



**British
Geological Survey**
NATURAL ENVIRONMENT RESEARCH COUNCIL

A REVIEW OF THE HYDROGEOLOGY ELEMENT OF THE
GREEN KNOWES WIND FARM ENVIRONMENTAL
STATEMENT

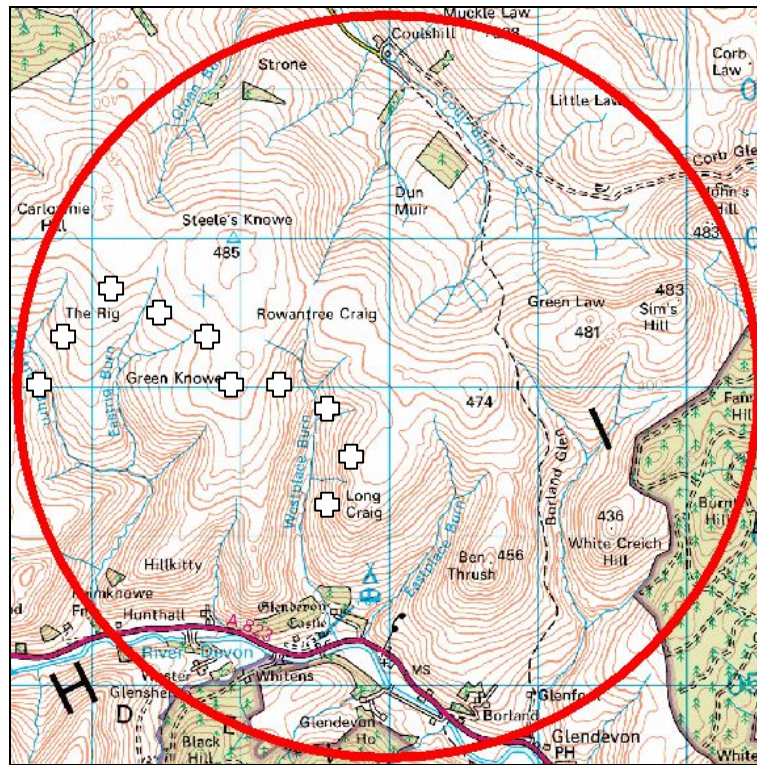
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Section 1

Location of the Green Knowes site

The proposed development is located on the northern slopes of Glen Devon.



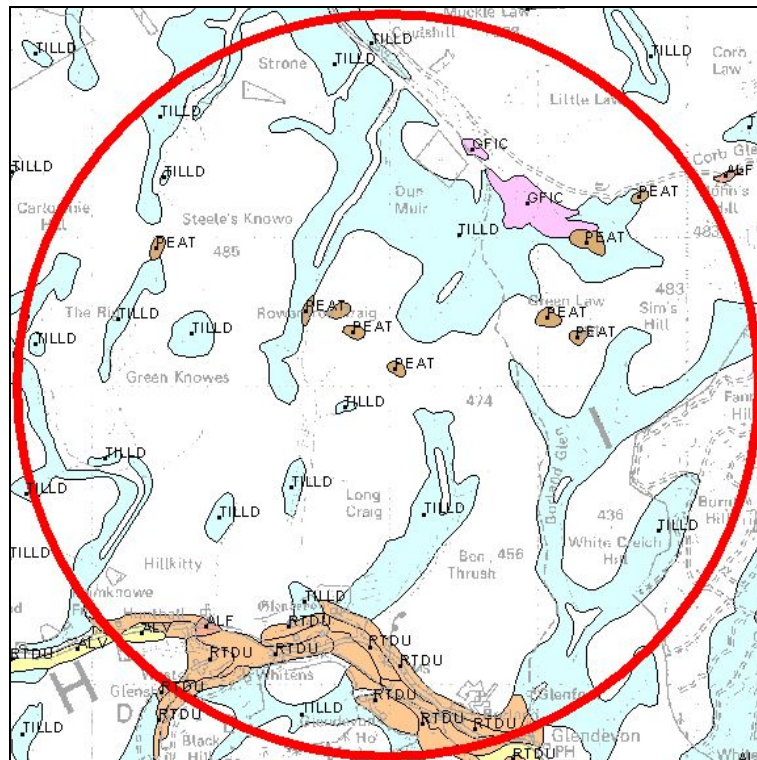
Scale: 1:50000 (1cm = 500m)

⊕ Approximate area of turbines

Figure 1: Location of the Green Knowes site

1 Geology

Superficial deposits



Scale: 1:50000 (1cm = 500m)

Key to Superficial deposits:

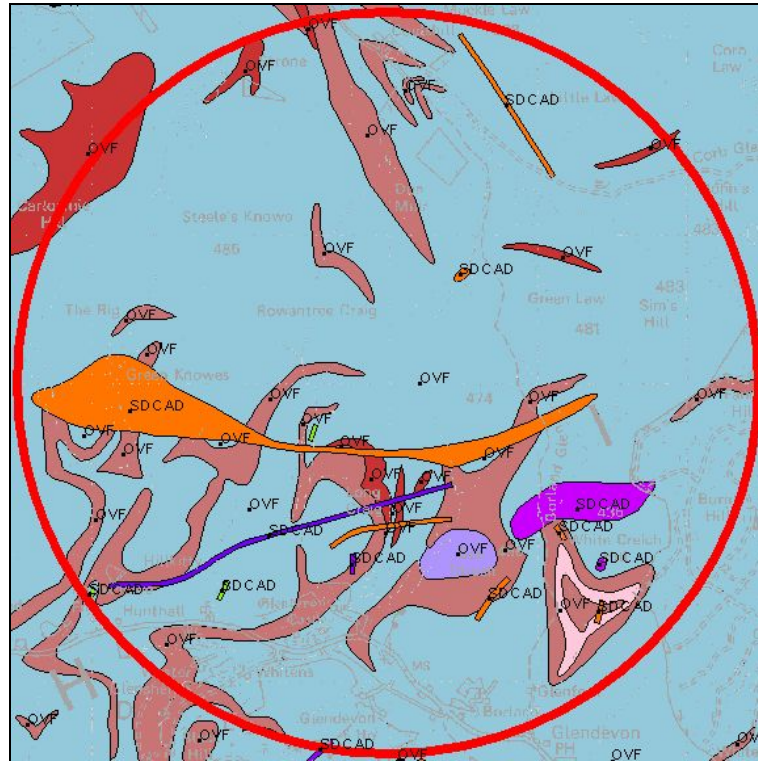
Map colour	Computer Code	Rock name	Rock type
	ALF	ALLUVIAL FAN DEPOSITS	SAND AND GRAVEL
	ALV	ALLUVIUM	GRAVEL, SAND AND SILT
	PEAT	PEAT	PEAT
	RTDU	RIVER TERRACE DEPOSITS (UNDIFFERENTIATED)	SAND AND GRAVEL
	GFIC	GLACIOFLUVIAL ICE-CONTACT DEPOSITS	SAND AND GRAVEL
	TILLD	TILL, DEVENSIAN	DIAMICTON

Figure 2: Superficial deposits

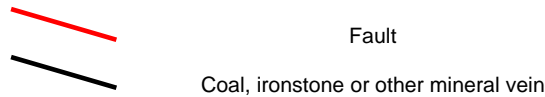
Small areas of the site area are underlain by thin, patchy glacial till (Figure 2). This is a predominantly clayey, stony deposit with occasional coarser grained sand and gravel horizons. The main proposed area for turbine installation is underlain by very thin superficial deposits, with bedrock either at or very close to surface. Slightly thicker till is present in the valley of the Eastplace Burn in which the main access track is planned. Alluvium and River Terrace Deposits (typically comprising poorly consolidated sands, gravels, silts and clays) are mapped on the floor of the River Devon flood plain where the access tracks commence. A small area of Glaciofluvial Ice Contact Deposits (comprising sand and gravels) are mapped to the north of the

proposed site and there are several areas of peat mapped close to the proposed locations of the turbines.

Bedrock



Scale: 1:50000 (1cm = 500m)



Note: Faults and Coals, ironstone & mineral veins are shown for illustration and to aid interpretation of the map. Not all such features are shown and their absence on the map face does not necessarily mean that none are present

Key to Bedrock geology:

Map colour	Computer Code	Rock name	Rock type
	OVF	OCHIL VOLCANIC FORMATION	BASALTIC ANDESITE
	OVF	OCHIL VOLCANIC FORMATION	ANDESITE
	OVF	OCHIL VOLCANIC FORMATION	BASALT
	OVF	OCHIL VOLCANIC FORMATION	CONGLOMERATE
	OVF	OCHIL VOLCANIC FORMATION	TRACHYANDESITE
	SDCAD	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	BASALT AND DOLERITE
	SDCAD	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	DIORITE
	SDCAD	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	MICRODIORITIC-ROCK
	SDCAD	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	MICROGRANODIORITE, PORPHYRITIC
	SDCAD	NORTH BRITAIN SILURO-DEVONIAN CALC-ALKALINE DYKE SUITE	MICRODIORITE, PORPHYRITIC

Figure 3: Bedrock geology

Lower Devonian Basaltic-Andesite rocks of the Ochil Volcanic Formation underlie the whole site (Figure 3). Minor igneous intrusions cut through these older volcanic rocks in places. The volcanics are hard, fractured rocks that have been subjected to heat and pressure to form complex structures. The upper few metres of the rock are normally highly fractured as a result of glacial activity and weathering processes.

2 Hydrogeology

Superficial deposits

Groundwater is present mainly within sandy, gravelly beds interbedded within the patchy till deposits. These are common in the area, particularly on the lower slopes of the valleys where significant flows of groundwater are present. These can form useful, but vulnerable, domestic supplies. However, the main body of till itself can also have a significant permeability owing to the sandy nature of the material and the presence of fissures and fractures. The groundwater flow paths in till are very localised and can be complex. Their direction of flow is influenced mainly by the location of the more permeable beds and the local topography.

Groundwater is also found in the alluvium and river terrace deposits under the floor of the River Devon flood plain. These deposits contribute significant baseflow to the rivers.

Areas of peat and mire can, in places, be supplied with groundwater from springs emanating in upland tills.

Bedrock

The upper weathered zone of the Ochil Volcanic Formation is the principal layer where groundwater is present, although even here it is in relatively small quantities. Rainfall enters this zone either from direct recharge from surface exposures of bedrock or via till and peat. From here, groundwater moves down slope to appear at springs. Many shallow wells are dug into this layer to intercept shallow groundwater flow.

Section 2: The Environmental Statement review

The Environmental Statement (ES) has been produced by Scottish Power and is not dated but was received by Perth and Kinross Council in August 2004.

The proposal is for the construction of 18 turbines at Green Knowes (centred at approximately NN 980 070).

Chapter 9: Hydrogeology and Hydrology

Geology

Sections 9.16 and 9.17 provides a short geological description. BGS maps for the area have been used. Appendix 3 provides a survey of peat depth in the area.

Overall, an accurate summary of the bedrock geology. However, scant attention is paid to the patchy superficial deposits (Alluvium, River Terrace Deposits, Till, peat and Glaciofluvial Ice Contact Deposits), the only reference to them being that most of the site is directly on bedrock. Greater attention should be given to the tills along the Eastplace Burn, leading down to the River Devon and within which the access road is planned.

Hydrogeology

9.18 refers to the BGS hydrogeological map of Scotland and provides a description of the hydrogeological conditions across the site. Recognition of the relatively small amount of groundwater held in storage in the bedrock is made and that springs may be present where dilated joints are present.

No mention is made of the potentially significant shallow groundwater present in the coarser grained, sands and gravels within the till and in the alluvium and river terrace deposits near the end of the planned access road. This could be very important when considering the potential impact on surface waters, as the water in these deposits, particularly the alluvium and river terrace deposits, may provide a significant contribution to baseflow in nearby surface waters and supply private properties. Many boreholes provide water supplies in other parts of Scotland from similar superficial deposits.

9.46 states that the underlying geology is impermeable and without significant groundwater.

Significant quantities of groundwater may occur in the upper weathered zone of the bedrock. Abstraction of groundwater can also be made from water bearing fissures and fractures over 60 metres below surface.

Groundwater vulnerability

No mention is made of groundwater vulnerability.

SEPA's latest vulnerability maps, produced by the BGS, indicate that fractured bedrock with thin or no sandy till cover is highly vulnerable to pollution. However, these maps are not available to consultants yet. The fractured nature of the aquifer can lead to rapid flow of water and the aquifer is therefore vulnerable to contamination from the surface.

Receptors

Private water supplies:

9.35 states that Scottish Waters Castlehill Reservoir is fed by the River Devon.

Figure 9.2 shows the locations and nature of 38 private water supplies identified in the area. 9.36 and table 9.3 lists five private water supplies identified as lying within the proposed Green Knowes Wind Farm catchment area.

Personal communication with local residents suggests that there are several properties with private water supplies that are not included in the ES such as High Cleugh, Low Cleugh, Glendevon Castle and Huntall. It is likely that many of the properties are either supplied from shallow groundwater in the sand and gravel horizons that occur within the till or from the bedrock, as where it is locally fractured and weathered it has the potential to provide significant quantities of water. Due to the fractured nature of the bedrock, rapid flow can occur and sources some distance away may be affected by the proposed development, although it is unlikely that any deep abstraction boreholes located more than 2 km from the margins of the development would be affected. Similarly, those properties to the north of the development are unlikely to be affected.

The Glendevon Manse, The Old School House and Borland Farm are all located within 600 metres of the proposed development and their catchments lie within the wind farm site area and therefore these supplies could be affected by the development. The catchments for the private water supplies at Kaimknowe Farm and Coulshill are not thought to lie within the area affected by the development.

Surface water:

Chapter 9 describes the hydrology of the area. It considers the potentially polluting effects of the development on the local surface water and the relevant mitigation measures that should be carried out. The summary of effects table (p 9-8), considers that with mitigation measures carried out, all the potential effects are ‘not significant’ except for sedimentation during construction and decommissioning and this is considered to be a ‘short term, minor to not significant effect’.

Discussions with local residents has indicated that the majority of farms in the area rely on surface water for their livestock. The BGS considers that groundwater baseflow to streams and maintaining the wetland areas may be significant. Therefore, the construction of tracks and pits some distance from streams may have a temporary effect on the quality of water in them and also the private water supplies of any properties that use surface water for water supply. This is unlikely to be significant, but the role of shallow groundwater flow in bedrock and superficial deposits as baseflow to surface streams should be recognised.

Groundwater-dependent ecosystems

Chapter 7 considers the ecology of the proposed Green Knowes wind farm site area. Table 7.1 provides a summary of the effects and mitigation measures on the local

ecology. It considers loss of wet heath habitat during the construction phase to be of minor significance.

The BGS considers that there may be a minor, localised, impact on surface waters and groundwater dependent ecosystems during construction, from the discharge of sediment into nearby water bodies from surface water run off during construction, operation and decommissioning but that this is considered to be low risk.

Monitoring

9.79 to 9.81 refers to the PPP for monitoring requirements and noted that regular inspections of the site drainage and natural watercourses will be carried out.

Monitoring should also include private water supplies, particularly the five identified as lying within the wind farm catchment area (Coul's Hill, Kaimknowe, Borland, Old Schoolhouse and Glendevon Manse). In addition, High Cleugh, Low Cleugh, Glendevon Castle and Huntall sources should be investigated as these also are likely to lie within the catchment.

Residual effects

The residual significance of construction on the five private water supplies listed in Tables 9.4 and 9.5 (change to flow, spillages) are considered in the ES to be 'not significant'. Sedimentation is considered 'minor to not significant'. For groundwater in general, all impacts are 'not significant'.

These conclusions are, in the opinion of BGS, broadly correct, although the detail of the locations of private supplies near Glendevon Castle must be investigated further, as they may originate from the large area of till present on the valley sides. Construction of the access track may affect supplies in the tributary valley.

Conclusions

- Shallow groundwater in the sandy till and weathered bedrock zone is likely to be providing significant amounts of groundwater as baseflow to streams and springs and a number of shallow wells and boreholes exploit these groundwater resources. Shallow groundwater also supports areas of mire and wet heath.
- It is important that the location and nature of all private water supplies in the vicinity are identified. From discussions with local residents there are a number of properties reliant on private water supplies that are not identified in the ES. In particular, any water sources near the Eastplace Burn should be investigated in more detail.
- Whilst the BGS consider the overall risk to groundwater receptors as low, there may be local impacts on shallow groundwater with temporary reductions in water quality and effects on groundwater dependant ecosystems. There are three private water supplies identified in the ES that could potentially be affected by the developments and there may be others not specified by the ES.
- Routine quality inspections of sensitive environmental features within the vicinity of the site should be carried out, (both pre, during and post construction) including monitoring of the five private water supplies identified as lying within the wind farm catchment area.

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