**Appendix 3.2:** Private Water Supply Risk Assessment (Natural Power)


# Craiginmoddie Wind Farm

## Private Water Supply Risk Assessment

October 2021

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# Document history

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# Contents

# 1. Introduction

Natural Power Consultants Limited (Natural Power) have been commissioned by EnergieKontor UK Ltd (“the Client”) to provide an assessment to determine the potential level of risk posed to Private Water Supplies (PWS) from the construction and operation of the proposed Craiginmoddie Wind Farm (the Proposed Development). The Proposed Development will consist of up to 14 turbines and associated infrastructure.

Natural Power have carried out an updated review identifying properties known to have a PWS, re-consulted with residents to confirm supply arrangements and assessed the risk to those supplies based on a source-pathway-receptor model, which has been refined using information obtained through site walkover surveys. Further detail on the background of the assessment is provided below.

The intention of this assessment is to support the Client in the submission of Further Environmental Information (FEI) for Craiginmoddie Wind Farm.

For the avoidance of doubt, the assessment considers the area within which the PWS are situated, which in many cases extends beyond the Application Boundary for the Proposed Development (see Appendix A). The area within which all of the PWS are situated will be referred to herein as The Study Area. The assessment has been undertaken with cognisance to the relevant national, regional and local guidance and policy, which is detailed in Appendix B.

## 1.1. Background

The information included within this assessment expands upon the previously submitted details to further assess the impact of the Proposed Development on PWS.

An assessment of private water supplies was included as part of the Environmental Impact Assessment Report (EIAR[1]), identifying seven properties which may be hydrologically connected to the Proposed Development. Following further consultation and more detailed consideration, two of these properties (Knockrochar Farm and Dalquhairn Farm) were assessed to be hydrologically and hydrogeologically disconnected from the Proposed Development. The remaining five are considered further as part of this assessment due to the potential for sources or supply infrastructure being hydrologically or hydrogeologically connected with the Proposed Development or due to supply source being unverified during the preparation of the EIAR.

Following further consultation with the SAC Environmental Health Officer (EHO), an additional property (Doughty Cottage) is included within the assessment. The SAC EHO also indicated that Dalwayne Farm is permanently unoccupied and therefore no further assessment is required at this time. The EAIR identified a Minor risk to this PWS as a result of the construction and operation of the proposed Development. In the event the occupation status of this property changes prior to construction, detailed assessment for this PWS could be undertaken if required.

The five properties included within the assessment include:

- Dobbingstone Farm.
- Lindsayston Farm.
- Delamford Cottage & Farm.
- Corphin Cottage.
- Doughty Cottage.

[1] EnergieKontor UK (Ltd) (2020), Craiginmoddie Wind Farm EIAR Volume 1: Chapter 12: Hydrology, Hydrogeology and Geology

Standard good practice mitigation measures relevant to this assessment have already been detailed on pages 37 to 58 of Chapter 12 of the EAIR[1]. This includes measures associated with pollution management and prevention, and contingency measures in the event of an unexpected incident.

This Private Water Supply Risk Assessment (PWSRA) is designed to complement the assessment provided in Chapter 12 of the EIAR and address specific requirements of South Ayrshire Council (SAC) provided in their Scoping Response[2]:

*"The applicant shall submit to the planning authority a site-specific hydrogeological report (not desk top study), which contains a review of the risks to all private water sources, their catchment areas, and the supplies, that have the potential to be affected by the development. Work shall not commence on site prior to the written approval of the Planning Authority being obtained. The report should include a field assessment of all private water sources and supplies and their catchment areas, and focus on the effects of the development on the quality and quantity of water supplied to all private water users both within and out-with the boundary of the proposed site that have the potential to be affected by the development. A conceptual site model should be included as this is key to developing a robust assessment of all risks to all potentially affected private water supplies. Attention should also be given to possible leachate generation at any Borrow Pit excavations."*

## 1.2. Scope of Work

Establishing a conceptual site model (CSM) is key to developing an understanding of the likely source for each PWS and establishing a reasonable assessment of risk to the PWS. The CSM uses available published literature and other available data.

The scope of works was proposed as follows:

- Where available, collection and review of existing sources of data related to the water environment, to include but not exclusively consist of, geology, hydrogeology, hydraulic parameters, groundwater levels, surface water courses, PWSs, springs, drainage patterns and baseline water quality data;
- Develop a hydrogeological conceptual model of the site and surrounding area;
- Meet and discuss the water supply design and historical issues with the PWS owners;
- Undertake a site walkover to view identified features and refine the conceptual model;
- Review factors associated with the Development which could impact the water supply and assess, at an outline level, potential impacts of the works based on potential risks to water resources identified in the context of the activities; and
- Report on the findings. This may include the identification of any **additional measures**, that should be included as part of the environmental documentation prepared by the contractors, to avoid and mitigate against any potential adverse effects resulting from the Development.

## 1.3. Disclaimer

This report has been prepared by Natural Power with all reasonable skill, care and diligence for the Client, for the specific purpose of assessing the risk to private water supplies posed from the construction and operation of Craiginmoddie Wind Farm.

This report details the findings of the risk assessment considering information provided by SAC, the relevant landowners, Client and property residents and is therefore, as accurate as this information will allow. This document should be considered live and as such, changes will be made should new information come to light.

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[2] South Ayrshire Council (2020), Scoping Response to Proposed Craiginmoddie Wind Farm Scoping Report (received via EnergieKontor on 21/10/2020)

Natural Power accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Natural Power beforehand. Any such party relies upon the report at their own risk. Natural Power disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the services.

Owing to the inherent complexity of the subsurface, it is rarely possible to determine the mechanics of a system with absolute certainty. In this regard, investigations as part of this assessment will strive to determine the circumstance of each supply based on the evidence available to support this assessment. Where uncertainty exists associated with understanding the details of a private water supply or in accurately conceptualising the subsurface, this will be stated and risks and assessment considered appropriately.

Whilst the assessment assesses relative risk, no detailed quantitative risk assessment has been completed.

# 2. Environmental Setting

## 2.1. Site Setting and Land Use

The PWS are all situated within SAC administrative area, situated to the north of the Stinchar Valley and the south of the Girvan Valley in the south-east part of South Ayrshire.

Land-use in elevated areas is a combination of commercial forestry (mature and felled) and open moorland used as rough grazing. Closer to valley basins land cover is semi-improved grasslands again used for grazing. Some deciduous woodland is also present in lower catchment areas.

Locations of PWS abstractions are presented in the figures in Appendix A.

## 2.2. Geology

Maps of the local geology are provided in Appendix A and a brief description is provided below.

### Superficial Geology Summary

Glacial till is mapped extensively as overlying the bedrock across the Study Area. More minor areas of alluvial sediments are also mapped within riparian zones around the Delamford Burn, Lindsayston Burn and River Stinchar. Whilst not mapped, peat is also known to be present on the higher ground.

### Bedrock and Structural Geology Summary

The bedrock geology of the Study Area forms part of the southern margin of the Midland Valley Terrane, and is dominated by Siluro-Devonian Lanark Group sandstones, siltstones, mudstones and conglomerates in the north and the older Ordovician Benan Conglomerate Formation in the south. An intrusive igneous outcrop is also present close to the summit of Craiginmoddie. A brief description of the most significant geological units are presented in Table 2.1.

**Table 2.1: Geological Summary**

| System | Group | Strata | Geological Description |
|---|---|---|---|
| Quaternary | - | - | Organic accumulations of peat varying in thickness from <0.5 m to 3.0 m. Mainly constrained to ground >250 m AOD |
| | Devensian | Diamicton | Red-brown diamicton of stiff clay and subrounded pebbles, or sandy clay and pebbles |
| Sil. – Dev. | Intrusive Igneous | Microgabbro | Mafic-semi mafic intrusion of igneous rock |

| System | Group | Strata | Geological Description |
|---|---|---|---|
| Devonian | Old Red Sandstone (Lanark) | Swanshaw Sandstone Formation | Red-brown, grey-green and chocolate-brown, medium and coarse-grained terrestrial sandstones with subordinate pebble beds and conglomerates, minor fine-grained sandstones, siltstones and mudstones. |
| | | Greywacke Conglomerate Formation | Conglomerate of cobbles and boulders up to 250mm diameter but most clasts are less than 70mm, mostly subrounded, consisting of greywacke, minor chert and quartzite, with a few sandstone beds. |
| Ordovician | Whitehouse Group (Lanark) | Shalloch Formation | Thin grey flaggy greywacke with siltstone turbidities |
| | Barr Group (Leadhills) | Benan Conglomerate Formation | Boulder conglomerate constrained to the north side of the Stinchar Valley. |

*Source: British Geological Survey Maps and Publications*

There are several structural geological features mapped within the Study Area, with the most significant and named being the Bargany Fault mapped just north of Lindsayston PWS, and the Stinchar Valley Fault being ~5 km south of Doughty PWS. Other unnamed faults are also present, with one mapped close to the abstraction for Dobbingstone PWS and another near Corphin Cottage PWS. All of these structures conform to the regional orientation of similar structures in Southern Scotland, striking SW-NE. There are a few secondary fault structures orientated perpendicular to the main fault lines, with the most significant being close to Corphin Cottage.

Mapped dip data indicating the orientation of the bedding planes would suggest the Old Red Sandstone in the north of the Study Area is synclinal, and closer to Craiginmoddie dips to the northeast between 10 and 30 degrees. The Benan Conglomerate dips generally north / northeast between 30 and 50 degrees.

## 2.3. Hydrogeology

**Aquifer Status & Vulnerability**

The following aquifer productivities have been identified for the specified bedrock groups according to the 1:625:000 scale Hydrogeological Map of Scotland[3];

- Lanark Group (Moderately Productive): Regional aquifer of sandstones, in places flaggy, with siltstones, mudstones and conglomerates and interbedded lavas. Locally yields up to 12 L/s.
- Leadhills Supergroup (Low Productivity): Highly indurated greywackes with limited groundwater in near surface weathered zone and secondary fractures.
- Intrusive Igneous (Low Productivity): Small amounts of groundwater in near surface weathered zone and secondary fractures; rare springs.

According to The Groundwater Vulnerability Map of Scotland[4], aquifers underlying the Study Area are considered vulnerable to pollutants that are not readily absorbed or transformed (Classes 4a & 4b). The most vulnerable aquifer will be the moderately productive Lanark Group sandstone and conglomerate formations.

[3] British Geological Survey (1988), Hydrogeological Map of Scotland, 1:625,000 Scale. NERC.

[4] British Geological Survey (2011), User Guide: Groundwater Vulnerability (Scotland) GIS dataset, Version 2, http://nora.nerc.ac.uk/id/eprint/17084/1/OR11064.pdf, accessed 19/11/2020

Information regarding groundwater WFD classification was obtained from SEPA's Water Classification Hub[5]. The Site is primarily underlain by the Girvan groundwater body (waterbody ID 150607), which has an overall WFD classification of Good (2018). The southwestern tip of the Study Area is underlain by the Lendalfoot groundwater body (waterbody ID 150617), which also has an overall classification of Good (2018). These two groundwater bodies have classifications of Good for both Quantitative status (groundwater water level) and chemical status (groundwater quality).

### Groundwater Levels

Groundwater level data is absent and the depth to groundwater within the vicinity of each PWS is unknown. However, groundwater is considered to be at ground level at the point of discharge from springs. Perched groundwater within the peat is also likely to be present.

### Aquifer Properties

No site specific hydraulic data is available for the Study Area. However, more general published information for bedrock units present within the Study Area investigated elsewhere in Southern Scotland[6] and the Midland Valley[7] provides an indication of the likely hydrogeological conditions.

The hydrogeology of the Carboniferous **Lanark Group** sedimentary aquifers in the Midland Valley tend to form cyclical sedimentary sequences of alternating fine- and coarse-grained rocks and in some instances, the organisation of the strata essentially form multi-layered aquifers, interspersed with lower-permeability siltstones and mudstones. Sandstones are typically well-cemented and extremely hard and dense, and in consequence show low primary porosity and intergranular permeability. As such, groundwater flow is more dominantly through fractures or other structural features, with aquifer permeability proportional to the degree and nature of fracturing. Groundwater flow paths are likely to be complex, due to the naturally layered nature of the aquifers, which tends to impart preferential horizontal flow, and the predominance of fracture flow. Groundwater may be present under unconfined or confined conditions, at various depths, and different groundwater heads are seen in different aquifer layers. Locally, groundwater flow in bedrock is likely to broadly reflect topography, although the fractured nature means that bedrock catchments may not necessarily coincide with the surface water catchments and may be influenced by the orientation of fractures, faults and other structural geological features such as open beds, with flow lengths ranging from 1 to 10 km. Groundwater residence times can be in excess of 60 years. Published hydraulic conductivity ranges from 0.0008 to 1.676 m $d^{-1}$, with a median value of 0.104 m $d^{-1}$.

The dominantly fine-grained, well-cemented nature of the **Leadhills Supergroup** rocks means intergranular permeability is generally low. Apart from a sometimes well-developed weathered zone at rockhead, in which intergranular permeability is enhanced, fractures in the rocks are thought to contribute virtually all groundwater storage and flow. Groundwater flow paths are likely to be controlled by fracture patterns and to be generally relatively shallow, relatively short and localised.

When unweathered, **Igneous** rocks have negligible intergranular porosity and permeability. The main controls on aquifer permeability are the characteristics of rock fracturing, and the degree of weathering along junctions between individual lava flows

The widespread till deposits which overly the bedrock are generally fine-grained and contain significant amounts of clay, particularly where they overlie mudstone units. They are also relatively dense as a result of glacial compaction,

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[5] Scottish Environment Protection Agency (2020), Water Classification Hub, https://www.sepa.org.uk/datavisualisation/water-classification-hub/ , accessed 18/11/2020

[6] MACDONALD A M, Ó DOCHARTAIGH B E, KINNIBURGH D G AND DARLING W G. 2007. Baseline Scotland: groundwater chemistry of southern Scotland. British Geological Survey Open Report, OR/08/62. 89pp.

[7] Ó DOCHARTAIGH B É, SMEDLEY P L, MACDONALD A M, DARLING W G AND HOMONCIK S. 2011. Baseline Scotland: groundwater chemistry of the Carboniferous sedimentary aquifers of the Midland Valley. British Geological Survey Open Report, OR/11/021. 105pp

and therefore have correspondingly low permeability and storage. Relatively small groundwater seepages are likely to occur throughout sandier and gravellier horizons in the till, sometimes feeding small springs where these horizons crop out at the ground surface. Compact, clay-rich glacial till will limit infiltration into underlying aquifers where present. Where the vertical and lateral extent allows, flow pathways will follow the local topography.

## 2.4. Hydrology

### Precipitation and Groundwater Recharge

According to the Hydrometric Statistics Handbook[8], the River Stinchar (NGR NX108 832) approximately 10 km SW of the Study Area estimates Average Annual Rainfall between 1973 and 2005 of 1615 mm per year with a mean annual loss of 620 mm which represents possible evaporation and infiltration.

The stated Base Flow Index of Approximately 0.3 suggests a relatively impermeable catchment with only a limited contribution to runoff from the bedrock and other stored sources. This is in line with the understanding of local geology and hydrogeology presented above.

### Surface Water

Hydrologically, the Study Area lies within the catchments of the River Stinchar and Water of Girvan. The headwaters of the River Stinchar are located within the Carrick Forest. The River Stinchar has a catchment area of 314 $km^2$ and the watercourse flows north initially from its source then flows south west for the majority of its 45 km course before discharging into the Firth of Clyde of Ballantrae. The catchment of the Water of Girvan is approximately 250 $km^2$ and flows west for approximately 45 km from its source at Loch Girvan Eye through Straiton and Dailly before discharging into the Firth of Clyde at Girvan. The Site is located within the catchment of the Lindsayston Burn, which discharges into the Water of Girvan. More detailed information is presented within Chapter 12 of the EIAR[1].

The limited permeability of the bedrock away from weathered / fractured zones combined with the low permeability of the overlying glacial till and peat is likely to encourage overland flow / water saturation of soils where topographic and ground conditions allow.

## 2.5. Water Quality

No detailed groundwater quality data is available, however a limited range of chemical parameters were sampled from surface waters and a suspected spring head near the Dobbingstone PWS abstraction.

Published data obtained from the Baseline Scotland Ground Chemistry Report[9] suggests that where present, bedrock groundwater in the Carboniferous sandstones is typically moderately to highly mineralised (SEC 353–1450 µS/ cm, median 694 µS/cm) with a slightly alkali pH (6.7–8.0, median 7.3). There is a wide range of chemical types with the most dominant type being Ca (Ca-Mg)-HCO3. More highly mineralised groundwaters can be dominated by CaMg(Na)– SO4 (Cl) with variations linked to depth of sample, residence time and local geology. Redox conditions are variable, and where groundwater is reducing, Fe and Mn concentrations are often elevated.

Where waters are observed to be significantly less mineralised, with more acidic pH as well as higher concentrations of atmospheric indicators (such as Na, Cl or SO4), it can be inferred that groundwater is likely to have had a limited residency time / be related to accumulation of surface water and subsequent runoff.

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[8] Marsh, T. J. and Hannaford, J. (Eds). 2008. UK Hydrometric Register. Hydrological data UK series. Centre for Ecology & Hydrology. 210 pp. Available at http://nora.nerc.ac.uk/id/eprint/3093/1/HydrometricRegister_Final_WithCovers.pdf (accessed 07/10/2021).

[9] MACDONALD, A M, Ó DOCHARTAIGH, B É, and SMEDLEY P L. 2017. Baseline groundwater chemistry in Scotland's aquifers. British Geological Survey Open Report, OR/17/030. 77pp.

# 3. Description of Private Water Supplies

An inspection of the PWS abstractions for Dobbingstone Farm, Lindsayston Farm, Delamford Cottage & Farm, Corphin Cottage was completed on Wednesday 29th September. The weather was bright with occasional showers. Prior to the visit, the weather was also showery, but the months preceding had been extremely dry.

An inspection of the PWS abstraction at Doughty Cottage was undertaken on Wednesday 6th August. Weather on the day on the visit and in the days before had been showery.

## 3.1. Dobbingstone

### Description of PWS

The abstraction (NX 30787,99518) is situated in a separate catchment from the PWS property, adjacent to an unnamed tributary burn of the Dobbinstone Burn. The abstraction is a small chamber sunk into a flush-type feature ~50 m west of the unnamed tributary.

At the time of writing, the pipework (black HDPE) route had been investigated by Scottish Woodlands and was marked by a series of trial pits and marker canes, running from the abstraction down under the Dobbingstone Burn and crossing Dobbingstone Hill to the property. There is a settling tank also used as a holding header tank adjacent to the PWS property.

The PWS User commented that the abstraction has never dried up and that quality is only impacted during prolonged wet weather, where some peaty discolouration is evident.

*Source: Natural Power*

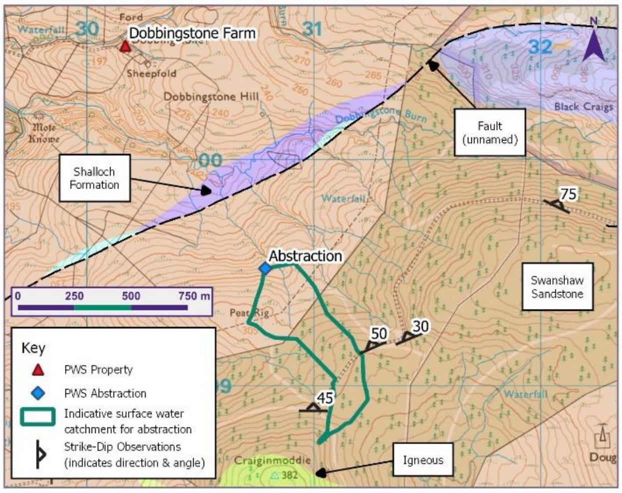




**Figure 3.1: Location and layout plan showing the geology and structural features. The indicative surface water catchment (based on GIS) is also shown.**

*Source: Natural Power*

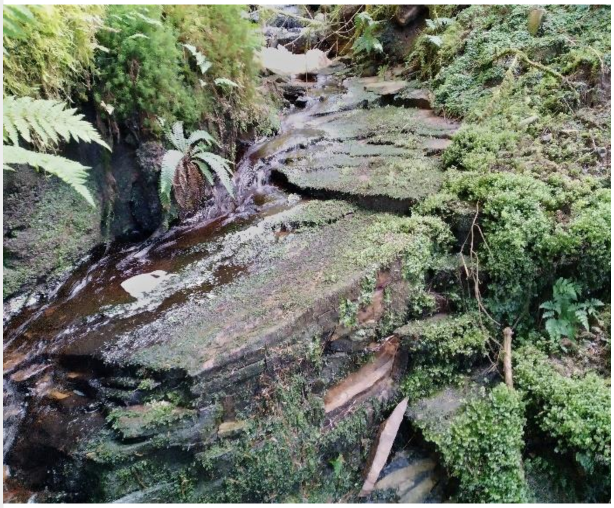

**Figure 3.2: Thinly bedded sandstones at NX 31421 99207 out cropping within a watercourse. The sandstone was dipping gently to the northwest**

### Description of the Catchment

Topographically, the catchment for the PWS abstraction extends southeast towards Craiginmoddie (320 m AOD). The flush features, within which the abstraction is situated, appears to rise ~100 m upslope of the abstraction chamber and is marked by an area of rushes (NX 30808,99473). Within the flush feature there are a few steeper sections where the soil thins and is predominantly gravel and mosses. The topography above the flush feature is marked by a break in the slope angle, with a transverse drainage ditch also being positioned a few meters above the top of the flush. The drainage ditch was dry and did not show evidence of containing any flow.

On the hillside above the flush, there are several other drainage ditches which cross the grassland, emanating from the forest and running obliquely from its edge striking in a northerly direction towards the unnamed tributary. Most of the drainage ditches encountered were stagnant / dry. The topography above the flush was slightly concave but orientated in a manner to encourage flow towards the minor stream and not in the direction of the abstraction.

The headwater of the minor stream was noted as a large area of rush pasture, with no obvious inflow channel from the direction of the forest (NX 30915,99363), even though a watercourse is mapped. Further downslope, the stream becomes more defined (NX 30886,99436). After this point the stream banks become gradually larger ranging from ~1 to 10 m in height.

### Additional Observations

The flow within the flush feature above the abstraction chamber had no discernible channel, with water appearing to seep through patches of mosses and gravels. Below the chamber, a small, incised channel was evident (~0.3 m deep x 0.2 m wide) with a flow of ~1 l/s. The abstraction chamber was not inspected at the request of the PWS User, so inflow rate into the chamber itself is not known.

Water quality monitoring was undertaken within the minor stream adjacent to the PWS abstraction (HW1). Additional monitoring was also undertaken within the flush feature, ~50 m downgradient from the abstraction chamber. Tabulated results are presented in Appendix C. In general, when compared with nearby surface waters, the water within the flush feature was more mineralised, had a high alkalinity and higher concentrations of calcium. As the levels of mineralisation were slightly lower than regional baseline averages for bedrock groundwater (see Section 2.5), this could indicate the mixing of groundwater and surface waters.

Above the abstraction, the orientation of the drainage ditches combined with the arrangement of the topography is likely to limit the extent to which surface water can discharge towards the abstraction. As such, the approximate surface water catchment within which water can flow to the abstraction is likely to be considerably smaller than the indicative catchment (shown in Figure 3.1).

Inspection of the geology in the forest within the vicinity of the indicative surface water catchment area indicated the bedrock comprises of grey / orange sandstone, which was mostly thinly bedded and dipping in a northerly direction between 30° and 75° (Figure 3.2). The superficial deposits comprised of matrix supported glacial till and peat (Figure 3.3 and 3.4).

*Source: Natural Power*

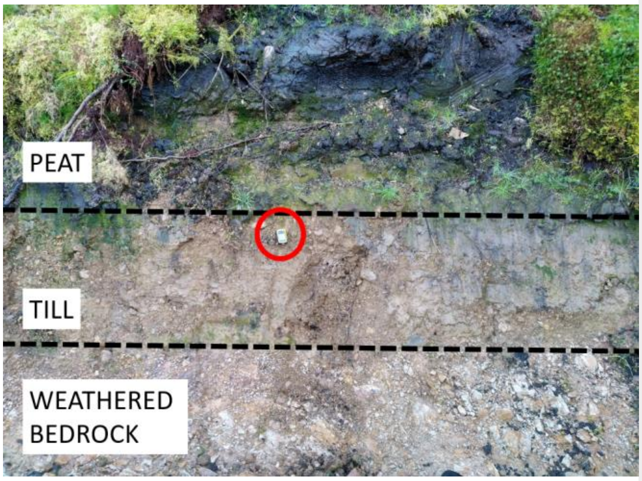


**Figure 3.3: Geological section adjcent to an access track at NX 30999 98890. GPS device for scale highlighted by red circle.**

*Source: Natural Power*

**Figure 3.4: Exposure of peat and glacial till with standing water nearby showing strong peat discolouration.**

No water quality monitoring was undertaken in the forested areas, however visual observations of standing water indicated strong discolouration as a result of peat (Figure 3.4).

## 3.2. Lindsayston Farm

### Description of PWS

The abstraction (NX 28791,99934) is a chamber sunk into the hillside to the south of the property. According to the PWS User, the chamber is a concrete cylinder placed against the rockhead and was backfilled with gravel. The chamber feeds a collection tank situated ~20 m downslope, before being fed to a larger settling tank just behind the property.

The pipework between the collection tank and settling tank is made of black HDPE plastic and its location is unknown, however it's suspected to have been routed down the hill, crossing the wall between the road and forest edge (see Figure 3.5).

The PWS User indicated the supply is typically of good quality and rarely dries up. Occasional issues with scaling.

*Source: Natural Power*

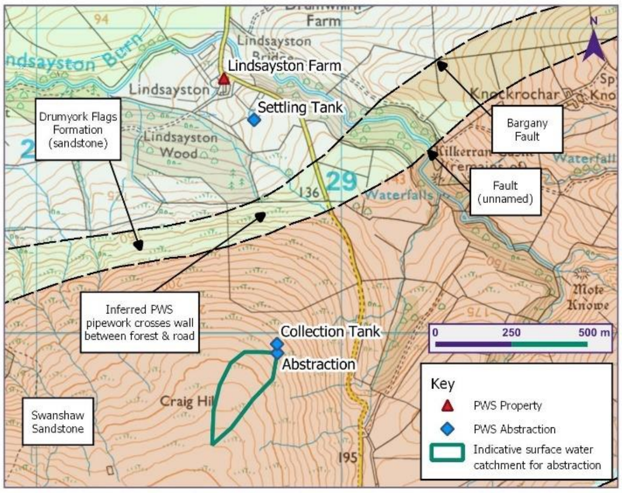




**Figure 3.5: Location and layout plan for the Lindsayston PWS**

*Source: Natural Power*

**Figure 3.6: PWS abstraction chamber at NX 28791 99934 situated on Craig Hill**

### Description of the Catchment

The catchment for the PWS abstraction extends on the hillside of Craig Hill to the south up to 240 m AOD. The abstraction chamber itself is situated on a break in the slope with the gradient easing in the ground above. The terrain also becomes more dominated by rushes around the elevation of the abstraction, with grassland being more dominant immediately upslope.

Although the full extent of the topographic catchment is not clear this could extend to the local watershed. However, it is possible that the catchment is also influenced by structural geology.

### Additional Observations

There are several other areas of water saturated ground (indicated by boggy conditions / rush pasture) within slight re-entrant / flush features. These occur mainly at similar elevations to, or below the abstraction.

Glacial erratics were noted to scatter the slope, and whilst no specific ground conditions could be inspected due to lack of exposures, it is likely that the underlying bedrock has been scoured and glacial till would probably be present.

An inspection of the wall between the road and the forest edge did not indicate the location of the buried PWS delivery pipework. A large drainage ditch running from the road obliquely towards the wall was also inspected with no evidence of the pipework encountered. The PWS User commented that the ditch was recently installed, and did not result in spoiling of the supply, suggesting the pipe could be buried >1 m depth, or runs further west.

## 3.3. Delamford Cottage & Farm

### Description of PWS

The abstraction is a chamber (NX 28858 99044) sunk into the hillside on the north side of the road, ~100 m east of a disused quarry. The chamber is of brick / block construction and is situated at the top of a flush feature and has a small 4” inflow pipe from the upslope side. As much of the ground was obscured by dense ferns, it was not clear if the flush feature extended beyond the abstraction chamber. When inspected, the water in the tank was clear, with the inflow being ~0.5-1 l/s. The precise origin of the inflow pipe is unknown.

From the chamber, the pipework is understood to follow the north side of the road until a corner at NX 28993 99116. After crossing under the road the pipework goes to the south side of Delamford Cottage, before going on to Delamford Farm. The pipework material is likely to be original, comprising of cast iron or clay and its exact location is unknown. The spring is noted to rarely dry up.

*Source: Natural Power*

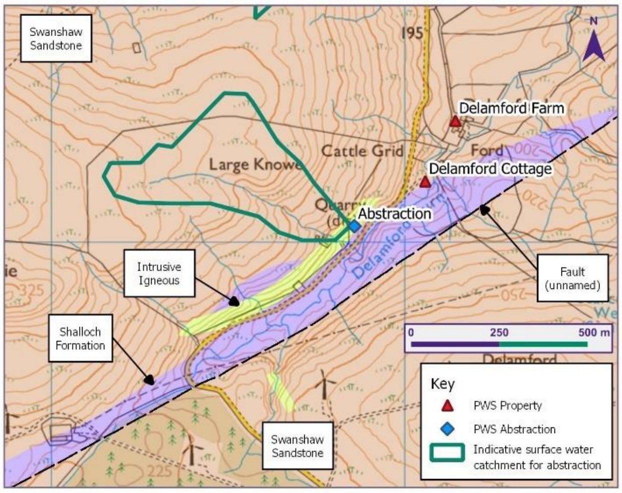




**Figure 3.7: Location and layout plan for the Delamford PWS**

*Source: Natural Power*

**Figure 3.8: Delamford PWS abstraction at NX 28858 99044**

### Description of the Catchment

Topographically, the abstraction encapsulates the moorland by Large Knowe and the nearby watercourse situated cross gradient attaining an altitude of ~250 m AOD. However, inspection of the topography within the vicinity of the abstraction and the upslope area would suggest that opportunities for water draining from the upper catchment of the marked watercourse to reach the abstraction are extremely limited and therefore the actual surface water catchment will be considerably smaller than the indicative catchment. Beneath the abstraction, the ground continues to be steep until the valley floor is reached by the Delamford Burn.

### Additional Observations

The abstraction chamber is situated ~200 m from the road and is at least 50 m vertical elevation above the road surface. The density of ferns meant it was not possible to identify any other possible spring rises in the immediate vicinity.

While no detailed geological observations could be made (due to the unstable appearance of the quarry face), the orientation of the bedding of the sandstone within the quarry appeared to be steeply dipping in a southerly direction, with the bedding striking ~E-W. The PWS User also stated the rock in the vicinity of the supply (and in the quarry) was “rotten”.

## 3.4. Doughty

### Description of PWS

The abstraction is a chamber sunk into the hillside below a slight escarpment west of the PWS property at NX 32373 97743. The chamber is a concrete cylinder with a metal lid and stands ~1.5 m above ground level (Figure 3.10).

It was not possible to discuss the circumstance of the abstraction with the PWS User. It is assumed the delivery pipework goes directly from the abstraction to the PWS property.

*Source: Natural Power*

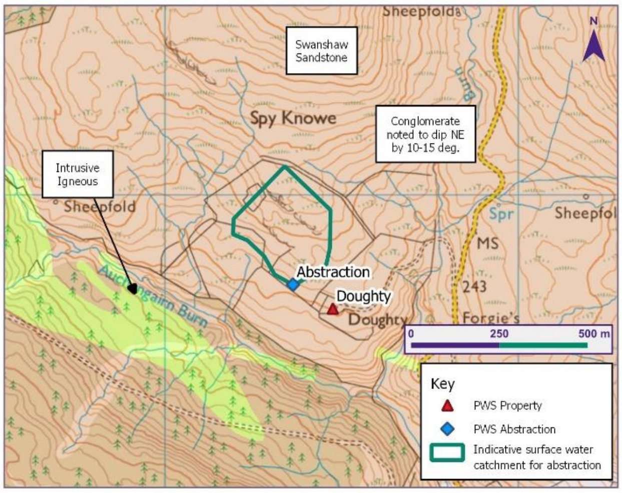




**Figure 3.9: Location and layout plan for the Doughty PWS and abstraction**

*Source: Natural Power*

**Figure 3.10: PWS abstraction for Doughty at NX 32373 97743**

### Description of the Catchment

The indicative surface water catchment area for the abstraction extends northwards to ~300 m AOD south of the slope of Spy Knowe. In reality the complex topography of the ground within the vicinity of the abstraction is caused by the gently dipping nature of the sandstone beds, which outcrop in several locations upgradient, and will mean that overland flow pathways are different to those inferred by the indicative surface water catchment.

There are also numerous drainage ditches which encourage the conveyance of surface water towards existing burns. According to Figure 12.5 Interpolated Peat Depths from Chapter 12 of the EIAR, peat is recorded in the upper catchment to depths 0.5 m to 1.0 m.

### Additional Observations

Drainage within the vicinity of the abstraction was highly variable, with flatter areas between outcrops along bedding planes typically being water saturated, with small channels and boggy areas discharging in a south-easterly direction rather than directly downslope towards the valley bottom (Figure 3.11).

The presence of extensive areas of bog and water saturated ground on top of the bedding planes could suggest that infiltration into the Conglomerate bedrock is limited. An inspection of bedrock outcrops demonstrated few fractures, with imbricated, well rounded clasts set chaotically within a well cemented rock matrix that did not appear to have any intergranular permeability. A few larger vertically orientated structural features were noted striking in the directing of the dipping beds (northeast-southwest) indicated by breaks between outcrop buttresses.

*Source: Natural Power*

**Figure 3.11: Gently dipping Conglomerate beds (north east direction) close to the Doughty abstraction**

*Source: Natural Power*

**Figure 3.12: An outcrop of the conglomerate bedrock close to the Doughty abstraction**

## 3.5. Corphin Cottage

### Description of PWS

The abstraction chamber (NX 28626,96794) is situated on the hillside northwest of the PWS property. The chamber could not be accessed, but is apparently fed by a spring directly into the chamber, but also via pipework which originates from an unknown location upslope.

*Source: Natural Power*

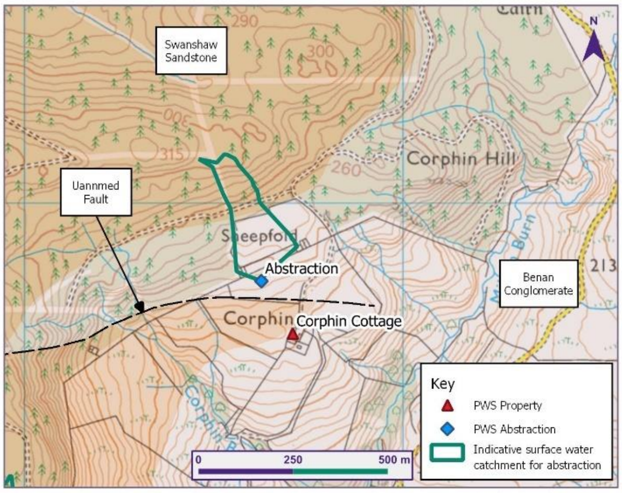




**Figure 3.13: Location and layout plan for Corphin abstraction and property**

*Source: Natural Power*

**Figure 3.14: PWS abstraction chamber at NX 28626 96794. PWS property beyond.**

### Description of the Catchment

The PWS property is situated at ~200 m AOD, with the abstraction situated ~160 m to the northwest at ~225 m AOD. The catchment above the abstraction is a combination of improved grassland used for grazing and mature commercial forestry.

The chamber itself is situated within a flush feature, which has been trampled by cattle / sheep with mud and debris discharging into the PWS chamber.

### Additional Observations

Water level in the chamber is ~0.3-0.5 m below ground level but is understood to have been dry for most of the summer. The PWS for the nearby Glengennet situated ~1 km to the southwest is also a spring supply but is understood to have not dried up.

An unnamed fault is mapped within the vicinity of the abstraction, however no visual evidence was identified on site pertaining to its presence. This was mainly due to a lack of any bedrock outcrops.

The line of the pipework between the property and the abstraction chamber is unknown, but is expected to go directly to the property. The PWS representative commented that it is likely to be leaking, as evidenced by a large area of boggy ground near the cottage in the yard.

# 4. Conceptual Site Model

For a pollutant linkage to exist, sources, pathways and receptors must align in a manner that facilitates the transmission of a pollutant (or harm) to a receptor. The main impacts that can be imparted upon a private water supply receptor is a degradation in water quality or a reduction in quantity. This section presents a conceptual site model (CSM) based on the available data.

## 4.1. Preliminary Consideration

The desktop assessment and field inspections of PWS abstractions and local hydrogeology indicate the presence of two main groundwater systems; a shallow system that is largely dependent on surface water runoff and a deeper system heralding from the underlying bedrock. Shallow supplies may compromise catch pits and collection systems that obtain water over large areas which are topographically constrained. Supplies obtaining water from the underlying geology will be constrained by the nature and extent of tectonic features or fractures and be less constrained by topography. Under such circumstances, fractures will be a preferential flow pathway and may not conform to inferred surface water catchment area. In the cases of the PWS considered, it’s possible that recharge to abstraction points may be via a combination of both systems.

## 4.2. Potential Hazards

The main hazards which can manifest at a PWS are related to degradation in quality or quantity. The specific activities and operations associated with the Proposed Development which have the potential to impact water quality and quantity have been adapted from CIRIA[10] guidance documents and are presented below:

### Activities potentially affecting water quality

- Accidental discharges of fuels / oils / chemicals as a result of spillages;
- Accidental discharge of effluent as a result of spillages;
- Introduction and release of concrete materials;

[10] Full list of relevant CIRIA guidance documents in Table 12-1, of Chapter 12 of the EIAR.

- Discharge of sediment from surface water networks; and
- Accidental damage to the supply delivery infrastructure.

**Activities potentially affecting water quantity**

- Modification of overland flow pathways (i.e. installation of new drainage and addition of impermeable surfaces); and
- Modification of groundwater flow pathways (i.e. removal of superficial sediments, additional of impermeable surfaces, excavation of borrow pits and associated dewatering).

Point source pollution may arise from accidental releases of fuels / chemicals / effluent from a discrete location. Such sources may introduce contaminants of potential concern into surface waters or groundwater depending on the circumstance of the incident. This could include the accidental release of fuels or oils during construction, or the leaching of transformer oils or chemicals from permanent infrastructure such as the Substation. Other point source pollution may include the pouring of concrete foundations, or specific discharges from damaged or inadequate drainage networks

Diffuse source pollution may arise from non-point source specific activities such as the discharge of water from drainage networks. In such circumstances isolated and discrete discharges may not pose a source of contamination, however cumulatively these can combine to amplify the risk under more confining conditions such as within a watercourse.

A full list of the effects considered to have the potential to effect hydrological receptors arising from the construction and operation of the Proposed Development are presented in Chapter 12 of the EIAR[1].

## 4.3. Receptors

The receptors under consideration in the case of each PWS is the source of water which feed the abstraction. In the case of all of the PWS, discussion with the PWS user and field inspection would suggest each PWS abstraction is fed by a spring.

As well as the source of water, the infrastructure that delivers water from the PWS abstraction to the PWS property is also considered as a receptor.

## 4.4. Pathways

The main pathways for the hazards identified in Section 4.2 to impact upon PWS water sources is either through the transmission of a hazard (pollution etc) to the receptor, or for the PWS water source to be disrupted in a manner that supply quantify is reduced.

In terms of the catchments to the springs, based on the available data and field observations, two means of water supply to springs are considered to potentially contribute to the flow and it is possible that there may be a combination of sources. These are considered to be as follows;

- Shallow groundwater / surface water overland flow convergence following the topography above the PWS abstraction; and
- Emergence of groundwater as it flows along geological structures such as permeable bedding, fractures, faults etc.

Considerations regarding each flow pathway obtained from the desktop assessment and inspection of the PWS are outlined in the below sections.

**Shallow Groundwater / Overland Flow**

- Water sources from shallow groundwater / surface water overland flow will follow the local topography, with specific flow pathways also created by artificial drainage such as forestry ditches or grips. Natural drainage pathways have been significantly modified as a result of these features.
- Shallow groundwater will occur where water is able to infiltrate through upper soils, and is encouraged where further vertical drainage is impeded by lower permeability bedrock. Water may behave in a similar manner where the upper bedrock is extensively weathered.
- Shallow groundwater / overland flow will be fed by rainfall / areas of standing water. Where a PWS is highly dependent upon shallow groundwater / overland flow, the yield will be highly dependent upon rainfall.
- Shallow groundwater / overland flow pathways are vulnerable to disruption and pollution. This is both a product of their accessibility from the surface and limited aerial extent (which reduces opportunities for attenuation of pollutants).
- Visual evidence of flush features / boggy ground from across the Study Area confirm the existence of a shallow / overland flow system. Chemical sampling from within a surface water tributary within the Dobbingstone Burn indicated circumneutral pH, with low levels of mineralisation and slightly higher concentrations of potentially atmospherically derived ions (sodium and chloride) which would suggest that the movement of water through this system is rapid and is dependent upon rainfall volume.

**Groundwater Flow Along Structural Features**

- There is potential for the presence of enhanced permeability related to structural features including open bedding planes, faulting and fractures. The upland elevation of the PWS abstractions would suggest spring forms are likely to be hanging, or fault guided.
- Secondary data sources infer the occurrence of groundwater flow in structural features. The only evidence obtained by this study indicating the presence of groundwater flow along structural features is the chemical sampling data obtained around the Dobbingstone abstraction, which indicated higher levels of mineralisation, buffered pH as well as higher concentrations of geological weathering derived products (calcium and bicarbonate) than nearby and immediately adjacent surface water networks. The inheritance of weathering products would suggest water movement through such features is slow. It should be noted that no sampling was undertaken at other PWS abstractions so the wider occurrence of this system is uncertain.
- The supply of water to these features will occur at outcrop at higher elevations, or where soils are sufficiently thin as to enable infiltration of rainwater. It is noted that the majority of Craiginmoddie Hill is covered by blanket peats. Field surveys indicated that where peat was present, overland flow was the main observable pathway of water transmission (see Figure 3.4). The rate of movement through such bedrock features will vary depending on the aperture and orientation of flow structures, but a median value of ~0.1 m $d^{-1}$ has been published by the BGS for Devonian sedimentary rocks in the southern Scotland.

## 4.5. Summary of Conceptual Model

- The Study Area is dominated by open grassland / moorland and commercial forestry. Superficial soils are a combination of glacial till and in upland areas are overlain by peat. The underlying bedrock is dominated by compact Siluro-Devonian sandstones, conglomerates and a few minor outcrops of intrusive igneous rocks.
- Rainfall is likely to be the main input for water into the hydrological system, moving from upland areas downgradient as overland flow in rivers, streams and artificial ditches, particularly in areas of reduced infiltration capacity encouraging the formation of saturated ground, particularly in peatlands. Runoff may also infiltrate into the superficial soils / weathered bedrock sections and will follow local topographic gradients.
- Where water can infiltrate to the bedrock, bulk hydraulic conductivity for the bedrock is generally considered to be low and bedrock flow is likely to be constrained to fractures / faults / other tectonic features. Several sets of

fractures with different orientations may be present locally. Groundwater depth and pathways are likely to be variable. Movement of water through the bedrock system is likely to be much slower than superficial / overland pathways and may exhibit a confined aquifer response. Finally, no evidence has been identified in the desktop assessment or on the site walkovers suggesting artesian flow could occur.

- The main catchment for the PWS abstractions are likely to be topographically upgradient of the abstractions and groundwater flow could potentially be largely coincident with topography. The full extent of the catchment distance inferred based on the topography but may vary as a result of artificial drainage.
- However, based on an understanding of the wider geology of Siluro-Devonian sandstones in southern Scotland, preferential flow paths, potentially related to the presence of structural features could also be present within the bedrock. If present, such features could direct groundwater flow in directions other than that related to local topography and potentially outside the indicative surface water catchment areas. Where flows are significant, any interruption of these flow paths could result in significant interruption to groundwater flow and spring yields.

**Uncertainty**

Specific flow pathways occurring at PWS abstractions are inferred based on desktop information and observations made during field inspections and consider geological, hydrological, hydrogeological and topographical attributes. The concealed nature of the subsurface combined with the heterogenous nature of the mapped bedrock and superficial geologies make flow pathways difficult to accurately confirm. Whilst a conceptualisation of the system(s) has been presented, no detailed quantitative assessments have been undertaken by way of verification (i.e. intrusive site investigation).

# 5. Mitigation Measures

The implementation of specific and good practice mitigation measures is presented and committed to within the EIAR[1]. Should additional mitigation measures be required these will be presented accordingly for individual supplies.

## 5.1. Good Practice Mitigation

As presented within the EIAR, good practice mitigation measures will be implemented as outlined in the site-specific Pollution Prevention Plan and Drainage Management Plan as part of the Construction Environmental Management Plan (CEMP) for the Development

The site-specific CEMP will facilitate the implementation of industry good practice measures in such a manner as to prevent or minimise effects on the surface and groundwater environment. The CEMP will include details on the following:

- Drainage – all runoff derived from construction activities and site infrastructure will not be allowed to directly enter the natural drainage network. All runoff will be adequately treated via a suitably designed drainage scheme with appropriate sediment and pollution management measures. The Development is situated in an upland hydrological area and it is imperative that the drainage infrastructure is designed to accommodate storm flows based on a 1 in 200 year event plus climate change to help maintain the existing hydrological regime.
- Storage – all equipment, materials and chemicals will be stored well away from any watercourses. Chemical, fuel and oil stores will be sited on impervious bases with a secured bund at a designated location.
- Vehicles and Refuelling – the delivery, storage, transfer, handling and use of hydrocarbons often presents one of the greatest hazards sources to PWS. In addition to the good practice guidance such as:
  - Construction Industry Research and Information Association (CIRIA), ‘Environmental Good Practice On Site (C650) (2005).
  - CIRIA, ‘Control of Water Pollution from Construction Sites (C532)’ (2001); and

- Fuel management will be in adherence to relevant Pollution Prevention Guidance (PPG) and Guidance for Pollution Prevention (GPP) including re-fuelling (PPG7) and storage and disposal of waste oils (GPP8). In line with the measures above, measures for bulk delivery and transfer of oils and fuels will be carried out under supervision and designated personnel will be trained in spill response measures.

- Standing machinery will have drip trays placed underneath to prevent oil and fuel leaks causing pollution. Refuelling of vehicles, plant and machinery on the site will be carried out only in designated locations (which will be notified in writing to the planning authority and SEPA and may include, but need not be limited to, the construction compound) and in such a way that any spillage is contained within impermeable surfaces, and any fuel or water from such surfaces will be removed from the site and disposed of at an approved facility.
- Maintenance – maintenance to construction plant will be carried out in designated zones, on an impermeable surface well away from any watercourse or drainage, unless vehicles have broken down necessitating maintenance at the point of breakdown, where special precautions will be taken.
- Forestry – all works in relation to forestry and site clearance/felling will be undertaken in advance of the main construction works. The design and construction of tracks will follow good practices and will be outlined in the CEMP.
- Welfare Facilities – on-site welfare facilities will be adequately designed and maintained to allow the appropriate disposal of sewage. This may take the form of an on-site septic tank with soakaway, or tankering and off-site disposal depending on the suitability of the Proposed Development for a soakaway. Any discharge requirements will comply with relevant requirements issued by SEPA under the Water Environment (Controlled Activities) (Scotland) Regulations 2011.
- Cement and Concrete – fresh concrete and cement are very alkaline and corrosive and can be lethal to aquatic life. The use of wet concrete in and around watercourses will be avoided and carefully controlled;
- Monitoring Plan – All activities undertaken as part of the Development will be monitored throughout the construction phase to monitor environmental compliance.
- During the construction phase the Environmental Clerk of Works (ECoW) will carry out regular visual inspections of all receiving watercourses in conjunction with reviewing environmental mitigation controls. As a minimum, the following elements will be included in this programme:
  - Watercourses below working areas;
  - Surface water and sedimentation run-off mitigation;
  - Materials storage (fuels, oils, chemicals);
  - Contingency controls;
  - Waste management;
  - Management controls;
  - Compliance assessments (CEMP, PPP, RAMS etc.);
  - Emergency response and incidents; and
  - Environmental issues (litter, dust, noise etc.).
- Spill Response – a site specific Emergency Response Plan will be implemented in the unlikely event of a spill or other pollution incident. Spill kits and response materials will be available within the identified high-risk vehicles and plant working within water supply catchments and at designated locations across the construction site where hazardous materials are stored. The locations of key spill kit supply stores will be marked on a site location plan included within key documentation, which should also include a specific spill response procedure.
- Training – All relevant staff personnel will be trained in both normal operating and emergency procedures and be made aware of highly sensitive areas on site.

## 5.2. Private Water Supply Monitor Plan

It is recommended that prior to construction a Private Water Supply Monitoring Plan and Method Statement (PWSMP) be prepared detailing all mitigation measures to be delivered to secure the quality, quantity and continuity of water supplies to properties which are served by private water supplies which may be affected by the Proposed Development.

A water level and quality monitoring programme will be undertaken prior to any construction and during construction. The method statement shall include water quality sampling methods and shall specify abstraction points.

The PWS water monitoring programme will be aligned with the Construction Environmental Management Plan (CEMP) including wider surface water or groundwater monitoring programme related to the site development, i.e. sampling, frequency, and analysis suite (with exception to taste) are matched at the surface water monitoring locations. The document would also outline any site-specific additional mitigation outlined in this and later assessments, relevant to each PWS.

The PWSMP will also include a pollution response plan and contingency measures that would details responsibilities and lines of communication between Construction Contractors, PWS Users and other stakeholders. Contingency measures would include provisions to provide alternative water supplies on a temporary and permanent basis in the event of an unforeseen impact on the existing PWS arising from the construction and operation of the Proposed Development.

# 6. Risk Assessment

A methodology for risk assessment of PWS is contained within the Private Water Supplies Technical Manual[11]. Due to the nature of works being carried out at the Proposed Development, it was deemed impractical to use the methodologies set out in this guidance as this would have required taking into account factors, such as: proximity of the supply to wildlife, historical and current land use and historical maintenance carried out on the supply. While such factors are important for determining risk to the baseline qualities of the supply, they are inappropriate for determining the risk to the PWS during the construction and operation of the Proposed Development.

The methodologies set out are based on Natural Powers experience, however, the guidance has been utilised where possible, when trying to establish the varying factors which influence the baseline conditions of the supply. The risk assessment considered the type of hazard associated with the project, release and exposure potential and severity of impact. The Source-Pathway-Receptor concept model was used as the underlying model to assess the risk posed by the development activities. In this model:

- Source refers to the source of the potential risk hazard (not to be confused with *PWS source*).
- Receptor refers to anything or anyone that could be adversely affected by the hazard (including the source of water supplying the abstraction and associated infrastructure).
- Pathway refers to the mechanisms by which the hazard is transmitted to the receptor.

Where hydraulic connectivity or linkage exists between a potential contamination source and the receptor by means of a pathway, then a pollutant linkage and associated risk exists. Where there is no pollutant linkage, there will be no associated risk. For any PWS it must first be established if there is a risk to mitigate and then, if necessary, mitigation measures to reduce the risk introduced.

The risk assessment considers the type of hazard associated with the Development, the probability and magnitude of an impact occurring, based on the results of the investigation, and the severity of such an impact based on a combination of the probability and magnitude values. In addition to contamination, there is also the possibility that supply continuity could be jeopardised through water quantity reduction.

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[11] Scottish Executive (2006) Private Water Supplies Technical Manual, ISBN B47350 06/06

For the purpose of this assessment a generic approach has been adopted and considers the catchment to the water supply as the source of water for the supply, the PWS as the receptor and the natural water environment as the pathway that connects both of these.

In the presence of an identified risk or uncertainty meaning the presence of a potentially unacceptable risk, protection or mitigation should be provided that must ensure the PWS:

- Is adequately preserved in terms of both water flow and water quality; and/or
- Is replaced by an alternative process whereby potable water is made available on a temporary or permanent basis, as appropriate.

## 6.1. Risk Assessment Process

Tables 6.1 to 6.3 show the Likelihood, Magnitude and Significance Criteria for assessing risk to the PWS in relation to the main activities highlighted above. The methodology used is qualitative and provides a structure to assess, communicate and prioritise risks and remedial actions, it is not intended to provide mathematical probabilities.

The scope of the risk assessment presented is limited solely to those main risks potentially arising during works on the PWS and is not intended as an all-encompassing risk assessment for the operation.

It is highlighted that the magnitude of impact needs to consider the fact that this is the sole source of water supply, that there is no alternative supply to property and that a mains connection is not possible.

### Significant Criteria

The potential impact to private water supplies has been assessed in relation to the probability of an impact occurring on the receiving environment and the receiving environments sensitivity to change.

The probability has been classified as high likelihood, likely, low likelihood or unlikely based on criteria outlined in Table 6.1. The likelihood of any impacts on the quality and quantity of water serving the private water supplies is influenced by the type of supply and its source location within the hydrological and hydrogeological environment in relation to construction activities. Detailed assessment has been undertaken of each supply in relation to the potential position recharge zones. When determining risks from different pathways, the highest (most severe) probability rating will be used to define the combined risk.

**Table 6.1: Probability that a pollutant linkage exists to the private water supply (receptor)**

| Probability | Definition |
| --- | --- |
| High Likelihood | • There is pollutant linkage and an event would appear very likely in the short-term and almost inevitable over the long-term, or there is evidence at the receptor of harm or pollution. |
| Likely | • There is pollutant linkage and all the elements are present and in the right place which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short-term and likely over the long-term. |
| Low Likelihood | • There is pollutant linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a long period such an event would take place, and is less likely in the shorter term. |
| Unlikely | • There is pollutant linkage but circumstances are such that it is improbable that an event would occur even in the very long-term. |

*Source: Natural Power*

As outlined above the potential impacts on the private water supplies have been assessed taking account of the type of supply possible connection to the source through the presence / absence of pollutant linkages. The magnitude of potential change to that supply is defined below in Table 6.2

**Table 6.2: Magnitude of change to private water supply**

| Severity | Definition |
|---|---|
| Major | • Major change to the hydrological/hydrogeological conditions resulting in temporary or permanent change.<br>• Complete disruption to operation of supply, impacting on quality and quantity available, new resource to be identified. |
| Moderate | • Detectable change to the hydrological/hydrogeological conditions resulting in non-fundamental temporary or permanent change.<br>• Partial disruption to the operation of the supply, impacting on quality and quantity. Potential new supply is required for a temporary period of time. |
| Minor | • Detectable but minor change to the hydrological/hydrogeological conditions.<br>• Minor degradation in the operation of the supply in terms of quantity and or quality. |
| Insignificant | • No perceptible change to the hydrological/hydrogeological conditions. |

*Source: Natural Power*

### Impact Significant Matrix

The likelihood and magnitude of the potential impacts are combined to define the significance of the impact, as shown in Table 6.3. This table provides a guide to assist in the decision making but should not be considered a substitute for professional judgement and interpretation.

The significance of the risk considers the successful implementation of the good practice environmental management practices and design mitigation that will be adopted throughout the works. Should the supply still be considered at risk, further details on specific mitigation and/or monitoring recommendations are provided.

**Table 6.3: Combined Risk**

| Probability of Impact | Severity of Impact | | | |
|---|---|---|---|---|
| | Major | Moderate | Minor | Insignificant |
| High Likelihood | Very High | High | Medium | Medium/ Low |
| Likely | High | Medium | Medium/ Low | Low |
| Low Likelihood | Medium | Medium/ Low | Low | Negligible |
| Unlikely | Medium/ Low | Low | Negligible | Negligible |

*Source: Natural Power*

The risk categories above are defined in Table 6.4 below.

**Table 6.4: Risk Definition**

| Term | Definition |
|---|---|
| Very High | • There is a high probability that significant harm could arise to a designated receptor from an identified hazard at the site without appropriate mitigation. |

| Term | Definition |
|---|---|
| High Risk | • Significant harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate mitigation. |
| Medium Risk | • It is possible that without appropriate mitigation, harm could arise to a designated receptor but it is relatively unlikely that any such harm would be severe and if any harm were to occur, it is likely that such harm would be relatively mild. |
| Low Risk | • It is possible that significant harm could arise to a designated receptor from an identified hazard but it is likely that at worst this harm if realised would normally be mild. |
| Negligible | • There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe. |

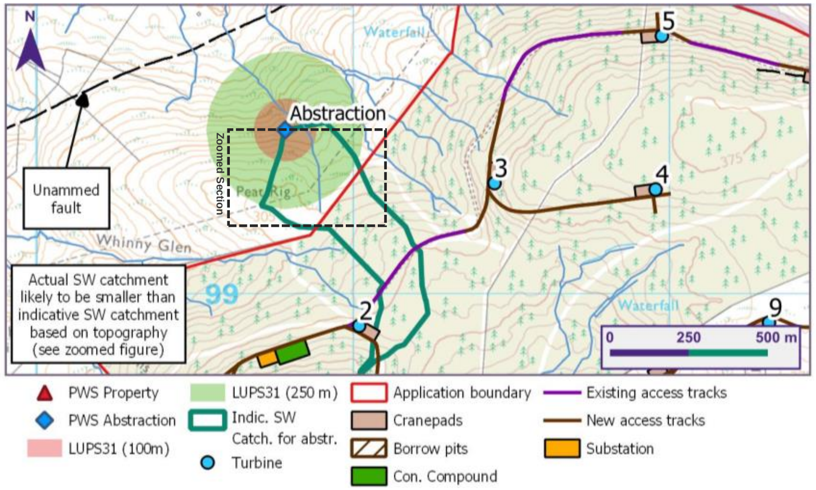
*Source: Natural Power*

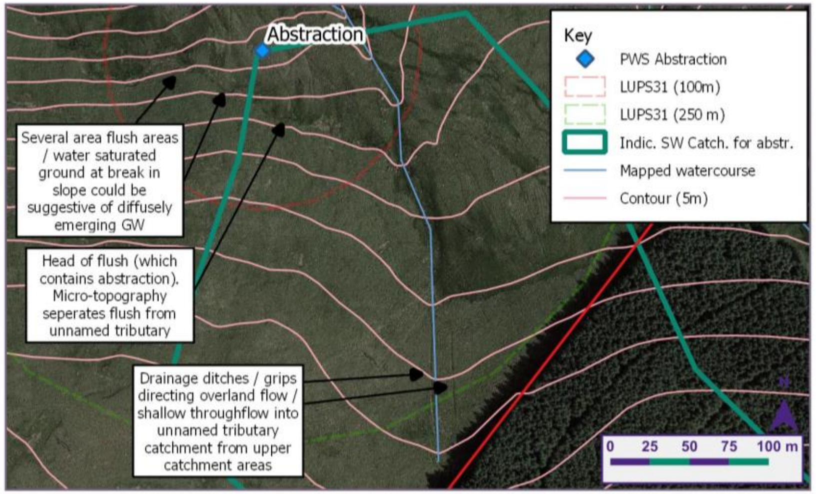
## 6.2. Risk Assessment Results

A risk assessment for each PWS has been completed, with the results presented below. Each risk assessment is based on the CSM and assumes the implementation of good practice mitigation outlined in Section 5 of this report.

## Dobbingstone Farm PWS

| Proximity of abstraction to Proposed Development | Assessment Notes |
|---|---|




### Assessment Notes

- PWS abstraction is situated downgradient from Proposed Development Infrastructure. Only the access track (existing) and cranepad (partly) are inside indicative surface water (SW) catchment;
- PWS abstraction will be partially fed by shallow groundwater / SW overland flow from immediate upslope areas. Field inspection suggests the actual SW catchment is smaller than the indicative catchment. This on account of micro-topography and artificial drainage encouraging shallow through flow / SW flow out of the indicative catchment and towards the unmanned tributary burn adjacent to the abstraction, with little opportunity in the shape of the upslope topography to encourage flow convergence towards the abstraction. As such, the likelihood of a pathway via SW / shallow groundwater is of **low likelihood**;
- PWS abstraction may also be supplied by groundwater. A structural feature (fault) is mapped immediately downslope and geological sections nearby identify thinly bedded sandstones dipping ~45° to the northwest. Chemical sampling undertaken from the abstraction indicates waters which are more mineralised than adjacent surface watercourses, with high buffering capacity and calcium. The PWS is also noted to be resilient during dry conditions. These factors combined with the limited upgradient catch-pit area would suggests the PWS is likely to be less dependent upon shallow groundwater / overland flow, and based on the information available, it is likely the PWS is at least partially nourished by bedrock groundwater;
- The CSM indicates the movement of groundwater will be constrained to structural features, and therefore a pathway between the abstraction and the Proposed Development would only exist if a network of fractures / faults / open bedding planes existed connecting them. However, the confirmation for the existence / absence of such a pathway is outside the scope of this assessment, but until it can be disproven, it remains a possibility, particularly given such features are mapped nearby (fault) and that surveyed bedding plans are orientated in a northwesterly direction towards the abstraction. Whilst structural features may not conform to topographical boundaries, the higher ground southeast of the abstraction is covered by peat and glacial till, which as per the CSM will hamper infiltration to the bedrock in such areas. The waters emerging at the spring would also have to have been interacting with the subsurface for an extended period to account for the increase in ionic strength, which could suggest a prolonged period between infiltration and discharge;
- Notwithstanding, given the partial dependence of the PWS on groundwater and the potential for a pathway between proposed infrastructure and the abstraction to exist via structural features in the bedrock, the likelihood for the existence of a pathway is considered **likely***
- The location of the PWS delivery infrastructure between the property and abstraction is unconfirmed but is **unlikely** to be impacted by the Proposed Development.

**Additional Mitigation**

*Further investigation should be undertaken to characterise the underlying groundwater system operating within the vicinity of the PWS abstraction and the upper indicative SW catchment where the proposed infrastructure is situated. This would be best achieved through intrusive site investigation, which could be undertaken as part of the detailed design prior to construction. The investigation should focus principally on turbine locations (T2 and T3) where superficial sediments will be removed, which as per the CSM would otherwise act as a barrier limiting any unexpected pollution discharging to the bedrock. Whilst the installation of the turbines could also modify infiltration to the bedrock and consequential volume of water able to recharge to the abstraction (if a pathway existed), the dominance of low permeability superficial sediments mean the additional hardstanding are unlikely to dramatically change existing drainage patterns. None the less, the assessment should also determine the possibility for flow reduction at the abstraction as a result of the construction and operation of the Proposed Development.

The further investigation would be used to design appropriate mitigation (if required). Notwithstanding, and in the absence of this assessment, it is recommended that at a minimum the following additional mitigation is considered;

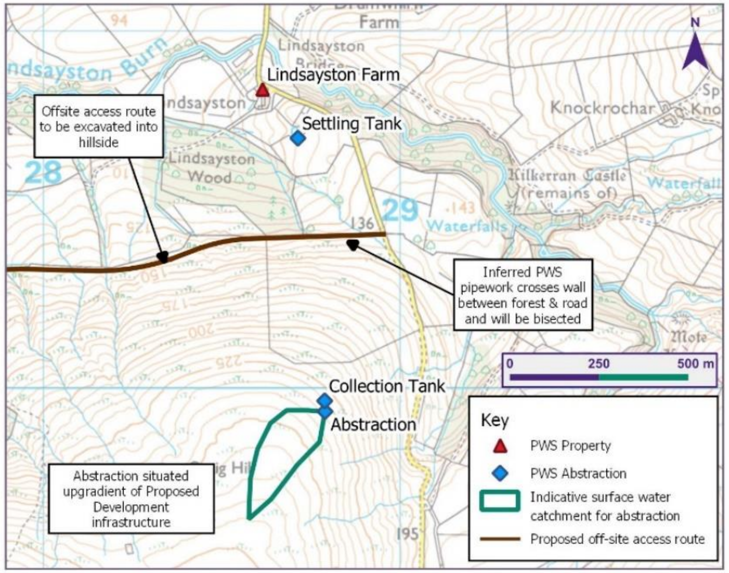
- No micro-sitting of turbines 2 or 3 in the direction of the PWS abstraction;
- Design of detailed drainage plans and specific method statements for dewatering activities to minimise water losses from the catchment and encourage infiltration;
- No storage of fuels / oils / chemicals within the vicinity of T2 and T3 or on the existing track connecting them. This should include refuelling activities;
- A programme of water quality and quantity monitoring will be developed to monitor this supply (as well as borehole monitoring, to be installed during the further investigation); and
- Monitoring and management measures (including contingency) to be outlined in PWSMP prior to construction and be based on the results of further investigation.

The above additional mitigation would not reduce the magnitude of the effect should an unexpected incident occur, but it would reduce the likelihood of such an incident occurring. Following the completion of further assessment and more detailed consideration of the associated risk, the additional mitigation presented should be reviewed and amended (as required) to ensure it is fit for purpose.

| Hazard Identification | Receptor | Likelihood of Impact | Magnitude of Impact | Significant of Impact | Additional Mitigation? | Revised Likelihood & Mag. | Residual Significance |
|---|---|---|---|---|---|---|---|
| **Activities affecting water quality** | SW / Shallow GW source of water serving PWS | Low Likelihood | Minor | **Low** | None | - | - |
| | Water sources from structural features serving PWS | Likely | Moderate | **Medium** | Yes (above) | Low Likelihood (L)<br>Moderate (M) | **Medium / Low** |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |
| **Activities affecting water quantity** | SW / Shallow GW source of water serving PWS | Low Likelihood | Minor | **Low** | None | - | - |
| | Water sources from structural features serving PWS | Likely | Moderate | **Medium** | Yes (above) | Low Likelihood (L)<br>Moderate (M) | **Medium / Low** |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |

## Lindsayston Farm PWS

### Proximity of abstraction to Proposed Development






### Assessment Notes

- PWS abstraction is situated upgradient of Proposed Development Infrastructure (off-site access route) and outside of the indicative surface water catchment;
- PWS abstraction is likely to be fed by a combination of shallow groundwater / overland flow from indicative surface water catchment. Topographical differences suggest a pathway is **unlikely** to exist;
- PWS abstraction may also be fed in part by diffusely emerging groundwater. No structural features are mapped nearby however the ground parallel with the abstraction is marked by a break and slope and water saturated soil which is absent from other areas. Given the difference in elevation and absence of a mechanism which could elevate water within structural features (i.e. artesian conditions) the occurrence of a pathway is **unlikely**;
- The location of the PWS delivery infrastructure between the property and abstraction is unconfirmed but is **highly likely** to be bisected by the proposed off-site access route.

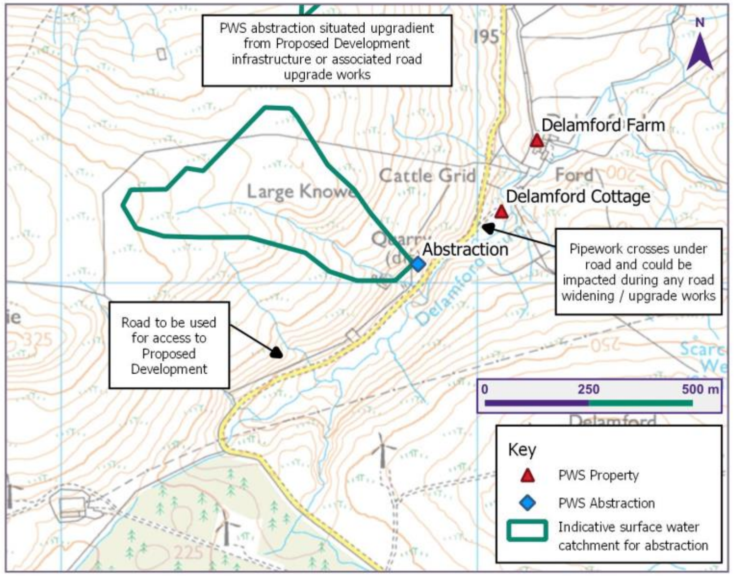
### Additional Mitigation

- Further investigation to be undertaken prior to construction to delineate the location of the supply pipework;
- As highlighted in Chapter 12 of the EIAR, metal plates on the running surface over the crossing point. Excavation of the track and installation of local protection measures around pipework, concrete slabs placed under the pipe, track make up material then placed over the top;
- Provision of a temporary supply that can be deployed immediately in the unlikely event that the supply pipe is disrupted. A programme of water quality and quantity monitoring will be developed to monitor this supply; and
- Monitoring and management measures to be outlined in PWSMP prior to construction.

| Hazard Identification | Receptor | Likelihood of Impact | Magnitude of Impact | Significant of Impact | Additional Mitigation? | Revised Likelihood & Mag. | Residual Significance |
|---|---|---|---|---|---|---|---|
| **Activities affecting water quality** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | High Likelihood | Moderate | **High** | Yes | Low Likelihood (L)<br>Moderate (M) | **Medium / Low** |
| **Activities affecting water quantity** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | High Likelihood | Moderate | **High** | Yes | Low Likelihood (L)<br>Moderate (M) | **Medium / Low** |

## Delamform Cottage & Farm PWS

### Proximity of abstraction to Proposed Development






### Assessment Notes

- PWS abstraction is situated upgradient of Proposed Development Infrastructure (public road upgrade) and outside of the indicative surface water catchment;
- PWS abstraction is likely to be fed by a combination of shallow groundwater / overland flow from indicative surface water catchment immediately above PWS abstraction. Supply catchment unlikely to include watercourse to the southwest. Topographical differences suggest a pathway is **unlikely** to exist;
- PWS abstraction may also be fed in part by diffusely emerging groundwater. No structural features are mapped nearby however the chamber is situated in a flush on a steep slope and its reported to rarely dry up. Given the difference in elevation and absence of a mechanism which could elevate water within structural features (i.e. artesian conditions) the occurrence of a pathway is **unlikely**;
- The location of the PWS delivery infrastructure between the property and abstraction is unconfirmed but is **highly likely** to be bisected during any road upgrade works (without additional mitigation).

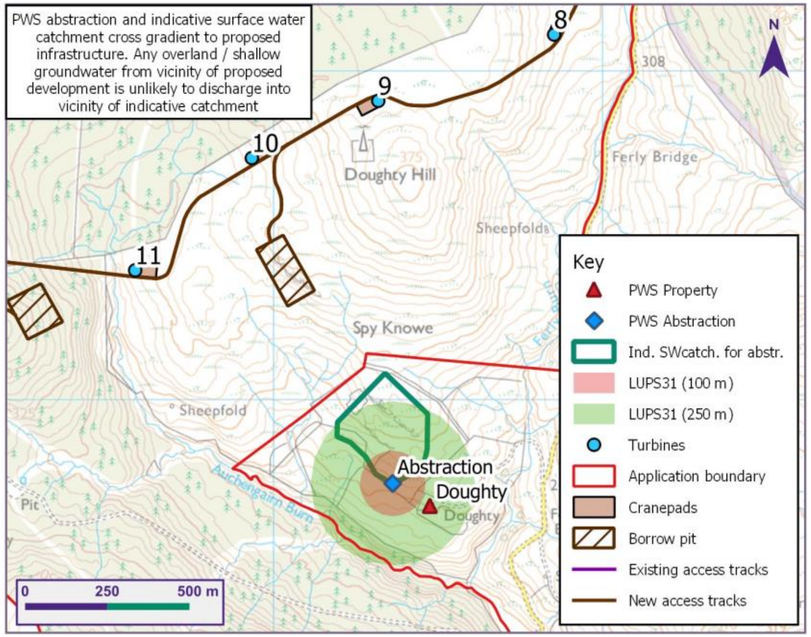
### Additional Mitigation

- Further investigation to be undertaken prior to construction to delineate the location of the supply pipework;
- Metal plates on the running surface over the crossing point. Excavation of the track and installation of local protection measures around pipework, concrete slabs placed under the pipe, track make up material then placed over the top;
- Provision of a temporary supply that can be deployed immediately in the unlikely event that the supply pipe is disrupted. A programme of water quality and quantity monitoring will be developed to monitor this supply; and
- Monitoring and management measures to be outlined in PWSMP prior to construction.

| Hazard Identification | Receptor | Likelihood of Impact | Magnitude of Impact | Significant of Impact | Additional Mitigation? | Revised Likelihood & Mag. | Residual Significance |
|---|---|---|---|---|---|---|---|
| **Activities affecting water quality** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | High Likelihood | Moderate | **High** | Yes | Low Likelihood (L) Moderate (M) | **Medium / Low** |
| **Activities affecting water quantity** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | High Likelihood | Moderate | **High** | Yes | Low Likelihood (L) Moderate (M) | **Medium / Low** |

## Doughty PWS

### Proximity of abstraction to Proposed Development






A diagram illustrating the bedrock geology as well as any mapped structural features is presented in Figure 3.9.

### Assessment Notes

- PWS abstraction is situated cross-slope from nearest Proposed Development Infrastructure (borrow pit) but is outside of the indicative surface water catchment;
- PWS abstraction is likely to be fed by a combination of shallow groundwater / overland flow from indicative surface water catchment immediately above PWS abstraction but may differ slightly on account of micro-topography / drainage ditches. Field inspection of the catchment suggests the actual SW catchment will be smaller than the indicative catchment;
- Therefore, the likelihood of impact via SW / shallow groundwater is considered **unlikely**;
- PWS abstraction may also be fed in part by groundwater. No structural features are mapped nearby however the chamber is situated adjacent to a bedrock outcrop, demonstrating thick beds of conglomerate dipping gently to the northwest. Based on the CSM, the outcrops of bedrock could facilitate points of recharge to the local groundwater. A similar outcrop is mapped at the proposed borrow pit. Higher in the catchment, peat and till are likely to be present and will limit infiltration;
- Whilst a pathway along structural features could exist between Proposed Development and the abstraction, the orientation of the observed structural geology (and therefore likely flow direction) is at perpendicular angle to the direction of the nearest infrastructure . Site observation also suggested that ponding of surface water on flatter areas between outcrops could be a result of the low infiltration capacity of the bedrock (see Figure 3.11 & 3.12) and would conform with the aquifer hydraulic data suggesting water movement is slow;
- Notwithstanding, the potential for a pathway between proposed infrastructure and the abstraction via structural features in the bedrock is considered of **low likelihood***;
- The location of the PWS delivery infrastructure between the property and abstraction is unconfirmed but is **unlikely** to be impacted by the Proposed Development.

### Additional Mitigation

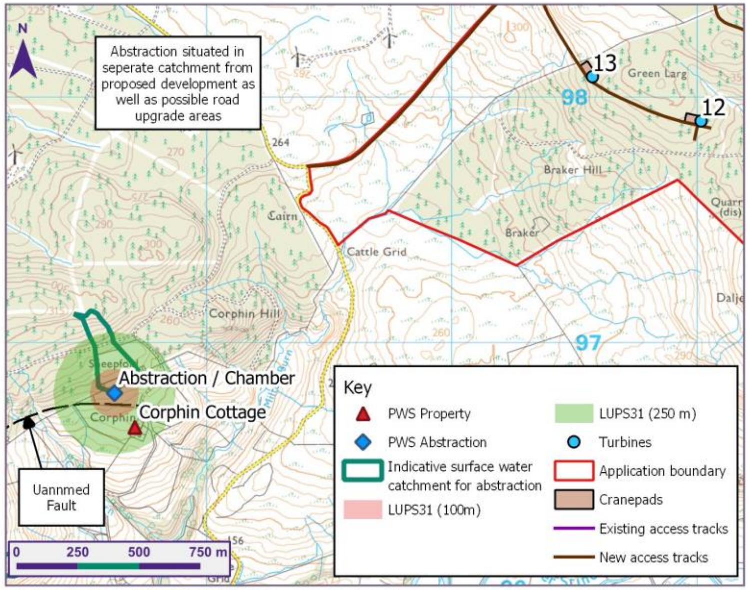
- A programme of water quality and quantity monitoring will be developed to monitor this supply; and
- Monitoring and management measures (including contingency) to be outlined in PWSMP prior to construction.

*It is highlighted that further assessment concerning the potential for connectivity via structural features in the bedrock between the Proposed Development and the abstraction could be undertaken and if a link is disproven, this would reduce the likelihood of impact from Low Likelihood to Unlikely.

| Hazard Identification | Receptor | Likelihood of Impact | Magnitude of Impact | Significant of Impact | Additional Mitigation? | Revised Likelihood & Mag. | Residual Significance |
|---|---|---|---|---|---|---|---|
| **Activities affecting water quality** | SW / Shallow GW source of water serving PWS | Unlikely | Moderate | **Low** | None | - | - |
| | Water sources from structural features serving PWS | Low Likelihood | Moderate | **Medium / Low** | Yes (above) | Unlikely (L)<br>Moderate (M) | **Low** |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |
| **Activities affecting water quantity** | SW / Shallow GW source of water serving PWS | Unlikely | Moderate | **Low** | None | - | - |
| | Water sources from structural features serving PWS | Low Likelihood | Moderate | **Medium / Low** | Yes (above) | Unlikely (L)<br>Moderate (M) | **Low** |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |

## Corphin Cottage PWS

### Proximity of abstraction to Proposed Development






### Assessment Notes

- PWS abstraction is situated in separate catchment from Proposed Development Infrastructure (including public road upgrade) and outside of the indicative surface water catchment;
- PWS abstraction is likely to be fed by a combination of shallow groundwater / overland flow from indicative surface water catchment immediately above PWS abstraction. Spatial location and topographical differences between abstraction and proposed Development suggest a pathway is **unlikely** to exist;
- PWS abstraction may also be fed in part by groundwater. An unnamed fault is mapped to the south of the abstraction, however anecdotal information suggests an inflow pipe partially feeds the PWS. This combined with supply drying-up during dry weather would be more suggestive of a less resilient SW / shallow groundwater source. Notwithstanding, given that mapped structural features don't extend in the direction of the proposed development and the relative positions of the abstraction and proposed development on the opposing sides of a large catchment, the occurrence of a structural pathway via is **unlikely**;
- The location of the PWS delivery infrastructure between the property and abstraction is unconfirmed but is **unlikely** to be impacted by the Proposed Development .

### Additional Mitigation

- None.

| Hazard Identification | Receptor | Likelihood of Impact | Magnitude of Impact | Significant of Impact | Additional Mitigation? | Revised Likelihood & Mag. | Residual Significance |
|---|---|---|---|---|---|---|---|
| **Activities affecting water quality** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |
| **Activities affecting water quantity** | All source of water serving PWS | Unlikely | Insignificant | **Negligible** | None | - | - |
| | Pipework delivering water from PWS to Property | Unlikely | Insignificant | **Negligible** | None | - | - |

# 7. Conclusion

Natural Power have been commissioned by EnergieKontor UK Ltd to provide an assessment to determine the potential level of risk posed to Private Water Supplies (PWS) from the construction and operation of the proposed Craiginmoddie Wind Farm (the Development). The Development will consist of up to 14 turbines and associated infrastructure.

Natural Power have carried out an updated review identifying properties known to have a PWS, re-consulted with residents to confirm supply arrangements and assessed the risk to those supplies based on a source-pathway-receptor conceptual site model (CSM), which has been refined using site-specific investigation data. Risk assessments have been undertaken considering the hazards which could impact upon PWS as a result of the construction and operation of the Proposed Development following the implementation of standard good practice mitigation. Where a potentially significant risk remains, additional site specific mitigation has also been proposed.

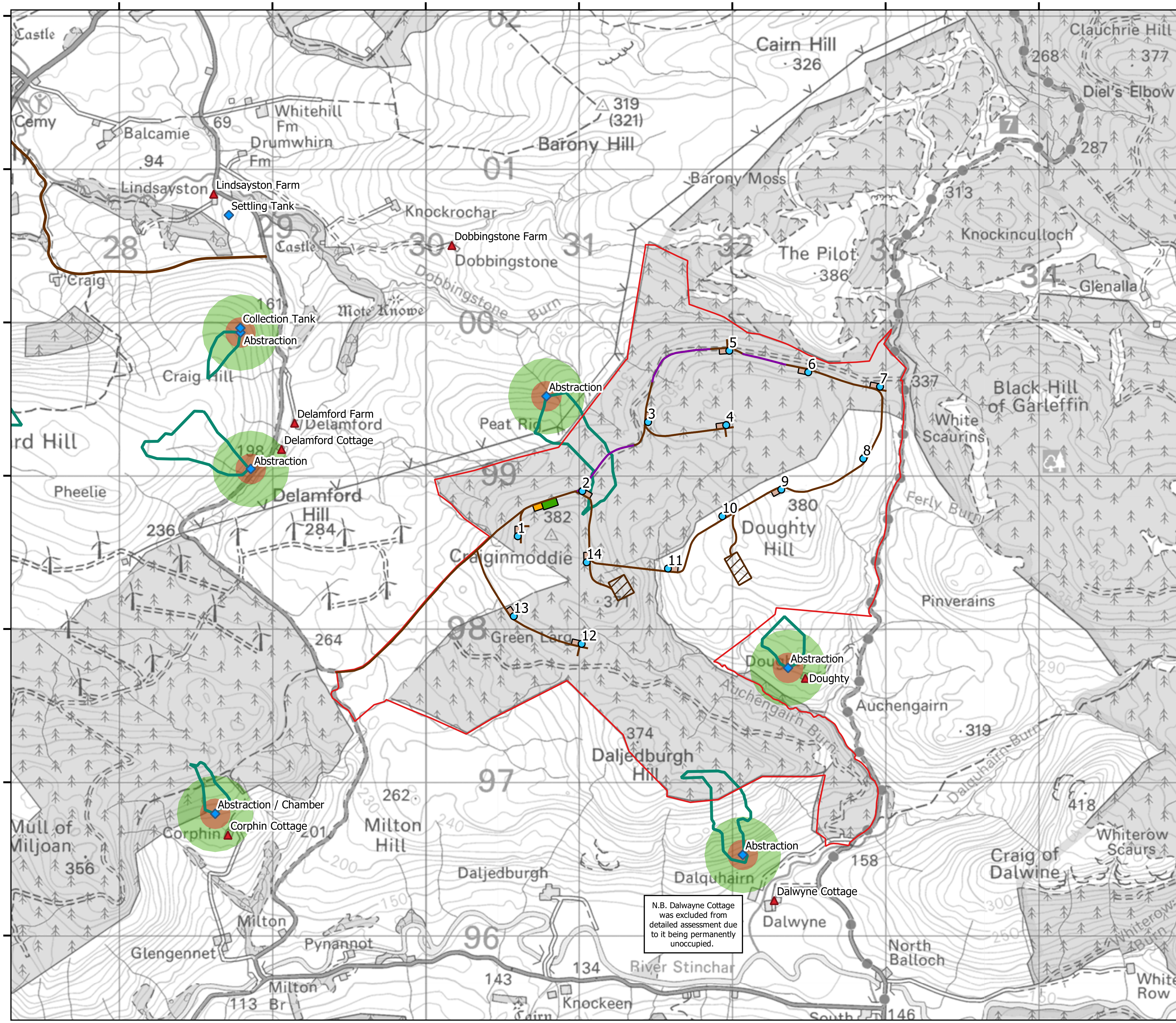
# 8. Recommendations

Standard good practice mitigation has been outlined in Section 5 of this assessment and would be included within Construction Environmental Management Plans (CEMP) which would be prepared prior to construction. In addition to this mitigation, it is also recommended that a Private Water Supply Monitoring Plan and Method Statement be prepared prior to construction and would detail all relevant mitigation, management measures, monitoring requirements and contingency plans relevant to PWS considered within this assessment and those listed in Chapter 12 of the EIAR. This includes supply protection measures required for Lindsayston Farm as well as Delamford Cottage and Farm.

With regards to Dobbingstone and Doughty PWS, this assessment has identified some uncertainty in the risk assessment associated with the potential influence of structural features within the bedrock to transmit hazards associated with the Proposed Development to PWS. This is specifically concerning with these PWS either utilising such features as part of the supply of water to the abstraction, or the modification / pollution as a result of the construction and operation of the proposed development. It is recommended that further investigation be undertaken as part of the detailed design process to determine the potential more accurately for a pollutant linkage to exist between these PWS and the Proposed Development infrastructure via this pathway. The results of the investigation should identify the requirement for any mitigation.

# Appendices

## A. Location and Layout Plan




Project:

**Craiginmoddie Wind Farm, South Ayrshire**

Title:

**Detailed PWSRA PWS Location & Layout Plan***

**Key**

**Development**

- Site boundary
- Proposed turbine
- Proposed borrow pit
- Proposed substation
- Proposed cranepad
- Proposed construction compound
- Existing access track
- Proposed access track

**Hydrology**

- PWS User (Property)
- PWS abstraction
- Indicative surface water catchment**
- SEPA LUPS 31 Buffer (100m)
- SEPA LUPS 31 Buffer (250m)

*This figure shows the location and layout of PWS considered by this assessment only. For a figure demonstrating all PWS considered by Chapter 12 of the EAIR, refer to Figure 12.2: PWS Users.

**Indicative surface water catchment areas based on GIS / 50 m contour and arrangment shown has not been amended reflecting findings of site walkover.



Scale @ A3: 1:25,000

Coordinate System: British National Grid

0 0.25 0.5 0.75 1 km

N

| Date: 14-10-21 | Prepared by: SW | Checked by: KW |
|---|---|---|
| Ref: GB202583_M_014_A | Layout: 161120_14t_A | |

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# B. Policy & Guidance Context

The assessment takes account of relevant legislation and policy of which an overview has been presented in the below sections.

**The Water Framework Directive (2000/60/EC)**

- The Water Framework Directive (WFD) represents a significant piece of environmental legislation which has been transposed into Scottish legislation as the Water Environment and Water Services (Scotland) Act 2003 (or WEWS) and has given Scottish Ministers powers to introduce regulatory controls over activities in order to protect and improve Scotland's water environment.
- The WFD aims to protect and enhance the quality of surface freshwater (including lakes, rivers and streams), groundwater, groundwater dependent ecosystems, estuaries and coastal waters.
- The key objectives of the WFD relevant to groundwater and this assessment are:
  - To prevent deterioration and enhance aquatic ecosystems.
  - To establish a framework of protection of surface freshwater and groundwater.

**The Groundwater Directive (80/68/EEC)**

- Historically, the most significant legislative instrument for protection of groundwater was the Groundwater Directive. The Groundwater Directive aims to protect groundwater from pollution by controlling discharges and disposal of certain dangerous substances to groundwater. These substances were separated into two lists based on toxicity, persistence and potential for bioaccumulation and were categorised as either List I or List II, with the former considered to have great polluting potential:
  - Hazardous substances are the most toxic and must be prevented from entering groundwater. Substances in this list may be disposed of to the ground, under a permit, but must not reach groundwater. They include pesticides, sheep dip, solvents, hydrocarbons, mercury, cadmium and cyanide.
  - Non-hazardous pollutants are less dangerous, and can be discharged to groundwater under a permit, but must not cause pollution. Examples include sewage, trade effluent and most wastes. Non-hazardous pollutants include any substance capable of causing pollution and the list is much wider than the previous List 2 substances. For example, nitrate is included as a pollutant, but it was excluded from List 2 in the 1998 GWR.

**The Groundwater Daughter Directive (2006/118/EC)**

- Following the repeal of The Groundwater Directive (80/68/EEC) in 2013, the Groundwater Daughter Directive which is provided under the WFD enables controls to be exercised on the discharge of all pollutants both hazardous and non-hazardous.
- As well as providing details on preventing and limiting pollution entering groundwater, the Groundwater Daughter Directive provides details on criteria for assessing good groundwater status and for identifying patterns and trends.

**The Water Intended for Human Consumption (Private Supplies) (Scotland) Regulations 2017**

- The regulations aim to ensure the provision of clean, safe drinking water and to deliver significant health benefits to those using private water supplies which provide water to ≥50 people or abstract ≥10m3 per day (known as a "Type A" supply).
- It is the responsibility of the local authorities to monitor, assess and regulate Type A private water supplies and in the event of non-compliance, enforce corrective measures.

### The Private Water Supplies (Scotland) Regulations 2006

- The regulations aim to ensure the provision of clean, safe drinking water and to deliver significant health benefits to those using private water supplies for domestic premise, suppling <50 people (Type B supplies).
- It is the responsibility of the local authorities to provide advice, assistance and discretionary powers in respect to sampling of Type B supplies.

### The Water Quality (Scotland) Regulations 2010

- These regulations relate to managing water quality failures on a private water supply, attributable to the domestic distribution or its maintenance, in premises where water is supplied to the public.

### Scottish Environment Protection Agency (SEPA), Land Use Planning Guidance Note 31 (2017): Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems (GWDTE), Version 3

- SEPA LUPS 31 is a protective framework for groundwater abstractions and groundwater dependent terrestrial ecosystems (GWDTE) being considered in EIAs, major and local planning applications and general consultations
- The framework prescribes protective “buffers” or distances between groundwater receptors and construction activities requiring excavation:
  - For excavations >1 m in depth, a 250 m buffer applies.
  - For excavations <1m in depth, a 100 m buffer applies.
- Where excavations are likely to occur within the specified buffer distances, qualitative / quantitative risk assessment must be undertaken. Where excavations occur outside the specified buffer distances, SEPA (as the Scottish Regulator) does not require detailed risk assessments to be undertaken.

### SEPA, Groundwater Protection Policy for Scotland, V3 (2009).

- Provides a mechanism to protect groundwater quality by minimising the risks posed by point and diffuse sources of pollution and maintain the groundwater resource by authorisation abstractions and by influencing developments, which could affect groundwater quality.
- Outlines the objectives for protecting groundwater related to specific activities and also describes the interaction of this measures with the planning system.

Additional legislation and guidance related to good practice during the construction of onshore wind farms that has been considered in the preparation of this document is provided within Chapter 12 of the Craiginmoddie Wind Farm EIAR[1].

# C. Water Quality Sampling Results

Hydrochemical sampling was only undertaken at Dobbingstone PWS. Sample locations;

- HW1 (NX 30886,99436) – Surface water sample from adjacent unnamed tributary at an elevation higher than the abstraction.
- HW2 (NX 39766 99596) - Surface water sample from adjacent unnamed tributary at an elevation lower than the abstraction
- DS1 (NX 30762 99557) – Surface water sample from flush just below the PWS abstraction.

**Table C.1: Water Sampling Results undertaken 29th September 2021**

| Parameter | Units | LOD | Chemical Results | | |
|---|---|---|---|---|---|
| | | | HW1 | HW2 | DS1 |
| **In-Situ Sampling** | | | | | |
| pH | Units | - | 5.87 | 7.01 | 7.06 |
| Temperature | Deg. C | - | 10.9 | 11.0 | 11.7 |
| Electrical Conductivity | µs/cm | - | 73.2 | 103 | 295 |
| **Extractive Sampling (EnviroLab Ltd.)** | | | | | |
| Electrical Conductivity | µs/cm | *10* | 67 | 95 | 283 |
| ANC | mEq/l | *1* | <1.0 | <1.0 | 3.7 |
| Alkalinity by titr. (HCO3-) | mg/l Ca CO3 | *15* | <15 | <15 | 130 |
| Total Dissolved Solids | mg/l | *20* | 115 | 68 | 168 |
| Ammoniacal nitrogen (N) | mg/l | *0.02* | 0.04 | 0.07 | 0.05 |
| Chloride | mg/l | *1* | 12 | 10 | 8 |
| Nitrite | mg/l | *0.1* | <0.1 | <0.1 | <0.1 |
| Nitrate | mg/l | *0.1* | <0.1 | <0.1 | 0.4 |
| Sulphate | mg/l | *1* | <1 | <1 | <1 |
| Arsenic | µg/l | *1* | <1 | <1 | <1 |
| Cadmium | µg/l | *0.2* | <0.2 | <0.2 | <0.2 |
| Calcium | mg/l | *1* | 5 | 9 | 28 |
| Copper | µg/l | *1* | <1 | <1 | <1 |
| Chromium | µg/l | *1* | <1 | <1 | <1 |
| Lead | µg/l | *1* | 5 | <1 | 1 |
| Mercury | µg/l | *0.1* | <0.1 | <0.1 | <0.1 |
| Nickel | µg/l | *1* | 1 | <1 | 4 |
| Potassium | mg/l | *1.2* | 1 | <1 | <1 |
| Selenium | µg/l | *1* | <1 | <1 | <1 |
| Sodium | mg/l | *1* | 8 | 6 | 5 |
| Zinc | µg/l | *1* | 13 | 10 | 11 |

*Source: Natural Power / EnviroLab Ltd.*

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