Whitelee Wind Farm Solar, BESS and Green Hydrogen

Detailed Private Water Supply Risk Assessment

May 2023

1296555

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1. Introduction

Natural Power Consultants Limited (Natural Power) have been commissioned by ScottishPower Renewables (UK) Ltd ("SPR") to provide a detailed private water supply risk assessment (DPWSRA) in response to request for further information and assessment on a number of private water supplies (PWS) situated within the vicinity of the proposed solar photovoltaic (PV) farm, battery energy storage systems (BESS), associated ancillary cabling elements and green hydrogen production facility (The Project). The Project is located immediately west of the existing Whitelee Windfarm, with BESS and cabling infrastructure within the existing Whitelee Extension Windfarm.

In support of the Section 36 Application, an Environmental Impact Assessment Report (EIAR)[1] and Further Environmental Information Report (FEI)[2] was prepared by Wood Group PLC that considered the significance of potential effects on hydrological receptors, including PWS. The EIAR identified a number of PWS within the vicinity of the Project and concluded that in most cases there was "no pathway connection possible" with the Project and therefore "no risk" (Paragraph 8.8.8). For three PWS (Drumtee PWS, P01; Best Friend's Cottage PWS, P03; and Cauldstanes PWS, P05), a connection was possible, however the EIAR considered the potential effects as adverse but not significant on account of the magnitude of change being very low through the implementation of good practice mitigation (Paragraphs 8.12.19). In response to the submission, East Ayrshire Council (EAC) stated;

> *Due to the fact that if potable PWS's are contaminated this can have serious effects for the users, the three PWS's potentially at risk are located in the same hydrological catchment area as the Development and the lack of detail in the hydrogeology, I would request a more detailed PWS Risk assessment to be carried out on the three PWS's,P01, P03 and P05 and also that a Private Water Supply Method Statement including a Water Quality Monitoring Plan be submitted and signed off by the local Authority.*

The aim of this PWSRA is to satisfy the requirements of EAC by providing an appropriately detailed risk assessment be undertaken for Drumtee PWS, P01; Best Friend's Cottage PWS, P03; and Cauldstanes PWS, P05 to inform mitigation and monitoring requirements outlined in the PWS Method Statement (PWSMS[3]). In meeting this aim, the PWSRA has the following objectives;

- Establish the baseline conditions including the environmental setting of each PWS through a desktop assessment;
- Undertake a field walkover survey including initial hydro-chemical monitoring from PWS;
- Develop a conceptual site model (CSM) using the desktop and site-obtained information; and
- Consider the hazards which could affect PWS during the construction and operation of the Project and outline any additional measures to reduce concurrent risk.

The aim and objectives of this PWSRA were developed in consultation with EAC.

Where applicable, the assessment has been undertaken with cognisance to the relevant national, regional and local guidance and policy.

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[1] Wood Group. 2021. Land Adjacent to Whitelee Windfarm – Solar PV, Green Hydrogen Production and Battery Storage Facilities: Environmental Impact Assessment Report.

[2] Wood Group. 2022. Land Adjacent to Whitelee Windfarm – Solar PV, Green Hydrogen Production and Battery Storage Facilities: Environmental Impact Assessment Report – Further Environmental Information

[3] Natural Power. 2022. Whitelee Wind Farm Hydrogen and BESS – Private Water Supply Method Statement (PWSMS). Document Reference: 1296556.

1.1. Information Sources

Various sources of information have been used in the compilation of this assessment.

- Primary information sources were obtained directly by Natural Power during the walkover survey undertaken by James Blaikie, on Thursday 13th October 2022 and by Ceana Heron, on Friday 28th October 2022;
- Secondary information sources include available online resources[4] and where utilised have been referenced in footnotes. Third party reports / maps / assessments provided by the SPR or other stakeholders include the following key documents:
  - Wood Group, S36, Environmental Impact Assessment Report, Volume 2, Chapter 8: Geology, hydrology and hydrogeology; and
  - Wood Group, S36, Further Environmental Information, May 2022.

1.2. Identified Private Water Supplies

The PWSRA has been undertaken for the PWS specified in the EAC consultation response to the Section 36 application, namely;

- Drumtee PWS, P01;
- Best Friend's Cottage PWS, P03; and
- Cauldstanes PWS, P05.

During the desktop assessment and review of the environmental setting of the Project two further properties potentially using a PWS were identified;

- Craigendunton PO8 (British National Grid Reference [BNGR] NS512451); and
- Windy Hill (BNGR NS502449).

Following consultation with EAC, Windy Hill was confirmed as being connected to Scottish Water Mains Supply, so will not be considered further in this assessment.

Craigendunton was confirmed as potentially using a PWS, so has been included in the scope of this PWSRA.

1.3. Approach

This PWSRA has been undertaken in accordance with good practice and statutory guidelines, where these are available. The assessment approach follows the source-pathway-receptor framework, whereby the risk to a receptor (in this case a PWS) is a function of both the presence of source of impact (hazard) and the plausibility of a pathway that would enable impact on a receptor. This PWSRA only considers hazards that may directly arise as a result of the construction and operation of the Project.

In completing this PWSRA, information on the environmental setting of each PWS has been collated using published information, secondary source information (with references stated where utilised) as well as information collected directly by Natural Power during field surveys.

The approach to investigation and assessment in compiling this PWSRA was discussed with East Ayrshire Council to confirm acceptability.

All site surveys and sampling were undertaken with express permission from the relevant PWS user.

[4] Application information available for download from the Energy Consents Unit portal. Available at https://www.energyconsents.scot/ApplicationDetails.aspx?cr=ECU00002198 (accessed 16/12/2022).

2. Environmental Setting

The Study Area is defined as all areas within and immediately adjacent to the Project including land within the vicinity of the PWSs.

2.1. Site Setting and Land Use

The Project and PWS are situated wholly within the East Ayrshire Council (EAC) administrative area, ~8 km north of Moscow, and adjacent to the existing Whitelee Wind Farm and Whitelee Extension Wind Farm. A figure showing the entire Project is presented in Appendix A, Figures, with an insert figure 2.1 below showing the PWS in relation to the Project.

Source: Natural Power

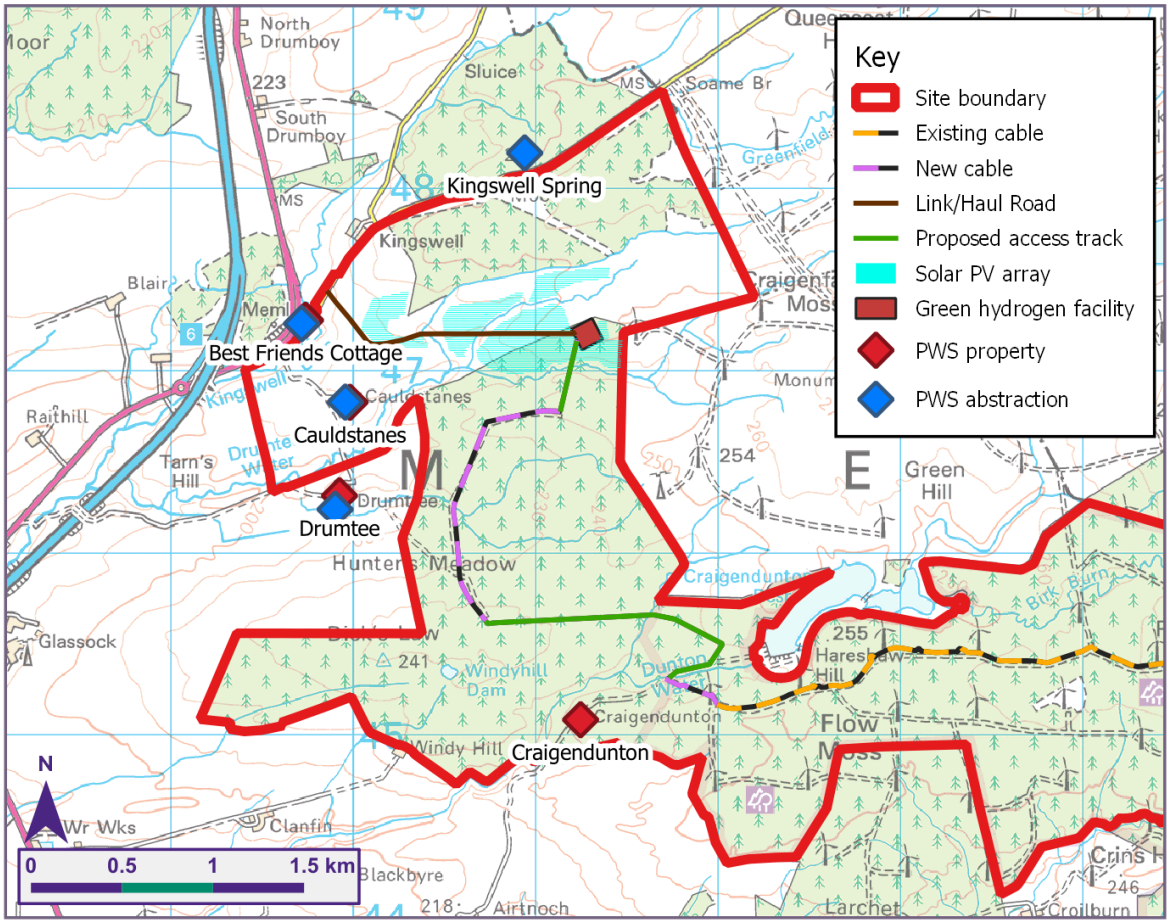

Figure 2.1: Location and layout plan for the PWS considered in this assessment.

The land-use in the Project and corresponding land surrounding the PWS abstractions is as follows;

- Semi-improved grassland used for grazing (Figure 2.2);
- Water-saturated rough grassland (Figure 2.3); and
- Commercial forestry plantation (Figure 2.3).

Source: Natural Power

Figure 2.2: Semi-improved grassland adjcent to the Drumtee Burn (taken 28/10/22).

Source: Natural Power

Figure 2.3: Water saturated rough grassland with commercial forestry planation in the background (taken 22/06/22)

More detailed location and layout plans are presented in the figures in Appendix A. A detailed description of each PWS is presented in Section 3.

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 adjacent to the Drumtee Water and Kingswell Burn. Peat is also mapped in the east of the Study area and underlies much of the commercial forestry and Project.

Bedrock and Structural Geology Summary

The bedrock geology of the Study Area is dominated by Carboniferous extrusive igneous rock of the Clyde Plateau Volcanic (CPV) Formation. 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	-	Peat	Organic accumulations of peat varying in thickness from <0.5 m to 5.0 m. Mainly constrained to ground >250 m AOD
	Devensian	Diamicton	Diamicton of stiff clay and subrounded pebbles, or sandy clay and pebbles
Carbonifer.	Extrusive igneous, Dinantian	Basaltic or doleritic dykes	Alkali basalt and subordinate basanite and 'ankaramites'. Comprises of lavas, tuffs and volcaniclastic sediments with a wide range of compositions

Source: British Geological Survey Maps and Publications

There are several truncated fault lines situated in the southern part of the study area striking southeast to north west, with the downthrow mapped to the southwest. In the northeast of the study area is another fault line striking southwest to northeast.

An extract from the British Geological Survey Map (BGS), Sheet 22E – Kilmarnock, is illustrated in Figure 2.4. The approximate location of the PWS abstractions has been superimposed.

Source: British Geological Survey

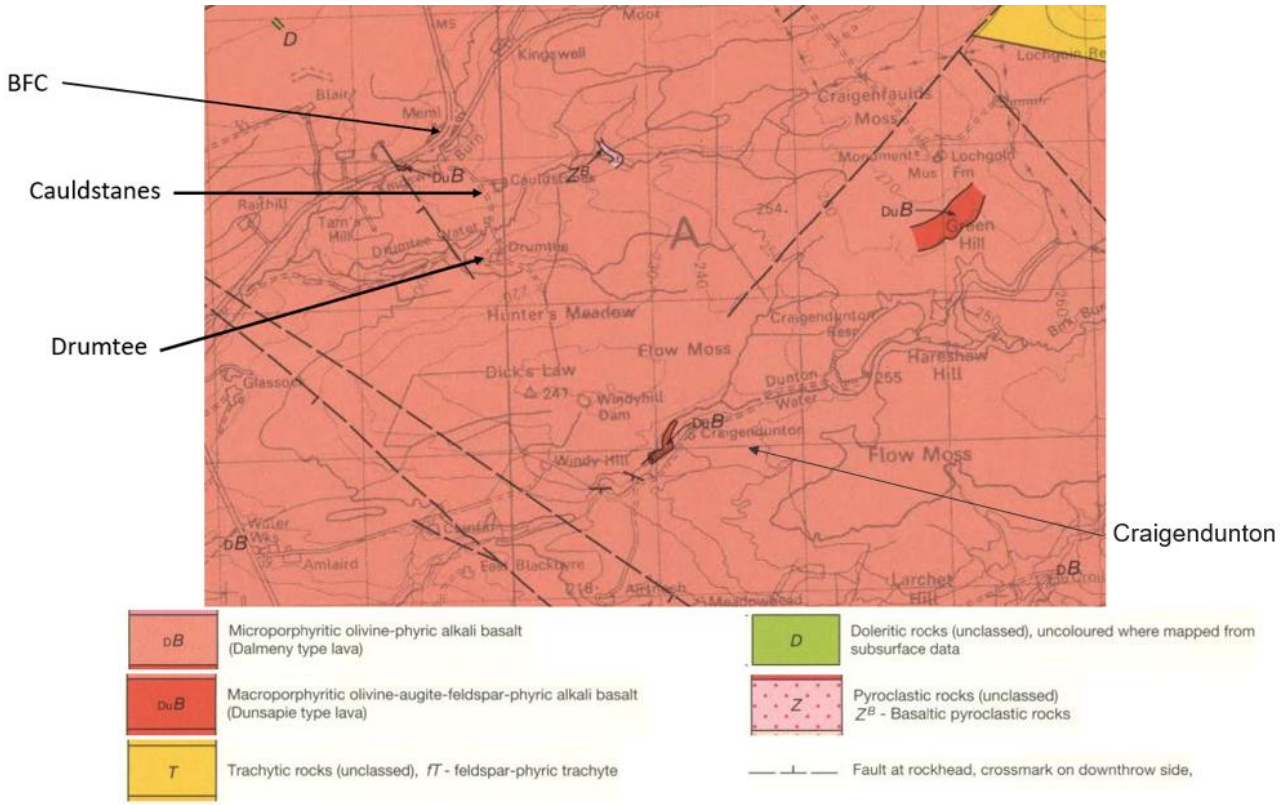

Figure 2.4: Extract from British Geological Survey Map, Sheet 22E – Kilmarnock.

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[5];

- 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[6], aquifers underlying the Study Area are considered vulnerable to pollutants that are not readily absorbed or transformed (Classes 4a & 4b).

Information regarding groundwater WFD classification was obtained from SEPA's Water Classification Hub[7]. The Study Area is underlain by the Whitelee groundwater body (waterbody ID 150599), which has an overall WFD classification of Good (2018).

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

[6] 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 15/11/2022

[7] Scottish Environment Protection Agency (2020), Water Classification Hub, https://www.sepa.org.uk/datavisualisation/water-classification-hub/ , accessed 15/11/2022

Groundwater Levels

According to the EIAR the boreholes within the east of the Southern Section, at the Whitelee Wind Farm Extension substation and BESS locations, recorded standing groundwater levels at 7.60 metres below ground level (mbgl) and 1.86mbgl respectively.

Caludstanes PWS utilises a borehole advanced into the underlying CPV bedrock. The resting water head is unknown.

Drumtee PWS utilises a spring that emerges into a chamber at ~2-3 m bgl. It is assumed the water table is representative of the spring emergence elevation.

Further details on the PWS can be found in Section 3.

Aquifer Properties

Site specific hydraulic data is not readily available for the Study Area. However, more general published information for bedrock units present within the Study Area investigated elsewhere in the Midland Valley[8] provides an indication of the likely hydrogeological conditions.

When un-weathered, igneous rocks have negligible intergranular porosity and permeability with limited yields at rare springs up to 2 l/s. The main controls on aquifer permeability are the characteristics of rock fracturing, and the degree of weathering along junctions between individual flows. Site-specific information presented in the EIAR indicated borehole yields in the southern part of Whitelee Wind Farm extension attained yields of between 5m3 h and 16m3 h. Groundwater flow paths are typically 0.1–1 km and usually follows local surface water catchments.

The 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, 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.

More limited volumes of water may also be present within the overlying peat, primarily as a result of the reduced infiltration capacity of the underlying bedrock and substate as well as the hydraulic properties of the lower amorphous peat. Hydraulic conductivity in the peat may vary by several orders of magnitude depending on the peat structure and hydraulic gradient. Where enhanced permeability features such as “peat pipes” are present, yield may be very high[9].

2.4. Hydrology

Precipitation and Groundwater Recharge

According to the Hydrometric Statistics Handbook[10], the River Irvine at Glenfield gauging station (NGR NS 430 369) approximately 10 km SW of the Study Area estimates Average Annual Rainfall between 1982 and 2005 of 1254 mm per year. The UK Centre for Ecology and Hydrology CHESS map indicates potential evapotranspiration over well wetted grass for the Study area is approximately 455 mm yr[11].

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[8] 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

[9] Ladbadz et al. 2010. Peatland Hydrology. Available at https://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/Review%206%20Peatland%20Hydrology_0.pdf (accessed 15/11/2022).

[10] 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 15/11/2022).

[11] Centre for Ecology and Hydrology. CHESS. Available at https://eip.ceh.ac.uk/apps/chess/ (accessed 15/11/2022).

The stated Base Flow Index of Approximately 0.26 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 catchment of the Drumtee Water, which is a headwater tributary of the River Irvine. The nearest hydrometric gauging station is on the River Irvine at Glenfield (NS 430369). Between 1982 and 2005 the gauging station had a mean annual discharge of 6.3 m3/s, with a Q95 of 0.3 m3/s. The Glenfield hydrometric station is further downstream in the catchment of the Irvine on a separate tributary branch. Whilst the catchment for the Irvine at Glenfield is considerably larger than the Drumtee Water, annual variations in discharge are likely to be comparable.

2.5. Water Quality

Published data obtained from the Baseline Scotland Ground Chemistry Report[12] suggests that where present, bedrock groundwater in igneous volcanic aquifers vary significantly in mineralisation and composition but are rarely highly mineralised (electrical conductivity [SEC] 178–704 µS/cm, median 383 µS/cm) as a result of resistance to weathering. The pH is near neutral with a slight alkali bias (pH 6.6–8.1 Units, median 7.3 Units). Groundwaters are often Ca-HCO_3 dominated, but other chemical types are also encountered. Oxic conditions are prevalent, and Iron (Fe) and Manganese (Mn) concentrations are rarely elevated. A piper plot diagram for igneous volcanic aquifers in Scotland is presented below in Figure 2.5.

Where groundwater is observed to be significantly less mineralised, with more acidic pH as well as higher concentrations of atmospheric indicators, it can be inferred that discharging waters are perhaps more reflective of a quickly recharging surface water system.

Source: Baseline Scotland

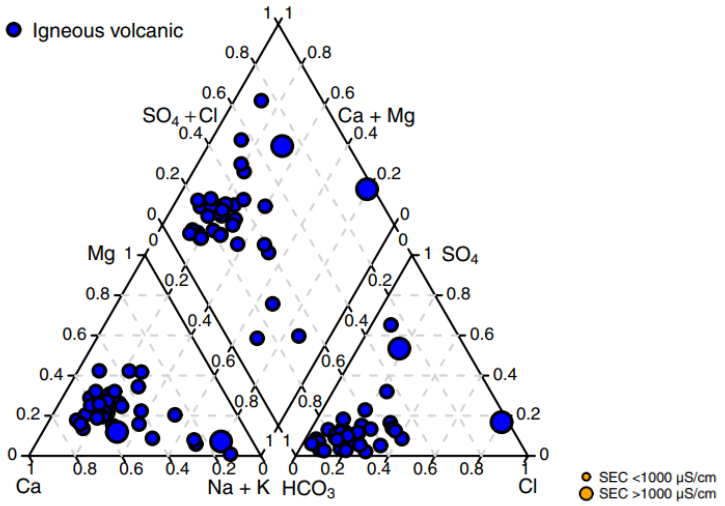


Figure 2.5: Piper plot indicating the prevailing water types and degree of mineralisation for igneous volcanic aquifers in Scotland (Baseline Scotland[8]). As indicated, waters are generally of the Ca-HCO3 type.

Site-specific water quality monitoring was undertaken as part of this assessment. The results are presented and discussed in Section 3 for individual PWS. Full tabulated results are provided in Appendix B.

[12] 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. Available at https://nora.nerc.ac.uk/id/eprint/519084/ (accessed 15/11/2022)

3. Description of the Private Water Supplies

An inspection of the PWS abstractions for Drumtee and Craigendunton was completed on the 13th October 2022. Dumtee was inspected again on the 15th November 2022 and Craigendunton was visited again on the 13th December 2022. An inspection of the PWS at Cauldstanes was undertaken on the 28th October and 15th November 2022.

There has been no inspection of the PWS for Best Friends Cottage due access being refused, despite a number of requests.

3.1. Drumtee (PO1)

3.1.1. Description of the PWS

The PWS abstraction (NS 49901 46237) is a concrete cylindrical chamber situated ~100 m south of Drumtee Farm adjacent to the Howe Burn. There is a pump house next to the chamber that abstracts the water and pumps it to Drumtee Farm where it is used as a domestic water supply.

Discussions with the PWS users indicated that the abstraction is a spring rise which feeds the chamber. The domestic supply does not undergo additional treatment, is resilient to drought or other impacts and is generally very reliable but does cause scaling in some household appliances. A separate supply is also taken directly from the Howe Burn for a few months each year to provide an agricultural supply for housed livestock during winter.

Visual observations in the inspection hatch illustrated that the water levels was ~2 m bgl. Water samples were obtained from the abstraction and also from the Howe Burn and are discussed in Section 3.1.3 below.

Source: Natural Power

Figure 3.1: Drumtee PWS abstraction situated adjcent to the Howe Burn

Source: Natural Power

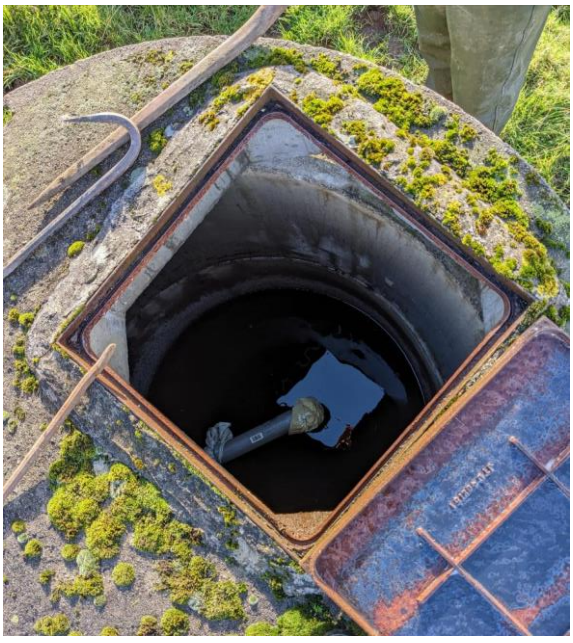


Figure 3.2: PWS abstraction is a concrete chamber fed by a spring rise. Water level was ~2 m bgl

3.1.2. Description of the Catchment

Topographically, the catchment for the Howe Burn and PWS abstraction extends ~2 km eastwards towards Howeburn Moss and Hunter's Meadow attaining a maximum elevation of ~235 m AOD, with the abstraction being at ~205 m AOD.

The land use within the vicinity of the PWS abstraction is farmland, mainly livestock but aerial imagery would suggest the fields on the south bank of the Howe Burn are also used for crop production. Within the upper catchment there is a large area of recently felled commercial forestry containing access tracks and evidence of forestry drainage. Whitelee Wind Farm is situated on the upper catchment watershed.

3.1.3. Additional Observations

Water quality monitoring was undertaken at the time of the PWS inspection with samples obtained from the PWS abstraction chamber, the PWS user point of consumption in addition to a sample collected directly from the Howe Burn (SW1).

Whilst the water level in the PWS abstraction chamber was broadly coincident with the flow level in the nearby Howe Burn, the chemical results for these were noted to starkly contrast. The water chemistry of the abstraction (and tap) were characterised as being weakly to moderately mineralised (140-180 uS/cm), with very low levels or organic carbon (0.5-1.9 mg/L), colour (10-21 Hazen) and aluminium (2-8.4 ug/L), with weathering derived product including calcium, magnesium and sodium being present and in the order of 10-15 mg/L, with carbonate alkalinity also being elevated to ~180 mgCaCO3/L. Conversely, the water chemistry from the adjacent Howe Burn was very weakly mineralised (35 uS/cm), with comparatively elevated levels of organic carbon (33 mg/L), colour (730 Hazen) and aluminium (140 ug/L). Weathering derived products were much lower in concentrations, particularly calcium. Alkalinity could not be determined due to the very high colour content, however following a subsequent sampling visit in November 2022 it was recorded at 81 mg$CaCO_3$/L (rainfall in November was also noted as high). Microbial indicators were also analysed with positive identification detected for colform bacteria, enterococci and e.coli at the PWS abstraction, the point of consumption and in the stream.

When compared with the statistics table presented for volcanic igneous aquifers in Scotland, the Drumtee PWS abstraction demonstrates mineralisation that is slightly lower than the mean value, with many of the associated weathering derived products such as calcium, magnesium and sodium similar to the average or again slightly lower. Notwithstanding, the majority of recorded parameter concentrations including conductivity, organic carbon, iron and manganese were all within the statistical interquartile range for the volcanic igneous aquifers, with those that are indicative of a surface water system being low in concentration. For the Howe Burn, there was very little correlation with the statistics primarily due to high levels of organic material, low conductivity and high aluminium.

The chemical sampling results are presented in Appendix B.

3.1.4. Conceptual Summary

- The Drumtee PWS abstraction provides a domestic water supply for Drumtee Farm;
- The PWS abstraction is a groundwater spring which feeds a chamber sunk into the ground south of Drumtee Farm, near to the Howe Burn;
- Chemical sampling indicates the PWS abstraction is unlikely to be influenced by the Howe Burn despite their proximity, and instead be reflective of a groundwater spring rise. Nonetheless, its likely there is limited interaction with surface runoff at the PWS abstraction on account of slightly reduced concentrations of weathering derived products when compared to the volcanic igneous baseline statistics as well as the presence of microbial indicator parameters which would be derived from a shallow / surface system.

3.2. Best Friend's Cottage (PO3)

Other than a written consultation response, the PWS user declined the opportunity to provide any information on the PWS that serves Best Friend's Cottage or allow an inspection or sampling.

3.2.1. Description of the PWS

Best Friend's Cottage is supplied by a borehole abstraction, which is understood to be situated within the property boundary / its immediate vicinity. The property is also served by an additional supply, which is a piped off-take of the PWS abstraction for Kingswell (referenced as PO4 in the EIAR that accompanied the Project).

Anecdotal information suggests the borehole was advanced to considerable depth before encountering suitably high yielding fractures. The spring for PO4 itself was assessed as not plausibly connected to the Project and therefore the abstraction itself will not be described or considered in this PWSRA. The pipework between the Kingswell PWS abstraction and Best Friend's Cottage crosses under the unnamed road which runs adjacent to the A77 and M77 and then southwards, before crossing back under the road to Best Friend's Cottage. It is understood that the supply pipework was replaced by Scottish Water during upgrade works on the nearby high pressure water main.

3.2.2. Conceptual Summary

- The Best Friend's Cottage PWS is a combination of a borehole assumed to be situated adjacent to the property and an off-take from the Kingswell PWS source;
- No details on the borehole supply are known, however secondary source information indicates a supply is drawn from the bedrock aquifer from considerable depth;
- The Kingswell PWS source is not considered in this assessment, however potential disruption to the supply pipework will be on account of its proximity to the Project; and
- No chemical sampling data is available for either the Kingswell PWS source or the borehole at Best Friend's Cottage.

3.3. Cauldstanes (PO5)

3.3.1. Description of the PWS

The PWS abstraction (NS 49957 46826) is a borehole situated in a shed immediately west of the property.

Discussions with the PWS user indicated the borehole was advanced to ~50 m bgl into solid bedrock, with water struck at ~30 m bgl. The borehole is capable of providing ~200 L of water before needing to recharge, which would suggest a sustainable yield of <0.2 m2 h. The water undergoes several phases of treatment including UV. The arising water is noted as being hard.

Resting water head levels are not known. Water samples were obtained from the abstraction and are discussed in Section 3.3.3 below. Photographs of the borehole headworks are shown below in Figure 3.3.

Source: Natural Power

Figure 3.3: Headworks for the borehole abstraction at Cauldstanes

Source: Natural Power

Figure 3.4: Photograph of the Drumtee Water, situated ~200 m south of Cauldstanes

3.3.2. Description of the Catchment

Cauldstanes is situated within the Drumtee Water hydrological catchment, with the catchments namesake watercourse situated ~200 m to the south of the borehole location. Topographically, the Drumtee Water catchment extends east towards Collory Bog and Craigenfaulds Moss, attaining a maximum elevation of 285 m AOD. Cauldstanes is situated at an elevation ~20 m above the nearest part of the Drumtee Water at ~215 m AOD. In its upper catchment the Drumee Water truncates into four minor watercourses.

The land use in the vicinity of the borehole is generally improved grassland assumed to be used for grazing livestock. In the central part of the catchment on the south side of the Drumtee Water is an area of previously felled commercial forestry. On the north side and in the remainder of the upper catchment the land cover is unimproved grassland and bog. Whitelee Wind Farm is situated in the upper catchment watershed.

3.3.3. Additional Observations

Water samples were obtained from a sampling point between the aeriation filter and the particulate filter and also from the point of consumption (tap). The water chemistry was characterised as being moderately to strongly mineralised (590 uS/cm), with very low levels or organic carbon (2 mg/L), colour (38 Hazen), aluminium (1.5-2.1 ug/L) and iron (4-140 ug/L). Carbonate alkalinity was very elevated (340-360 mgCaCO3) which was reflected in high concentrations of calcium, with additionally elevated levels of sodium and magnesium. Microbial indicators were also analysed with no positive identification for coliform bacteria, enterococci or e.coli.

When compared with the statistics table presented for volcanic igneous aquifers in Scotland, the Cauldtanes PWS abstraction demonstrates mineralisation that is equal to or above mean values. Manganese was more considerably elevated beyond the mean value, but did not exceed the volcanic igneous aquifers baseline maximum value.

A sample was also obtained from the Drumtee Water (SW2), with the results being generally reflective of the water chemistry identified in the Howe Burn (SW1). Chemical sampling results for the Cauldstanes water samples and the sample from Drumtee Water are presented in Appendix B.

3.3.4. Conceptual Summary

- The Cauldstanes PWS abstraction is a borehole that provides a domestic water supply for the property;

- The borehole and bedrock aquifer are dominated by fracture flow, with yield being low compared to published values;
- Chemical sampling indicates the water is abstracted from the bedrock aquifer, and is highly mineralised, with weathering derived products and ferrous metals such as manganese being above average values for volcanic igneous aquifers in Scotland. The high degree of weathering derived products combined absence of microbial indicators and very low concentrations of parameters such as colour, organic carbon and aluminium would suggest the groundwater is not readily interacting with surface waters.

3.4. Craigendunton (PO8)

3.4.1. Description of the PWS

The PWS abstraction (NS 51230 45063) is a shallow well situated immediately south of the property. The abstraction comprises of a section of perforated pipe buried into the soil and surrounded by gravel and topsoil. It's understood the PWS feeds the main property and a temporary dwelling in the woods just to the south via a pump in a manhole situated 10 m north east of the abstraction.

Photographs of the abstraction and the manhole chamber are shown in Figure 3.5 and 3.6 below. The water levels is ~0.5 m below ground level and the yield is unknown.

Source: Natural Power

Figure 3.5: Craigendunton PWS abstraction at NS 51267 45015

Source: Natural Power

Figure 3.6: Photograph of the holding tank outside Craigendunton at NS 51226 45071

3.4.2. Description of the Catchment

Craigendunton is situated within the Dunton Water hydrological catchment, with the catchments namesake watercourse situated ~150 m to the north of the abstraction location. The Craigendunton Reservoir is situated ~1.1 km to the east. The Calf Fauld Burn is ~130 m to the south of the abstraction and is a tributary to the Dunton Water.

Topographically, the Dunton Water catchment extends east towards Flow Moss, attaining a maximum elevation of 303 m AOD. The Craigendunton abstraction is situated at an elevation ~15 m above the nearest part of the Dunton Water at ~225 m AOD.

The land use in the vicinity of the abstraction is mature commercial forestry, being bounded by the moorland in the north and south. Further to the east is an area of felled commercial forestry and Whitelee Wind Farm, which extends into the upper catchment. There is extensive evidence of artificial drainage on both the moorland, in the areas of retained and felled forestry and associated with Whitelee Wind Farm.

3.4.3. Additional Observations

The PWS property is currently vacant. There is a temporary dwelling situated adjacent to the property which also takes a supply from the abstraction.

No further anecdotal information was available.

3.4.4. Conceptual Summary

- The Craigendunton PWS abstraction provides a domestic water supply for Craigendunton and a small temporary dwelling;
- The PWS abstraction is shallow well just south of the property;
- No chemical sampling has been undertaken yet. Its possible that the abstraction is nourished via a combination of direct rainfall within the immediate vicinity, runoff as overland flow from upgradient areas, shallow groundwater again from upgradient areas, or a spring rise via bedrock along structural features.

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. This section presents a conceptual site model (CSM) based on the available data.

4.1. Preliminary Consideration

Land-use within the Study Area includes agriculture (grazing animals), commercial forestry and an existing Windfarm. Any associated pressures on potential receptors arising from these existing land uses are outside the scope of this assessment, however the effects of these being modified as a result of construction of the Project (and associated hazards) has been considered.

4.2. Potential Hazards

The main hazards which could impact a PWS are related to degradation in water quality or quantity. The specific activities and operations associated with the Project which have the potential to impact water quality and quantity have been adapted from CIRIA guidance documents[13] 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 resulting in contamination;
- Discharge of sediment from forestry, construction areas or drainage networks / disturbance of existing 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);
- Modification of groundwater flow pathways (i.e. removal of superficial sediments, addition of impermeable surfaces, dewatering); and

[13] CIRIA C532. Control of water pollution from construction sites. Guidance for consultants and contractors.

- Accidental damage to the supply delivery infrastructure.

Point source pollution may arise from accidental releases of fuels / chemicals / effluent from a discrete location.

Diffuse source pollution may arise from non-point source specific activities. 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.

4.3. Receptors

The receptors under consideration in the case of the PWS is the source of water which feeds the abstraction. The CSM and consequential risk assessment considers PWS receptors to be of high importance.

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 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 quantity is reduced.

In terms of recharge to PWS, based on the available data and field observations, two means of water transmission are considered to potentially contribute to the flow and it is possible that there may be multiple sources. These are:

- Shallow groundwater / surface water overland flow convergence following the topography above PWS abstractions; and
- Emergence of groundwater as it flows along geological structures such as permeable bedding, fractures, faults etc. This may occur at the surface also when encountered at depth in boreholes.

Considerations regarding each flow pathway obtained from the desktop assessment and inspection of the PWSs 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 ditches. 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 to move laterally where further vertical drainage is impeded by lower permeability bedrock / glacial till. 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. Water chemistry will be reflective of rainfall inputs, and the limited time in which infiltrated water can react with soils and rocks;
- 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).

Groundwater Flow Along Structural Features

- Groundwater flow may also occur along structural features including open bedding planes, faulting and fractures, and where the contact with the ground surface may create springs (Figure 4.1). The upland elevation of the

PWS abstractions would suggest spring forms are likely to be hanging, or fault guided, with these structures being mapped to the south of the PWSs. Minor unmapped faults are also likely to be present.

- Evidence obtained by this study indicating the presence of groundwater flow along structural features is the chemical sampling data obtained from Cauldstanes and Drumtee, which indicated high levels of mineralisation and alkalinity, as well as higher concentrations of geological weathering derived by-products (i.e. calcium) than nearby and immediately adjacent surface water networks. The inheritance of weathering products, and absence of microbial indicators would suggest water movement rate through such features is slow, i.e. Cauldstanes.
- The supply of water to these features will occur where they outcrop at higher elevations, or where overlying fracture networks allow vertical transmission. The rate of movement through such bedrock features will depend on the extent, aperture and orientation of flow structures, with published[14] values for unfractured igneous rocks being 10^{-13} m/s to 10^{-8} m/s and fractured igneous rocks being 10^{-8} m/s to 10^{-3} m/s.
- Vulnerability to pollution for such features is greatest where they contact the ground surface and its noted that much of the Project is overlain by low permeability glacial till or peat. In addition to this, the vulnerability fracture systems would also be dependent upon the nature and extent of fracturing, the residency time of any infiltrated pollutant and the level of attenuation within the network.

Source: BGS

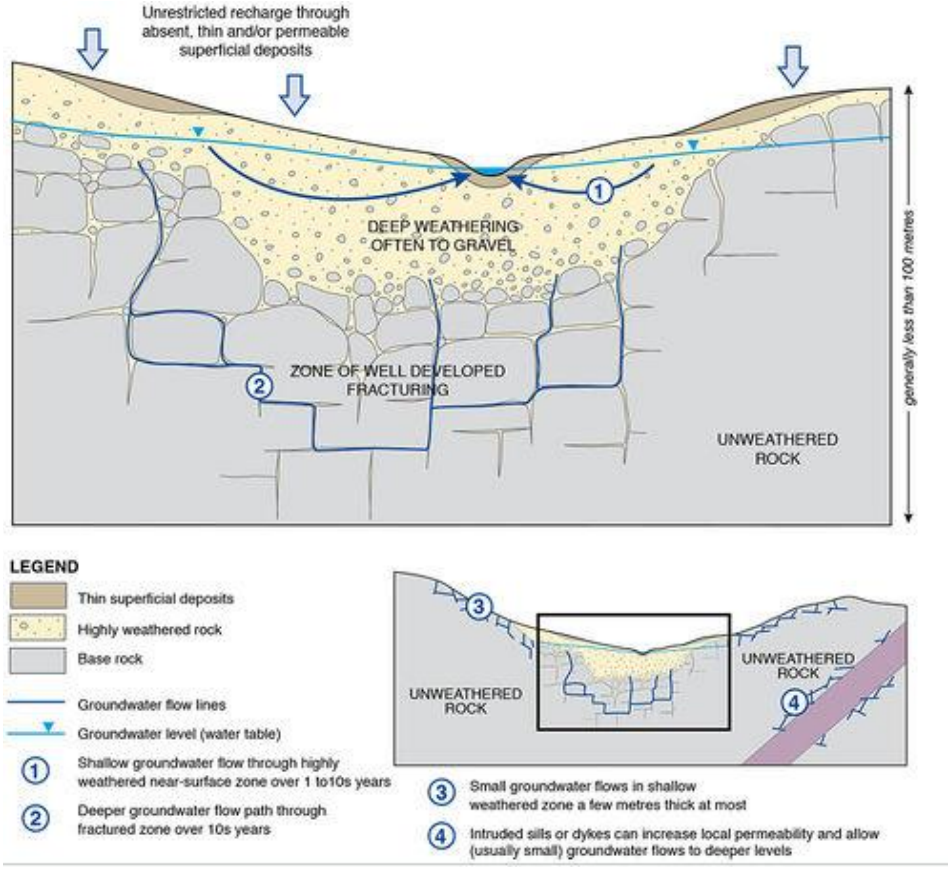


Figure 4.1: Schematic cross-section of the hydrogeology of igneous rocks in Scotland

[14] Freeze & Cherry. 1979. Table 2.2. Groundwater. Available at https://commons.wikimedia.org/wiki/File:Groundwater_Freeze_and_Cherry_1979_Table_2-2.png (accessed 15/12/2022)

4.5. Summary of Conceptual Model

- The Study Area is dominated by semi-improved grassland as well as a small area of felled commercial forestry. Superficial soils are a combination of glacial till and peat. The underlying bedrock is dominated by compact volcanic igneous bedrock. There is some faulting in the bedrock which is orientated northwest to southeast.
- Rainfall will be a significant input into the hydrological system. Runoff may be carried downslope as overland flow or it will infiltrate where ground conditions allow. All rainfall-runoff will follow local topographic gradients unless influenced by ditches or other features.
- PWS dependent upon rainfall runoff or shallow groundwater will have catchments extents controlled by topography. For a hazard to influence a PWS via overland flow or shallow groundwater, it would need to be located upgradient in the catchment. Overland flow / shallow groundwater pathways could be vulnerable to pollution or inadvertent modification.
- Based on an understanding of the local geology and the results of hydrochemical sampling preferential flow paths potentially related to the presence of structural features within the bedrock may act as a source of water recharge to PWS. Where present, structural features could direct bedrock groundwater flow independent of the local topography and would follow patterns in local fault / bed orientation. Depending on the arrangement of these features, a deeper bedrock system may be more resilient to inadvertent modification or pollution but will remain vulnerable at the point of abstraction. For other locations, opportunities for pollutant infiltration to bedrock aquifer fractures systems will be limited by the extent of peat and till and the overburden of competent bedrock. The high degree of weathering products identified through chemical analysis of the bedrock aquifer also suggests that residency times are likely to be significant, which combined with low flow rates (Cauldstanes borehole) would suggest adequate time for attenuation or dilution in the unlikely event fracture network pathways with PWS abstractions was plausible.

Uncertainty

Specific groundwater flow pathways 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 anticipate. 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. Risk Assessment

This risk assessment considers the likelihood (or plausibility) of a PWS being impacted by an associated adverse effect associated with the construction or operation of the Project.

The **Probability** (or plausibility) of a pathway is considered along with the estimated **Severity** that an active pollutant linkage would have on a receptor. The plausibility of a pathway or sensitivity of a receptor is based on the CSM.

The plausibility of a pathway combined with the severity of impact provides the **Significance of Impact**.

All of the risk assessments provided consider that good practice mitigation has been successfully implemented. Where additional mitigation is presented, this is highlighted and a **residual significance of impact** presented.

A framework for this approach to risk assessment, as well as significance criteria and an assessment matrix is presented in Appendix C.

5.1. Good Practice Mitigation

Control measures will be implemented to protect the water environment during the construction works, as outlined in the EIAR[1], FEI[2], Environmental Management Plans and associated guidance. These good practice mitigation measures which are also relevant to the protection of PWS, will be implemented as per the Construction Environmental Management Plan (CEMP) for the Project. 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 also contain additional site-specific measures such as those presented in Section 5.2.

A summary of relevant good practice mitigation considered by this risk assessment is presented in Appendix D.

5.2. Additional Recommendations

Recommended additional mitigation is presented to supplement embedded mitigation and standard good practice (Section 5.1).

5.2.1. PWS Method Statement

A Private Water Supply Method Statement (PWSMS)[15] has been prepared to deliver both good practice mitigation along with additional mitigation requirements identified in the risk assessment. The PWSRA will outline;

- Standard good practice mitigation;
- Construction methods and Principal Contractor activities;
  - Further investigation & demarcation on Project land;
  - Civil design to mitigate risks;
- Emergency contingency measures; and
- Water monitoring and reporting where required.

The PWSMS will also include a pollution response plan and contingency measures that would detail responsibilities and lines of communication between Principal Contractor, PWS users and other stakeholders. Contingency measures will 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 Project.

An extract of the PWSMS outlining the necessary construction mitigation (where required) is below;

[15] Natural Power. 2022. Whitelee Wind Farm Solar, BESS & Green HydrogenL Priavet Water . Reference : .

- *The Principal Contractor will ensure that an investigation and demarcation takes place prior to construction activities near the PWS and determine the location of the associated PWS infrastructure and the likelihood that the construction would impact the PWS.*
- *Non-intrusive means of investigation would be prioritised including the use of cable avoidance technology (CAT) scanners (if metallic), ground penetrating radar (GPR) or other geophysical survey methods. Intrusive methods such as a systematic trial pit survey would be done by-hand.*
- *Any investigation and demarcation works will require method statements and would be done in communication with the PWS user.*
- *If following further investigation it's confirmed there is the potential for the PWS infrastructure to be impacted through planned construction works then specific construction or working methods such as the use of a fit for purpose engineering design and detailed drawings will be prepared to ensure the continuity of the PWS. In this instance the Principal Contractor will be responsible for;*
  - *Planning and phasing works in communication with EAC Environmental Health and the PWS user to ensure they are aware of the likely disruption, to outline alternative temporary supply provisions and timelines for reinstatement;*
  - *Providing a temporary alternative water supply which will be provided to the PWS user prior to works commencing; and*
  - *Reinstating the water supply as soon as possible after works have been completed.*
- *The Principal Contractor will provide a construction method statement to EAC Environmental Health and the ECoW for review prior to works near the PWS commencing. This will also include alternative supply provisions, if required. Assuming the implementation of the mitigation provided above, no disruption to the PWS is expected.*
- *In the unlikely event of accidental permanent disruption to the PWS, the Project Manager and Principal Contractor will provide a permanent alternative supply that is similar in quantity and quality to the existing PWS. This should be done in communication with EAC Environmental Health.*

5.3. PWS Monitoring

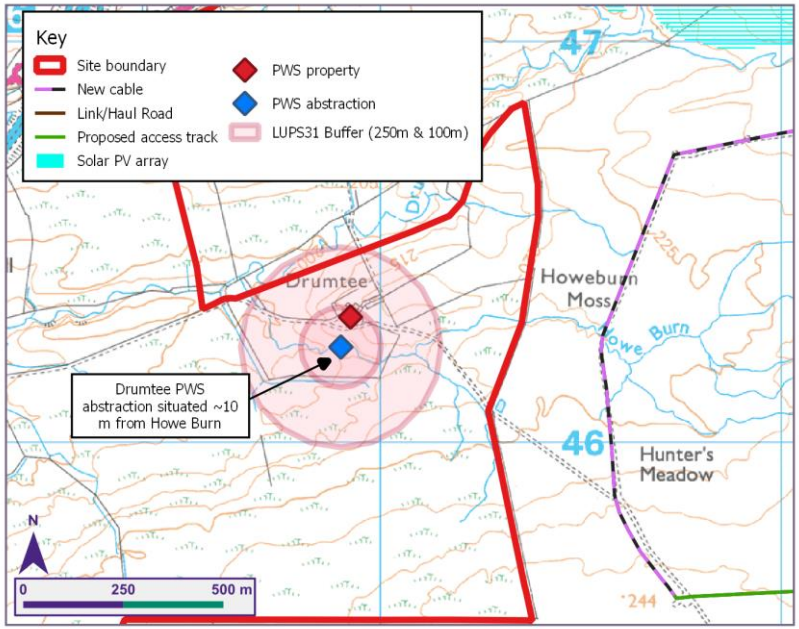
The PWSMS will include details on PWS water quality and quantity monitoring.

Where required, a water quality monitoring programme will be undertaken 6 months prior to any construction (baseline) and on a monthly basis during construction. The method statement shall include water quality sampling methods and shall specify abstraction points. Four rounds of bi-monthly post-construction monitoring would also be completed to ensure there is no long-term impact on water quality or quantity that could be associated with the Project.

5.4. Risk Assessment

Drumtee PWS

Proximity of abstraction to Project



Assessment Notes

- PWS abstraction is a collection tank situated downgradient of the Project, adjacent to the Howe Burn and provides domestic source of water. Neither the property nor abstraction are within the relevant SEPA LUPS31 buffer.
- Detailed analysis of the water chemistry of the PWS abstraction demonstrates it differs from the watercourse, suggesting recharging water in the abstraction is not sourced directly from the Howe Burn. A pathway to affect water quality or quantity via the Howe Burn (surface runoff) is **unlikely**. The mineralised composition combined with the presence of other parameters such as microbial indicators would suggest the spring is dependent on a combination of shallow groundwater, localised runoff and bedrock groundwater.
- The CSM identified groundwater as being shallow and following topography with groundwater flow lengths being limited (0.1-1km). Based on the CSM and distance to the shallow excavation works proposed in the upper catchment associated with the Project, the probability of a pathway via bedrock or shallow groundwater is considered of **low likelihood**.
- The location of the PWS delivery infrastructure between the property and abstraction is **unlikely** to be impacted by the Project.

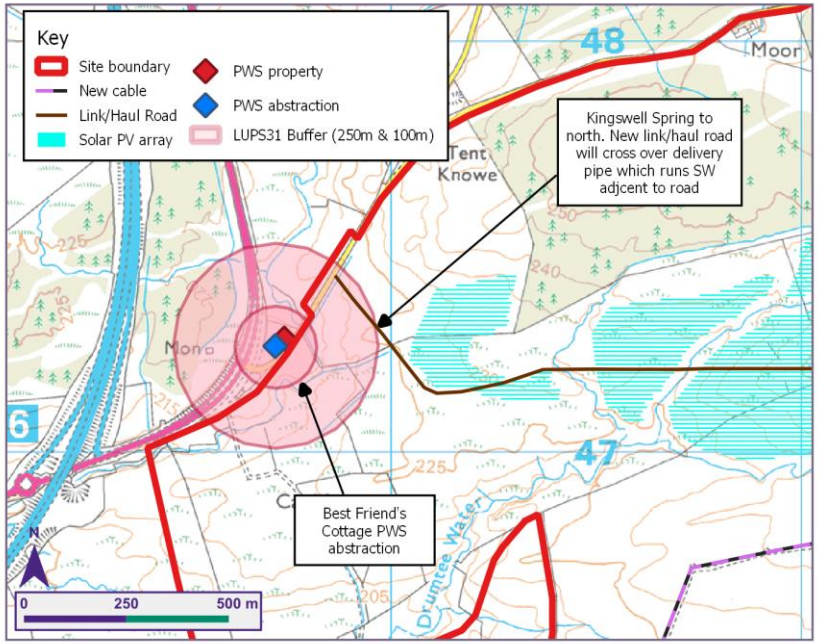
Additional Recommended Mitigation

- It is recommended that the following additional mitigation is considered;
  - A programme of water quality and quantity monitoring will be developed to monitor this supply; and
  - Management measures (including contingency) which would be outlined in PWSMS prior to construction and be based on the results of further investigation.

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

Best Friends Cottage PWS

Proximity of abstraction to Project



Assessment Notes

- PWS abstraction is a borehole. Borehole is within 250 m of new link / haul road. At this stage excavation depth is estimated to be <1 m. Borehole is >100 m from new link / haul road.
- Property also served by a possible spring (Kingswell PWS) which is not connected to the Project[1]. The delivery pipework will be crossed by the new link / haul road and without protection there is a **high likelihood** of impact. The delivery infrastructure for the borehole is **unlikely** to be impacted by the Project.
- Anecdotal information provided by the PWS user infers the borehole recharges from significant depth from the bedrock aquifer. The CSM identified groundwater as being shallow and following topography with groundwater flow lengths being limited (0.1-1km) or using structural features such as fractures. The only plausible pathway would be via structural features. However based on the CSM, and the significant depth from which groundwater recharges in the bedrock, any pathways resulting in impact via the bedrock aquifer is considered of **low likelihood**.

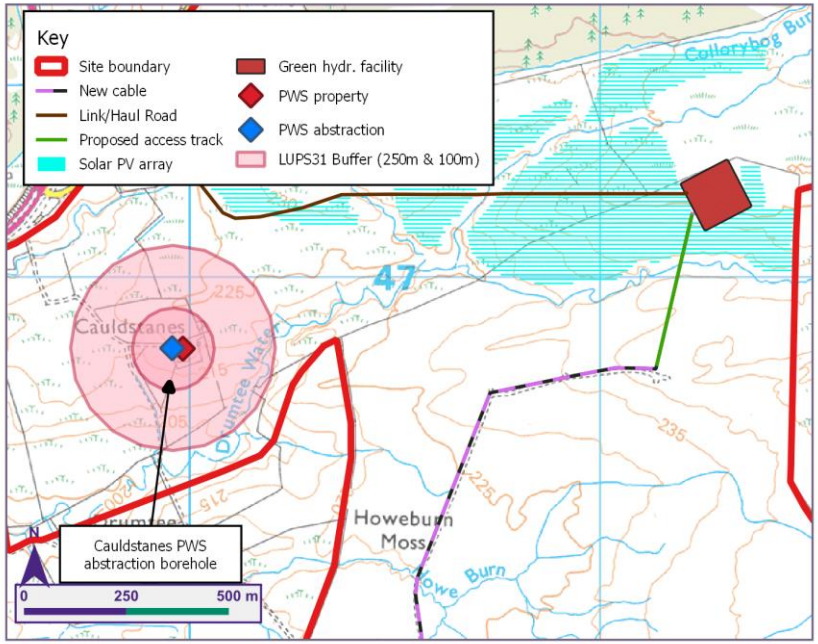
Additional Recommended Mitigation

- It is recommended that the following additional mitigation is considered;
  - Further investigation and demarcation by Principal Contractor (Kingswell PWS pipework only);
  - A fit for purpose engineering solution to allow the delivery pipe to be crossed (Kingswell PWS pipework only); and
  - Management measures (including contingency) which would be outlined in PWSMS prior to construction and be based on the results of further investigation.

Hazard Identification	Receptor	Probability of Impact	Magnitude of Change	Significant of Impact	Additional Mitigation?	Revised Probability.	Residual Significance
Activities affecting water quality	All source of water serving PWS	Low Likelihood	Moderate	**Medium / Low**	Yes (above)	Unlikely	**Low**
	Pipework delivering water to Property	High Likelihood	Moderate	**High**	Yes (above)	Unlikely	**Low**
Activities affecting water quantity	All source of water serving PWS	Low Likelihood	Moderate	**Medium / Low**	Yes (above)	Unlikely	**Low**
	Pipework delivering water to Property	High Likelihood	Moderate	**High**	Yes (above)	Unlikely	**Low**

Cauldstanes PWS

Proximity of abstraction to Project



Assessment Notes

- PWS abstraction is a borehole. The borehole is not location within the SEPA LUPS 31 250 m or 100 m buffer.
- The borehole recharges from significant depth from a fracture network in the bedrock aquifer. An analysis of the water chemistry indicates recharging waters are strongly mineralised, and are comparable with baseline values for volcanic igneous aquifers. The chemistry does not suggest the source of water is readily influenced by recently recharging surface waters.
- The CSM identified groundwater as being shallow and following topography with groundwater flow lengths being limited (0.1-1km) or using structural features such as fractures. The only plausible pathway would be via these structural features. Based on the CSM, a pathway resulting in impact via the bedrock aquifer is considered of **low likelihood**.
- The location of the PWS delivery infrastructure between the property and abstraction is **unlikely** to be impacted by the Project.

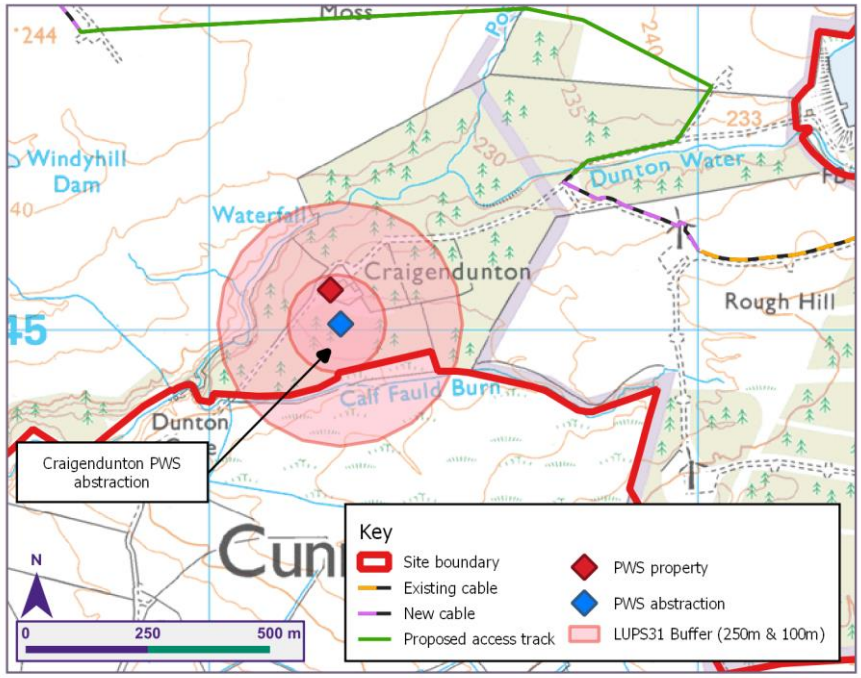
Additional Recommended Mitigation

- It is recommended that the following additional mitigation is considered;
  - A programme of water quality and quantity monitoring will be developed to monitor this supply; and
  - Management measures (including contingency) which would be outlined in PWSMS prior to construction and be based on the results of further investigation.

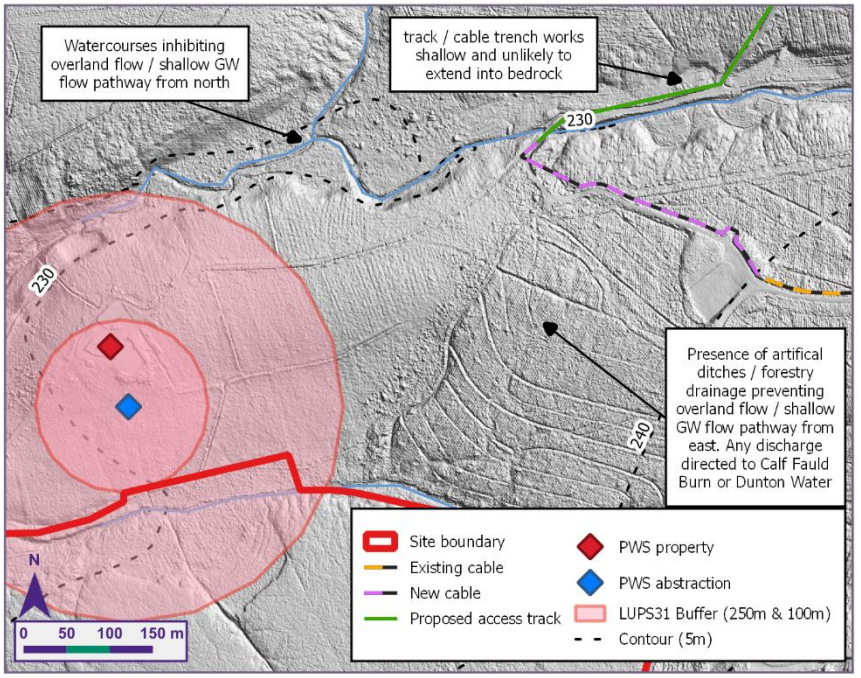
Hazard Identification	Receptor	Probability of Impact	Magnitude of Change	Significant of Impact	Additional Mitigation?	Revised Probability.	Residual Significance
Activities affecting water quality	All source of water serving PWS	Low Likelihood	Moderate	**Medium / Low**	Yes (above)	Unlikely	**Low**
	Pipework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

Craigendunton PWS

Proximity of abstraction to Project



Additional LiDAR mapping



Assessment Notes

- PWS abstraction is a shallow well. The abstraction is not location within the SEPA LUPS 31 250 m or 100 m buffer.
- The CSM identified groundwater as being shallow and following topography with groundwater flow lengths being limited (0.1-1km) or using structural features such as fractures. There is a low likelihood of a shallow groundwater and overland flow pathways between the Project and the abstraction due to the topography and the assemblage of artificial ditches and natural drainage channels. Another plausible pathway would be via bedrock structural features. However, based on the CSM (principally the absence of any such mapped features and generally low productivity of the bedrock aquifer), a

Craigendunton PWS

pathway resulting in impact via the bedrock is also considered of **low likelihood** and it is further highlighted that works on the track and new section of buried cable are shallow, and likely to remain within the subsoil and superficial overburden.

- The location of the PWS delivery infrastructure between the property and abstraction is **unlikely** to be impacted by the Project.

Additional Recommended Mitigation

- It is recommended that the following additional mitigation is considered;
  - A programme of water quality and quantity monitoring will be developed to monitor this supply; and

Monitoring and management measures (including contingency) which would be outlined in PWSMS prior to construction and be based on the results of further investigation.

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

6. Conclusion

A detailed private water supply risk assessment (DPWSRA) has been produced in response to a request for further information and assessment on a number of private water supplies (PWS) situated within the vicinity of the proposed Whitelee Wind Farm Solar PV, Green Hydrogen Production and Battery Storage Facilities (The Project).

Natural Power have carried out a detailed desktop assessment of the likely hydrological and hydrogeological conditions, re-consulted with residents to confirm supply arrangements and considered the hazards to the PWS based on a source-pathway-receptor conceptual site model (CSM). The CSM has been refined using site-specific investigation data that was collected on-site by Natural Power following the completion of the desktop assessment.

The assessment has concluded that the significance of any residual adverse effects is low for all of the PWS. This is based on the adoption of recommended additional mitigation measures to bolster standard good practice mitigation that has been outlined in the EIAR, FEI, and construction and environmental management plan (CEMP).

6.1. Disclaimer

This report has been prepared by Natural Power with all reasonable skill, care and diligence for the SPR, for the specific purpose of undertaking a hydrogeological assessment for the Project.

This report details the findings of the risk assessment considering information provided by EAC, the relevant landowners, SPR and property residents and is therefore, as accurate as this information will allow.

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.

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.

Appendices

A. Figures

B. Water Quality Sampling Results

C. Approach to PWS Risk Assessment

C.1. Risk Assessment

A methodology for risk assessment of PWS is contained within the Private Water Supplies Technical Manual[16]. Due to the nature of works being carried out at the Project, it is deemed impractical to use the methodologies set out in this guidance. When assessing supply compliance with the PWS regulations, local authorities are required to consider factors, such as: proximity of the supply to cattle and wildlife, historical and current land use, and historical maintenance carried out on the supply. While such factors are useful for understanding the baseline qualities of a supply, they are inappropriate for determining the risk to the PWS during the construction and operation of the Project, which is based on the Source-Pathway-Receptor model.

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 supplies.

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); and
- 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 proposed 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.

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.

C.1.1. Significance Criteria

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

[16] Drinking Water Quality Regulator for Scotland, Technical Guidance and Information, https://dwqr.scot/private-supply/technical-information/pws-technical-manual/

The probability has been classified as high likelihood, possible, low likelihood or unlikely based on criteria outlined in Table C.1. The likelihood of any impacts on the quality and quantity of water serving the PWS is influenced by the type of supply and its source abstraction location within the catchment in relation to construction activities.

Table C.1: Probability of impacts

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.
Possible	• There is pollutant linkage and all the elements are present and in the right place which means that it is possible 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.

As outlined above the potential impacts on the PWS 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 C.2.

Table C.2: Magnitude of change to PWS

Magnitude	Definition
Major	• Major change to the hydrological/hydrogeological conditions resulting in temporary or permanent change. • 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. • 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. • Minor degradation in the operation of the supply in terms of quantity and or quality.
Insignificant	• No perceptible change to the hydrological/hydrogeological conditions.

C.1.2. Impact Significance Matrix

The likelihood and magnitude of the potential impacts are combined to define the significance of the impact, as shown in Table C.3. This table provides a guide to assist in the decision making but should not be considered a substitute for professional judgement and interpretation. In some circumstances, the magnitude of effects may be unclear and professional judgement remains the most effective manner for identifying the potential significance.

The significance of the risk considers the successful implementation of the good practice environmental management practices 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 C.3: Combined risk

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

The risk categories are further defined in Table C.4.

Table C.4: Risk definitions

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.
High	• Significant harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate mitigation.
Medium	• 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	• 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.

D. Standard Good Practice Mitigation

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 should 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 proposed 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 hazard 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.
- 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 proposed 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, Risk Assessment Method Statement (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 private 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.

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