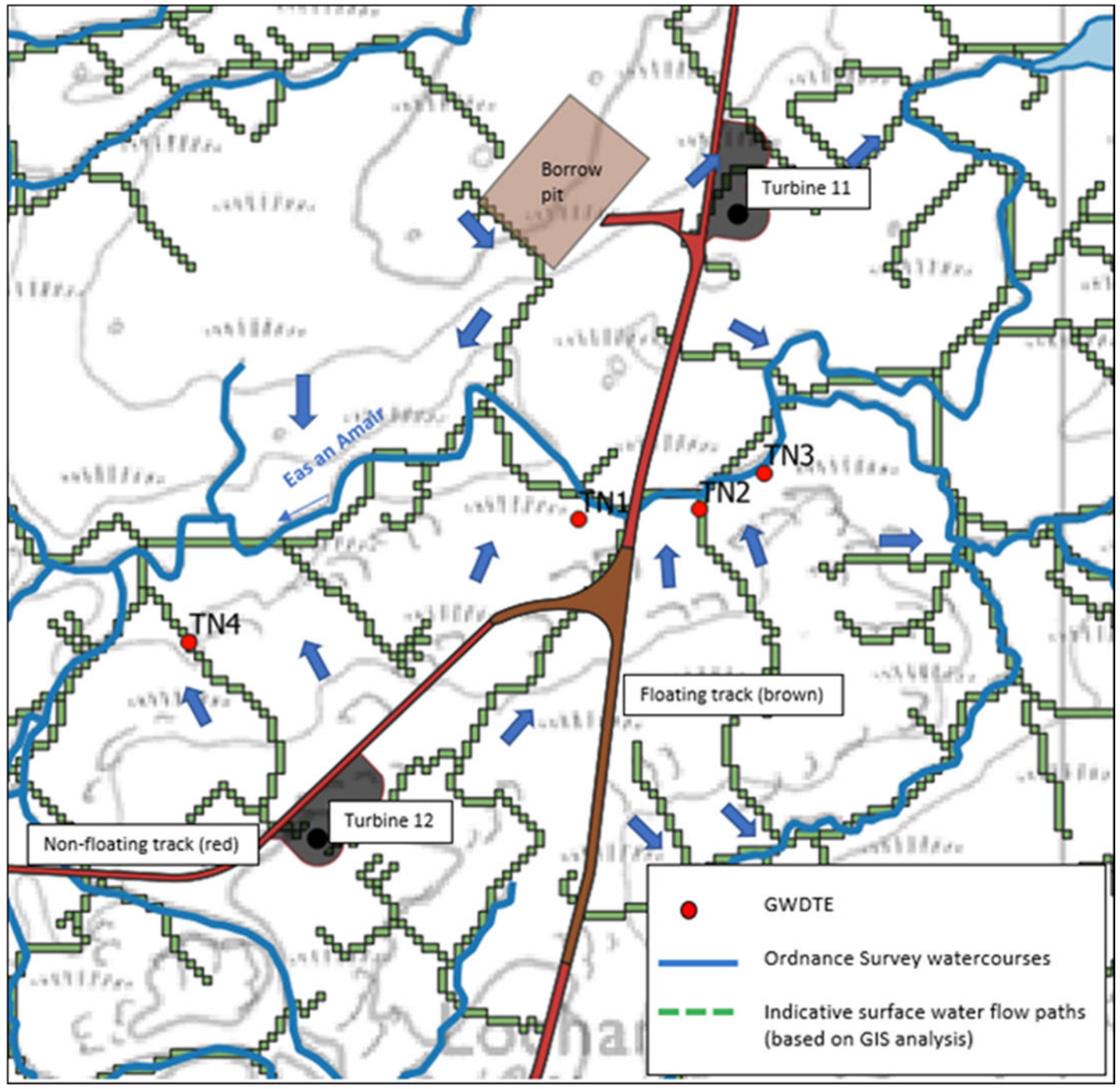
Based on the project description and construction methods outlined in **Chapter 4: Project Description** of the EIA Report, excavations for the turbine foundations and borrow pits will be deeper than 1m, while access tracks and other infrastructure (compounds and met station) will be less than 1m.

A.27 Table 2 identifies the GWDTEs that are either moderately or highly dependent on groundwater. All other potential GWDTEs were considered to have a low dependency on groundwater and are not considered further. A site-specific assessment of the moderate and high GWDTEs follows.

GWDTEs TN1 to TN3

A.28 The track between T11 and T12 crosses the Eas an Amair watercourse and is within the 100m buffer of three GWDTE locations (acid flushes at TN1, TN2 and TN3). In addition, T11 and the nearby borrow pit are within 250m of the GWDTE locations. Based on site surveys (see **Table 2**), the GWDTEs here are considered to be moderately dependent on groundwater, as it is likely that there is both surface water and groundwater contribution to the flow. The locations of the GWDTEs are shown on **Image 1** and described in context with available geological, peat and hydrological information.

Figure A.1: Location of moderately dependent GWDTEs (TN1, TN2, TN3 and TN4) in hydrological setting, showing indicative surface water flow paths and proposed infrastructure



A.29 British Geological Survey (BGS) 1:50K bedrock geology maps indicate that the geology around TN1 to TN3 comprises of quartzite metamorphic rock of the Crinan Grit Formation (**Figure 7.4** in the main report). These highly indurated metamorphic rocks generally have low aquifer productivities, with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities, with rates of up to 2L/s from rare springs.

A.30 BGS 1:50K superficial geology maps indicate that the superficial drift geology at the GWDTE site comprises of hummocky glacial deposits (**Figure 7.4** in the main report).

A.31 The NatureScot Carbon and Peatlands Map 2016 (**Figure 7.6** in the main report) shows that GWDTEs are within a Class 2 peatland area *"Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas of potentially high conservation value and restoration potential"*. The peat depth survey (**Figure 7.7** in the main report) undertaken for the EIA indicates no peat at the GWDTEs, with depths of less than 30cm recorded. However, there is a large peat filled depression ~100m south of the GWDTEs with peat depths exceeding 4.9m in places. It was noted during the Site survey that the peat filled depression drained northwards towards the GWDTEs and the Eas an Amair watercourse.

A.32 The three GWDTE TNs are located on the southern side of the Eas an Amair watercourse and are ~11m, 6m and 5m south of watercourse, respectively. Surface water flow paths indicate that the GWTDEs drain towards the Eas an Amair watercourse to the north (**Image 1**) and the surface water catchments to the GWDTEs are fairly small, comprising drainage from the peat areas to the south.

A.33 The borrow pit and T11 are located over 160m northwest of the GWDTEs on the other side of the Eas an Amair watercourse. T11 drains eastwards and the borrow pit drains southwards toward the watercourse, which separates the infrastructure hydrologically from the GWDTEs. In addition, the borrow pit and T11 are located at least 6m higher than the GWDTEs. It is considered unlikely that excavations at the infrastructure will have an impact on the GWDTEs, as the infrastructure location is not hydrologically connected to the GWDTEs.

A.34 The proposed access track is located within 30m of the GWDTEs. The track will be a floating track to the south as it crosses the area of deep peat and a non-floating track at the watercourse crossing location. Surface and sub-surface flow paths are from the south. Floating tracks are designed to maintain hydrological connectivity and allow sub-surface flow through the underlying peat; hence it is considered that the floating track will not interrupt shallow and sub-surface flow to the GWDTEs. The non-floating track section is short and perpendicular to flow direction to the GWDTEs and is not considered to have a significant effect on any groundwater flow to the GWDTEs. There is a risk runoff from the tracks could result in increased sediment/pollution draining towards the GWDTEs.

A.35 Surface water flow paths, based on the available topography data (**Image 1**), indicate that the flow paths feeding the GWDTEs are in a different sub-catchment to the borrow pit and T11 and excavations here are unlikely to affect the GWDTEs. The track could have an effect of negligible to minor magnitude on the GWDTEs. Given the moderate groundwater dependence of the GWDTEs (as it is partly sourced by surface/sub-surface water draining the peat), the effect on the GWDTEs is considered to be of minor magnitude, but temporary, resulting in an effect of **minor significance** during construction. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

A.36 Embedded mitigation measures (e.g. SUDS 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' (2019)[5] 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. Specific measures will be implemented on a case-by-case basis as directed by the Ecological Clerk of Works (ECoW) during construction.

A.37 The track is proposed to be floated and designed to enable subsurface flows to be maintained. Monitoring will be put in place to assess the quantitative and chemical effect of the infrastructure to ensure 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 and will comprise groundwater monitoring at the three seeps. Pre-construction monitoring will commence at least six 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.

[5] Scottish Renewables, Scottish Natural Heritage (now NatureScot), SEPA and Forestry Commission Scotland (2019) Good Practice during Windfarm Construction (4th Edition)

A.38 Additional mitigation and monitoring will reduce the likelihood of any significant effects on the GWDTE and the residual effect is considered to be **minor or none**.

GWDTE TN4

A.39 T12 and its associated access track are located 140m southeast of a potential GWDTE location (TN4 – blanket bog, with some M6). It is considered to be at most moderately dependent on groundwater, but most likely low. The location of the GWDTE TN4 is shown on **Image 1** and described below.

A.40 BGS 1:50K bedrock geology maps indicate that the bedrock geology around TN4 comprises of quartzite metamorphic rock of the Crinan Grit Formation (**Figure 7.4** in the main report). These highly indurated metamorphic rocks generally have low aquifer productivities, with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities, with rates of up to 2L/s from rare springs.

A.41 BGS 1:50K superficial geology maps indicate that the superficial drift geology at the GWDTE site comprises hummocky glacial deposits (**Figure 7.4** in the main report).

A.42 The NatureScot Carbon and Peatlands Map 2016 (**Figure 7.6**) shows that GWDTE is within a Class 2 peatland area *"Nationally important carbon-rich soils, deep peat and priority peatland habitat. Areas of potentially high conservation value and restoration potential"*. The peat depth survey (**Figure 7.7**) undertaken for the EIA indicates that TN4 is located on the edge of a peat bog area, with peat depths exceeding 0.5m.

A.43 Surface water flow paths indicate that the GWTDE drains towards the Eas an Amair watercourse to the north (**Image 1**) and the surface water catchment to the GWDTEs comprises drainage from the location of T12.

A.44 T12 drains towards the GWDTE and is located on a higher bedrock ridge at an elevation of ~355m AOD. The GWDTE is at ~330m AOD, ~25m below the turbine location. Given the elevation difference, it is considered unlikely that excavations at turbine infrastructure (assumed to be 3.5-5m deep for the foundations) will have an impact on groundwater flows to the GWDTE. In addition, the site surveys suggest that the GWDTE is only at most moderately dependent on groundwater and partly surface water fed, associated with the peat bog. Therefore, the effect on the GWDTE is considered to be of negligible magnitude and temporary, resulting in an effect **significance of none** during construction. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

A.45 Embedded mitigation measures (e.g. SUDS 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' (2019) will be employed to ensure that the infrastructure does not affect groundwater flow or chemistry to sensitive receptors. No additional mitigation measures are proposed.

GWDTE TN5

A.46 The track between turbines T5 and T6 is located 66m east of a highly dependent GWDTE (bryophyte-dominated spring – TN5). The GWDTE is on the northern side of a small rocky outcrop/ridge and a small but noticeable flow was observed, with a very small surface water catchment and defined change in topographic slope and indicative bryophyte vegetation. Given the hydrogeological setting, flow was determined to come from ground water.

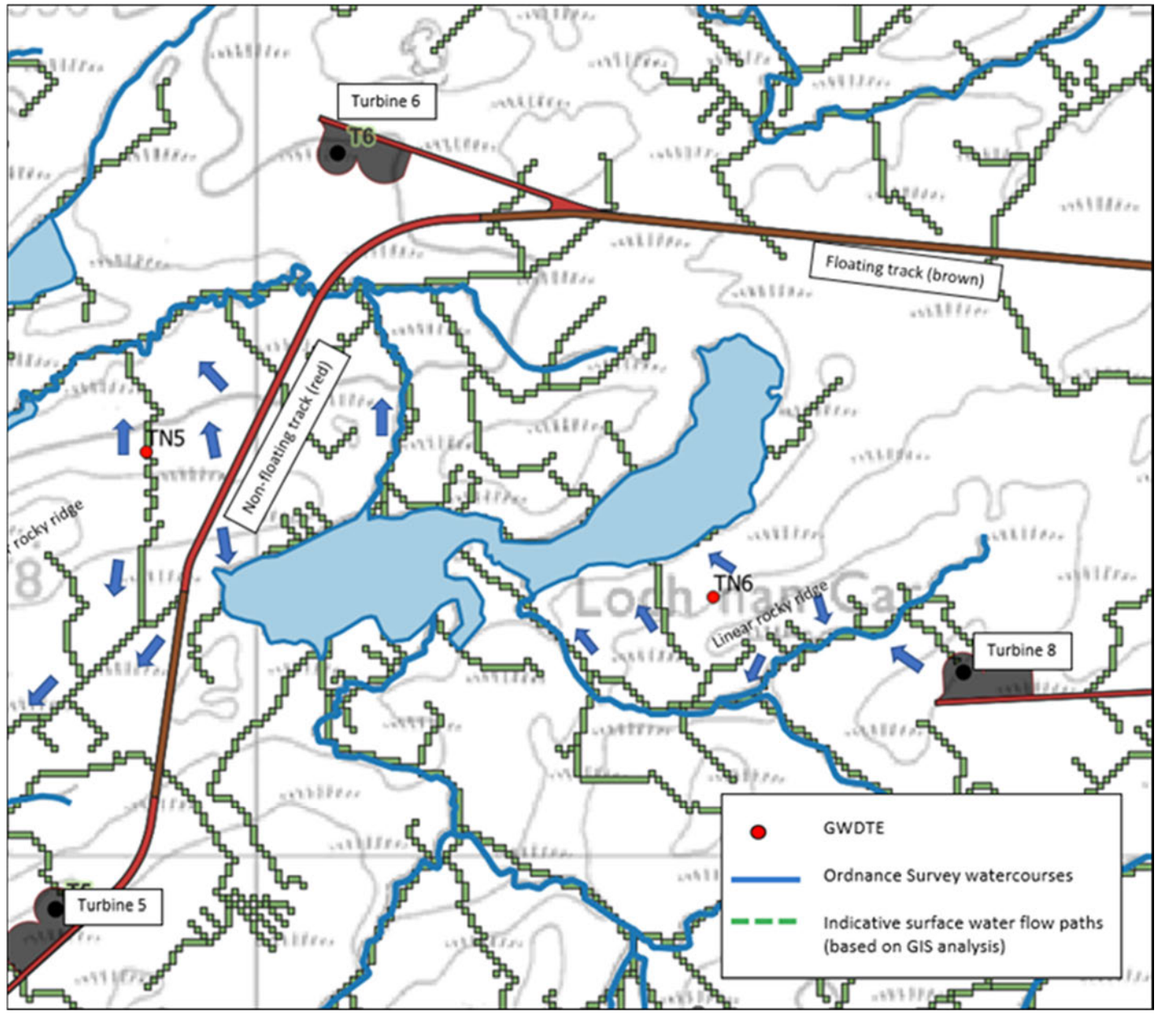
A.47 BGS geological mapping[6] and field investigation indicates this linear rocky outcrop/ridge is composed of metamorphic schist, while the surrounding lower ground is composed of quartzite/phyllite. Several flushes were located around the base and flanks of this outcrop. Therefore, there is a likely geological boundary or feature which is allowing groundwater to upwell at the surface here, around the flanks of this small ridge.

A.48 The NatureScot Carbon and Peatlands Map 2016 (**Figure 7.6** in the main report) shows that GWDTE is within a Class 2 peatland area. The peat depth survey undertaken for the EIA indicates no peat at the GWDTE, with depths of 30cm recorded close to the GWDTE location (**Figure 7.7** in the main report).

A.49 Surface water flow paths indicate that the GWTDE drains towards a watercourse to the north (**Image 2**) and the surface water catchment to the GWDTE is fairly small, comprising the rocky outcrop to the south of the GWDTE. The GWDTE spring is at an elevation of 354m AOD.

A.50 The proposed track is upgradient of the GWDTE at an elevation ranging from 365m to 355m AOD and is a non-floating track. Surface water flow paths, based on available topography data (**Image 2**), indicate that the flow paths from the track are to the south in the southern part of the track and to the north in the northern section of the track; the flow paths do not flow directly to the GWDTE. It is considered unlikely that excavation of the track 66m away from the spring source and sitting some 10m higher than the GWDTE spring will have a significant effect on groundwater flows to the GWDTE. However, given the unknowns regarding groundwater levels and flow paths and the high groundwater dependence of the GWDTE, the effect on the GWDTE is considered to be of minor magnitude, but temporary, resulting in an effect of **minor significance** during construction. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

Figure A.2: Location of highly dependent GWDTEs (TN5 and TN6) in hydrological setting, showing indicative surface water flow paths and proposed infrastructure



[6] British Geological Survey (1955) Inveraray Solid and Superficial Geology Map (Sheet 37, scale 1 inch to a mile)

A.51 Embedded mitigation measures (e.g. SUDS 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' (2019) 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 GWDTE and ensure that any proposed track drainage does not alter the natural drainage conditions of the site.

A.52 The track will be designed to enable subsurface flows to be maintained, with suitable culverts installed under the track so that it does not cut off natural flow pathways. Monitoring will be put in place to assess the quantitative and chemical effect of the infrastructure to ensure that the groundwater flow and quality to the GWDTE are not statistically significantly changed post construction. Monitoring will be carried out based on SEPA guidance and will comprise groundwater monitoring at the spring and at a series of groundwater monitoring wells. Pre-construction monitoring will commence at least six 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.

A.53 Additional mitigation and monitoring will reduce the likelihood of any significant effects on the GWDTE and the residual effect is considered to be **minor or none**.

GWDTE TN6

A.54 T8 is located ~215m southeast of a GWDTE (bryophyte-dominated spring – TN6). A spring was observed at the base of linear rocky ridge. The spring drains northwards to enter Loch nan Car, which is ~40m away. There is no obvious surface water catchment to the spring, as it sits at the bottom of the bedrock ridge and is considered highly groundwater dependent.

A.55 The bedrock geology at the GWDTE location comprises of quartzite metamorphic rock of the Crinan Grit Formation (**Figure 7.4** in the main report). The bedrock geology has low aquifer productivities, with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities, with rates of up to 2L/s from rare springs.

A.56 The GWDTE is within a Class 2 peatland area and the peat depth survey indicates no peat at the GWDTE location, with probed depths of 20-30cm recorded close to the GWDTE location (**Figure 7.7** in the main report).

A.57 T8 is located on the southern side of the rocky ridge and a watercourse is also present between the turbine and the GWDTE. Surface water flow paths indicate that the GWTDE drains towards Loch nan Car to the north (**Image 2**), while the turbine flows towards the small watercourse. The GWDTE spring is at an elevation of 370m AOD and the turbine sits at 392m AOD, with a watercourse and a rocky linear ridge separating the two. It is considered that they are not hydrologically connected and it is unlikely that excavation at the turbine will affect groundwater flows to the spring source.

A.58 The effect on the GWDTE is considered to be of negligible magnitude resulting in an effect **significance of none** during construction. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

GWDTE TN7

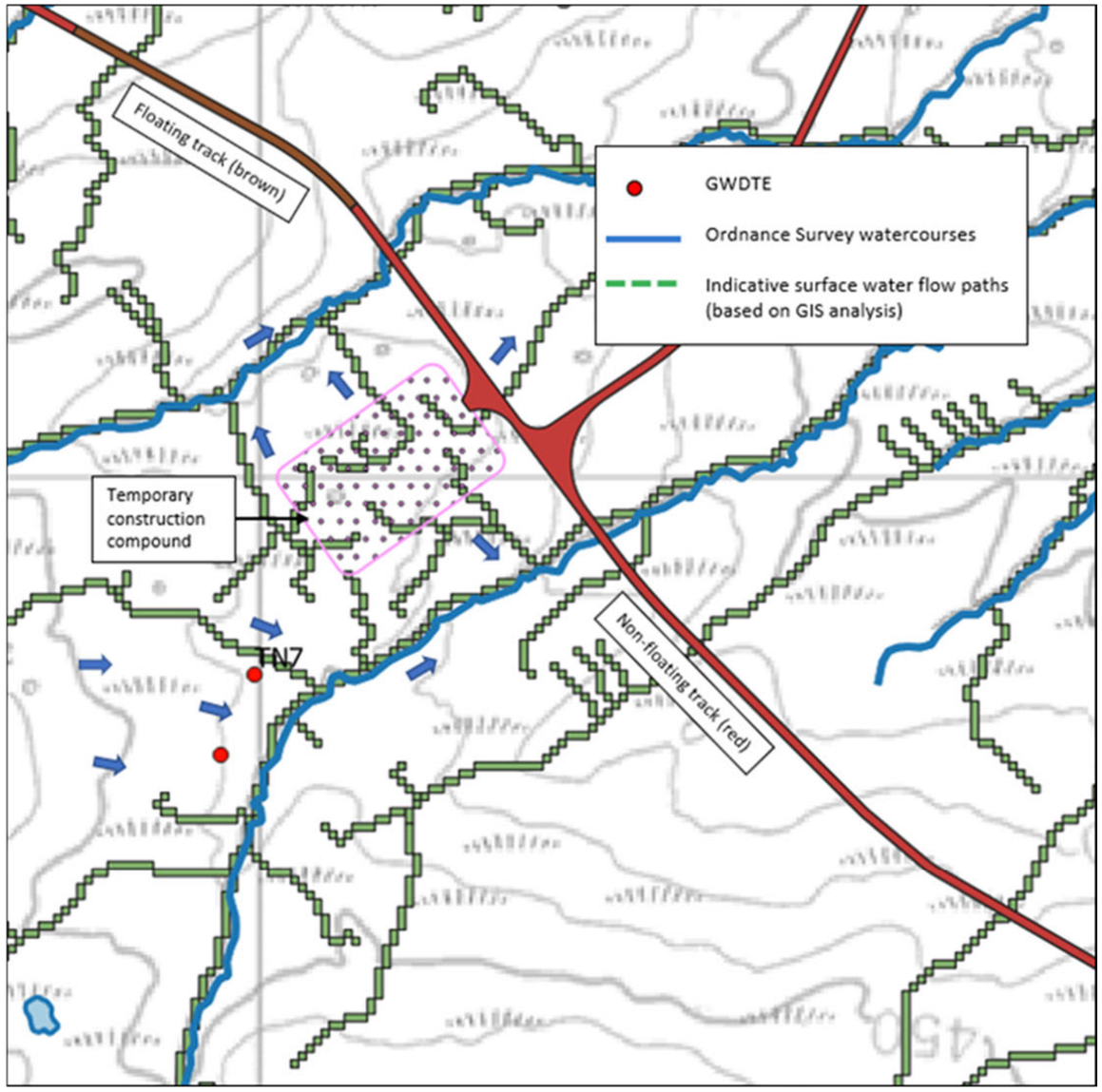
A.59 The temporary construction compound is located 90m northeast of a GWDTE (bryophyte-dominated spring – TN7). A second GWDTE TN was mapped to the south of TN7, however as this is outside of the 100m infrastructure buffer it was not assessed in detail. The TN7 spring is located on the side of a small but prominent mound feature near a watercourse, approximately 300m east of Lochan Erallich. During the field investigation it was noted that there was a substantial amount of flowing water at the spring and an obvious channel. Based on the hydrogeological setting the GWDTE is considered highly groundwater dependent.

A.60 The bedrock geology at the GWDTE location is at a geological boundary between metagabbro and metamicrogabbro metamorphic rock of the Dalradian Supergroup to the south and quartzite metamorphic rock of the Crinan Grit Formation to the north (**Figure 7.4** in the main report). The bedrock has low aquifer productivities, with limited groundwater in the near surface weathered zone and fractures. Flow is virtually all through fractures and other discontinuities, with rates of up to 2L/s from rare springs.

A.61 The GWDTE is within a Class 2 peatland area and the peat depth survey indicates no peat at the GWDTE, with probed depths of 30cm recorded close to the GWDTE location (**Figure 7.7** in the main report).

A.62 The spring is located upgradient of the construction compound and is situated at ~ 438mAOD. The construction compound is lower at ~ 434mAOD. Surface water flow paths indicate that the GWTDE drains towards a watercourse to the east (**Image 3**), while flow paths from the construction compound area are to the south-east, north-west and north and are not directed towards the GWDTE. It is considered unlikely that any excavations (<1m in depth at the compound) will have an effect on groundwater flows to the GWDTE, as the GWDTE will likely be fed from a groundwater catchment upgradient (west) of the GWDTE. The effect on the GWDTE is considered to be of negligible magnitude resulting in an effect significance of none during construction. There is not expected to be any long-term effect on hydrology and sub-surface flows during operation.

Figure A.3: Location of highly dependent GWDTEs (TN7) in hydrological setting, showing indicative surface water flow paths and proposed infrastructure

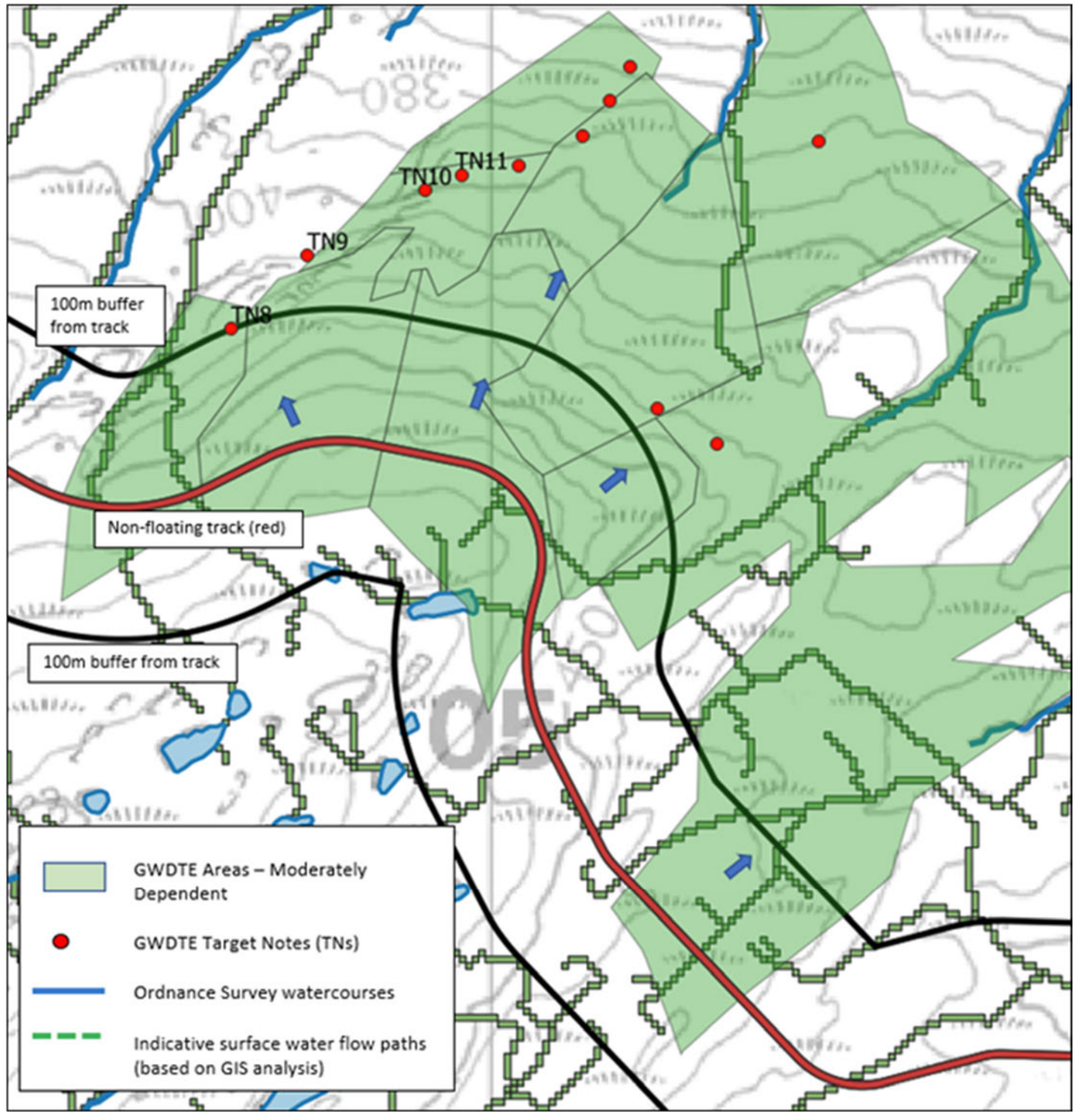


GWDTE TN8 and Moderately Dependent GWDTE Polygons

A.63 A series of highly dependent GWDTEs were located nearby or directly at the north-facing foot of a large scree slope. The hill above the scree slope known as Garbh Achadh is geologically different to most of the surrounding site, composed of intrusive igneous felsite and quartz porphyry units, rather than the usual surrounding quartzite/phyllite. A sequence of springs and flushes were found

around this locality, all of which were confirmed to be highly groundwater dependent. During early design iterations the track infrastructure was moved south to avoid these GWDTEs. All the GWDTE TNs are outside of the 100m buffer from the track, with the exception of TN8 which is located ~100m north of the track. The GWTDE polygon areas along this section of the track are considered moderately dependent if a TN is situated within the polygon area (**Image 4**). TN9, TN10 and TN11 are located further north, outside the 100m buffer, but within the same spring sequence. There are several other springs further north well out of the 100m buffer.

Figure A.4: Location of highly dependent GWDTEs (TN8, TN9, TN10, TN11 and others) and moderately dependent GWDTE polygons in hydrological setting, showing indicative surface water flow paths and proposed infrastructure



A.64 BGS 1:50K geology maps indicate that the bedrock geology comprises felsite igneous rocks of the Scottish Highland Suite and that there is a distinct geological change at this location (**Figure 7.4** in the main report).

A.65 The NatureScot Carbon and Peatlands Map 2016 (**Figure 7.6** in the main report) shows that GWDTEs are all within a Class 2 peatland area. The peat depth survey (**Figure 7.7** in the main report) indicates no peat at the GWDTE TN locations. Peat depths along the proposed track route were generally less than 50cm, with a couple of probe location recording depths of up to 80cm. A non-floating track is proposed for this section.

A.66 Surface water flow paths, based on available topography data (**Image 4**), are from south to north and the track is within the same surface water catchment as the GWDTEs. The track is considerably higher than the GWDTEs, at an elevation of 466m AOD, when compared to the elevation of GWDTE TN8, which sits at the foot of the steep slope at 421m AOD. Given the elevation difference (45m) and the distance from the track to the GWDTEs (at least 100m) it is considered that excavation during construction of the track will have an effect of negligible magnitude on the GWDTE, resulting in an effect **significance of none**. There is not expected to be any operational effects on the GWDTEs.

A.67 Embedded mitigation measures (e.g. SUDS 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' (2019) will be employed to ensure that the infrastructure does not affect groundwater flow or chemistry to sensitive receptors.

Summary

A.68 GWDTE locations were buffered and considered early in the design process for the Proposed Development. Where possible, the recommended 250m buffer has been avoided for siting turbines and borrow pits, and 100m buffer has been avoided for siting roads, tracks and trenches, as per SEPA guidance. However, it has not been possible to avoid all buffers.

A.69 There are six GWDTEs where infrastructure is proposed within the recommended buffers. These are assessed in detail and reported herein. Based on the GWDTE Decision Tool (**Table 1**) they have been assessed to have either a moderate or high dependence on groundwater.

A.70 The effects of the Proposed Development on each 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 A.3: Summary of assessment of GWDTEs within 100m of excavations <1m deep and 250m from excavations >1m deep

Potential GWDTE Polygon (P) or Target Note (TN)	Groundwater Dependency based on Site Surveys	Distance from Infrastructure	Significance Before Additional Mitigation (including embedded mitigation measures)	Additional Mitigation	Significance After Additional Mitigation
TN1, TN2 and TN3 (LUC19, LUC18 and LUC17)	Moderate	TN1, TN2 and TN3 are 160m, 173m and 180m south-east of borrow pit, respectively. TN1 is 30m west of track. TN2 is 40m east of track. TN3 is 71m east of track.	Minor	Track will be floated and designed to enable subsurface slows to be maintained. Pre and post-construction monitoring.	Minor or None
TN4 (LUC0)	Low to Moderate	140m north-west of T12. 120m north-west of track.	None	None.	None
TN5 (LUC2)	High	66m west of track that connects T5 and T6.	Minor	Track will be designed to enable subsurface flows to be maintained. Pre and post-construction monitoring.	Minor or None
TN6 (LUC3)	High	215m north-west of T8.	None	None.	None
TN7 (LUC10)	High	90m south of temporary construction compound.	None	None.	None
TN8 (LUC28), TN9, TN10 and TN11 (LUC29, LUC30 and LUC31)	High	TN8 is ~100m north of proposed access track. TN9, TN10 and TN11 are further north, located outside the 100m buffer, but within the same spring sequence. There are several other springs further north, located well outside of the 100m buffer.	None	None.	None
P1	Moderate	Access track passes through M15 habitat area but the confirmed GWDTE TN is ~100m north of access track.	None	None.	None
P2	Moderate	Access track passes through M15 habitat area but the confirmed GWDTE TN is outside the 100m buffer, ~127m north of track.	None	None.	None

A.71 Embedded mitigation measures (e.g. SUDS and use of best practice construction techniques) will minimise the risk of pollution/sediment to the GWDTEs. Additional mitigation measures will be put in place during construction to maintain the baseline subsurface flows towards the GWDTEs and ensure that any proposed drainage does not alter the natural drainage conditions of the site. Mitigation measures primarily aim to ensure that the water supply to a GWDTE is not interrupted and that any proposed drainage does not alter the natural drainage conditions of the site. Specific measures will be implemented on a case by case basis as directed by the ECoW during construction.

A.72 Monitoring at two GWDTE locations will be carried out to assess the quantitative and chemical effect of the infrastructure to ensure that the groundwater flow and quality are not significantly changed, which would put the sensitive receptors at risk. Monitoring will be carried out before and after construction and will follow SEPA guidance; this will include the installation and sampling of several hand driven groundwater monitoring wells. Details of the proposed monitoring programme will be set out in the Construction Environmental Management Plan (CEMP) that will be agreed with SEPA and ABC in advance of the works.

A.73 With additional mitigation, the residual effects on the GWDTEs are assessed to be of minor or no significance.