

GeoSolve Ref: 160201  
30 May 2016

Blueskin Energy Ltd  
1121 Mt Cargill Rd  
Waitati  
Dunedin

Attention: Scott Willis

Dear Scott

## Groundwater Considerations for Wind Energy Development, Porteous Hill, Blueskin Bay, Dunedin

### 1 Introduction

This letter presents engineering geological comment in response to concerns that have been raised regarding potential adverse effects on groundwater aquifers as a result of a proposed wind energy development at the summit of Porteous Hill near Warrington, Dunedin.



Photo 1 – General view of Porteous Hill summit

The work was carried out for Blueskin Energy Ltd in accordance with GeoSolve Ltd's proposal dated 27 May 2016, which outlines the scope of work and conditions of engagement.

## 2 Proposed Development

We understand that the proposed development is to establish three wind energy turbines to be located at the summit of Porteous Hill. The full height of the turbines from ground level to rotor tip will be 90m. Earthworks will be required for the project to construct access tracks and to excavate foundations.

Based on initial test pitting investigations, the foundations of the turbines are likely to comprise shallow (2-3m deep) concrete pads (subject to confirmatory geotechnical drilling investigations) of 11m diameter. At this stage no deep piling or anchoring is expected to be required.

The access track would be approximately 5m wide and will involve undercut of near-surface soils to approximately 300mm depth followed by placement of permeable compacted granular fill to form a pavement for vehicles that will be required for construction and maintenance.

The locations of the three turbine sites are shown on Figure 1 & 2.

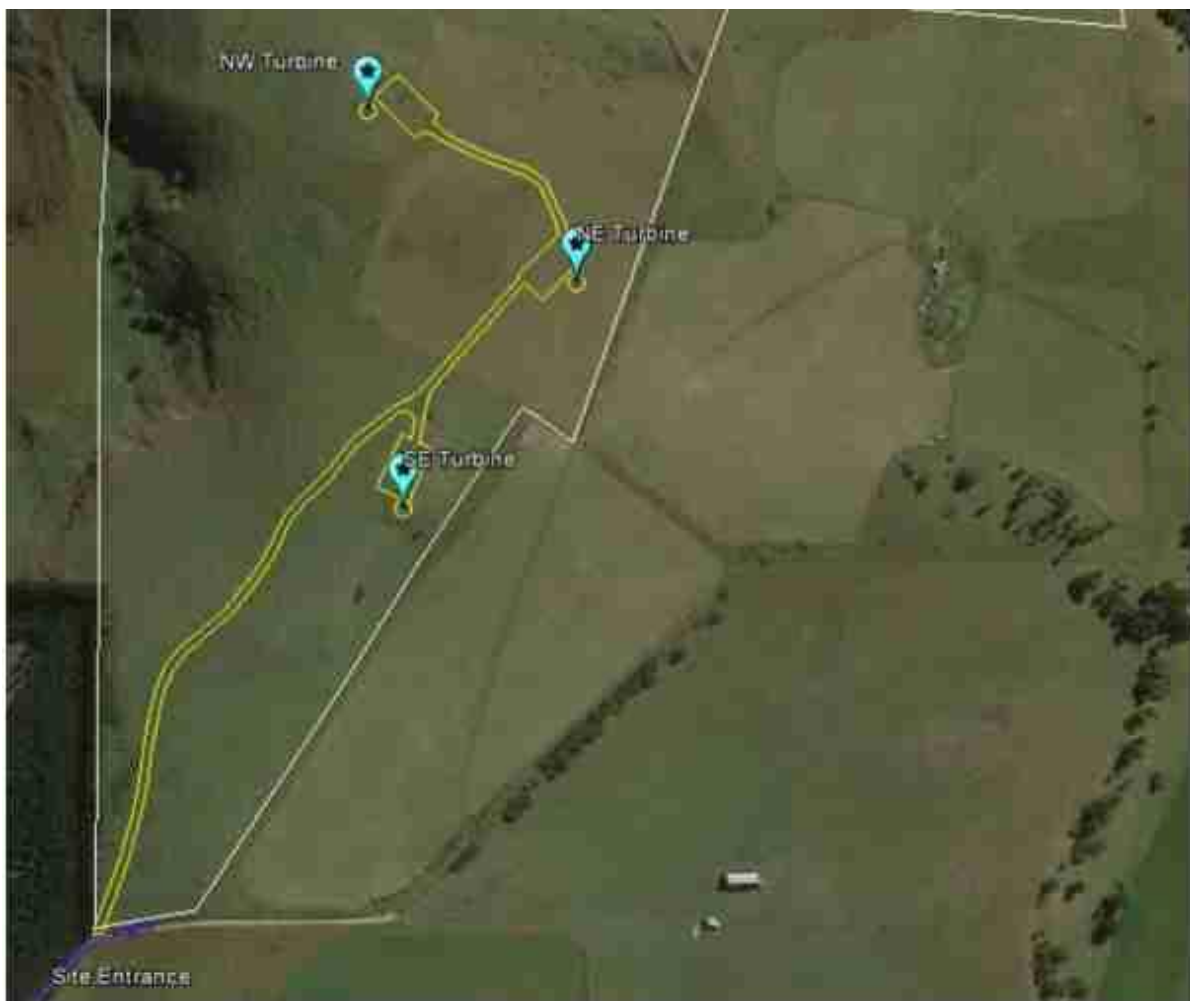


Figure 1 – Proposed Turbine sites and access roads (map view)



Figure 2 – Proposed Turbine sites and access roads (schematic view)

### 3 Nature of Objections

The Dunedin City Council planner has recommended that the Resource Consent application for the above development be declined for reasons that include uncertainty over the effect installing turbines would have on nearby groundwater springs.

Several objections have been received in regard to perceived potential adverse effects on spring flows in the Porteous Hill area. The objections raised above can be summarised as follows:

1. Concerns relating to physical effects on the groundwater system such as reduced groundwater flow, disruption to groundwater flow paths and changes to the locations and discharge rates of spring flows.
2. Concerns relating to contamination of groundwater by the development.
3. Concerns relating to land instability.

The following are examples of opposing submissions that specifically mention the above concerns:

2. Andy Barratt, 317 Apes Road, RD1 9471, Karitane. "... there are also hydrological implications of the work involved in providing foundations for the windmills. My understanding is that the proposed site is a source of spring water which supplies water to neighbouring properties for both domestic and farming use. At the very least, this proposal would need to be supported by expert evidence that these rural activities would not be put at risk by the proposed development, which would contravene the proposed and existing District Plans"

3. Eric Neuman, 392 Coast Road, 9471, Warrington. "We get some of our water from a spring below the proposed turbines and we are concerned that the excavation and placing of lots of concrete will disturb the fragile structure, and destroy our water supply, (and 11 other households which share this spring and resulting stream)."
4. Geraldine Tait, 33 Reservoir Road, RD1 Waikouaiti, 9471, Warrington. "There are no geological or hydrological reports. The whole North Coast area is prone to slips and is part of the hazard zone in the draft 2GP. Any work on the road, access track and site preparation could result in serious land movement. Major excavation is required to create a platform for the concrete bases, as the underlying geology is not known the depth and extent of this excavation may be considerably more than has been anticipated. The hill has an underground network of streams which come to the surface as springs, all the local farmers and many of the lifestyle blocks totally rely on spring water for household and stock water. Disturbance at the top of the hill could lead to pollution of this water or diverting of underground streams away from where they are presently utilized. Due to issues associated with land movement and water, a Resource Consent should also be required from the Otago Regional Council."
5. Grant Boyle, 235 Coast Road, 9471 Warrington. "There is no study on the potential effects the site earth works and foundations will have on the stability of the land or the ground water. A number of people who farm in the area have raised serious concerns over the suitability of building such large structures on this land."
6. John Thom, 58 Reservoir Road, 9471 Warrington. "There is little information on bird life, geotech & environmental effects. Effects on springwater for households and stock."
7. Murry Cumming - Raises the possibility of contamination of water supply and disruption of spring flows.
8. Polly Higham, 392 Coast Road, 9471, Warrington. "We get some of our water from a spring below the proposed turbines and we are concerned that the excavation and placing of lots of concrete will disturb the fragile structure, and destroy our water supply, (and 11 other households which share this spring and resulting stream)."
9. Simon Ryan and Jennifer Ashby, 90 Pryde Road, Merton – Express concerns relating to effects on spring flows.
10. Thomas and Linda Thompson, Rapid 5, Porteous Road, RD1 Waikouaiti, 9471. "The ground at Porteous Hill is unstable and massive excavation plus ground vibrations when towers are operational will have an unknown effect, varying from nil to possibly catastrophic to the entire hillside."
11. Nathan Parker, CMB103 Warrington, Otago 9449, "If the turbines are built of Porteous Hill there seems to be no guarantee that they will not have any adverse effect on local aquifers - this hill with its mix of basalt and loess is highly unstable. Local farmers report problems with land subsidence, slips and significant damage from only small disturbances to the land - this is historic for the area. From around Porteous Hill aquifers flow - in the past they were used as the main water supplies in Seacliff, Warrington, Omimi, Evansdale and Merton communities. Many of the farms are reliant on these continuing to flow. Our ability to be resilient/autonomous communities will diminish significantly if these aquifers/springs are damaged and so will our ability to grow food be limited with no water!"
12. Lyndon and Kirsty Clayton, PO Box 12044, Maori Hill, Dunedin, 9043 [they live at 22 Pryde Road] – Express concerns on the possible impacts that excavations could have on sensitive springs and underlying aquifers that are utilised for domestic and stock water.

## 4 Site Description

The proposed development will take place on an approximately 24 hectare property legally described as Lots 1 and 2, DP 473199 and OT 646829. The property is accessed from Porteous Road and lies at crest of the hillslope north-west of Warrington. The site is currently undeveloped and being used as farm land. A wind testing mast has been erected near the NW turbine site. Vegetation comprises pasture and the property is bounded by mostly pasture land on all sides. There are no buildings in close proximity to the proposed turbine sites.

The site is located at an elevation of approximately 390m at the crest of Porteous Hill. The slopes adjacent to the proposed sites are variable, with some moderate to steep slopes, particularly adjacent to the SE turbine site. No cross sections have been prepared at this preliminary stage, however detailed cross sections showing the full ground model should be developed as part of detailed design.

The site is naturally free draining and no spring flows are evident at the crest of the hill. Ephemeral watercourses and springs are present on the slopes and in gullies well below the hillcrest.

An engineering geological site appraisal has been undertaken with preliminary subsurface investigations. GeoSolve Ltd visited the subject property with members of the Otago University Geology Department on 7 April 2016, undertaking geotechnical investigations comprising three test pits which were advanced to a maximum depth of 2.8 m. Scala Penetrometer tests were undertaken at selected locations at each test pit location advancing to refusal.

## 5 Subsurface Conditions

### 5.1 Geology

Porteous Hill, East Otago, New Zealand is a Miocene volcanic centre with sedimentary rocks at depth and the regional geology has already been described by others.

The published geological mapping indicates that Porteous Hill comprises layered rock types of the Dunedin Volcanic Group overlying sedimentary rock of both marine (e.g. Caversham Sandstone) and non-marine origin (i.e. Older Floodplain Conglomerate or Kaikorai Leaf Beds). Benson 1940<sup>1</sup> indicates that the volcanic rock of Porteous Hill are likely to be fed by volcanic vents rather than simply comprising remnants of more extensive capping lava flows. The location of deeper vents and the full extent of the volcanic rocks below the site is currently unknown.

At this preliminary stage, the site appears well suited to the proposed development from the geotechnical point of view, with volcanic rock available at shallow depth at two of the three turbine sites. Further investigations are required for detailed design and this work is planned as well as mapping of the spring flows and development of geotechnical and groundwater cross sections.

### 5.2 Groundwater

No groundwater seepage was observed in any of the test pits during investigations. The soils observed were predominantly dry to moist in condition. However, there are well known spring flows that emerge on the lower slopes of Porteous Hill and the groundwater system has been considered

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<sup>1</sup> *Landslides and Allied Features in the Dunedin District in Relation to Geological Structure, Topography and Engineering*, W.N. Benson 1940

in an unpublished thesis held by the University of Otago (Rekker 1991<sup>2</sup>) which describes a perched groundwater system summarised as follows:

The aquifer material is jointed olivine basalt, porous lapillistone and lapilli tuff, and an oxidised marine silty sand named the Green Island Loose Sand. Aquicludes are marine mudstones, infilled and cemented tuff-breccia, and phonolite intrusions. The aquifer is reported to be unconfined except at some of the lower margins. The aquifer is recharged by rainfall infiltrating through the soil in the upland fields of Porteous Hill. Recharge is likely to also occur through the Tertiary sedimentary rocks. Ground waters usually flow out of the aquifer as springs just above the lower contact of the aquifer rock types with the aquiclude rock types. The springs emerge from landslide debris on the SW side of Porteous Hill at about 200-220m elevation and also from the base of the volcanic rocks.

This illustrates that the soils/rock developed at crest of Porteous Hill is likely to be relatively permeable, with a very low probability of artesian groundwater conditions at depth (owing to the unconfined nature of the aquifer).

The permeability of the soil and rock types at the SE and NW turbine sites is expected to be relatively high and these materials are expected to represent the recharge area for the aquifers described by Rekker 1991. The soils at the NE turbine site are expected to be of lower permeability. Permeability testing can be readily carried out if required for the purposes of detailed design.

The groundwater system is understood to be a primary source of private water supply for the area, (however a previous public water reservoir is now understood to be redundant).

## 6 Discussion

### 6.1 Concerns relating to physical effects on the groundwater system

Some objections relate to concerns such as reduced groundwater flow, disruption to groundwater flow paths and changes to the locations and discharge rates of spring flows.

The objectors do not provide any specific details or arguments why the development would physically impede or alter groundwater flows. Many concerns appear to be based on an assumption that the foundations of the turbines will involve volumes or depths of concrete large or deep enough to physically affect the water flows or that the foundations will affect a fragile groundwater system. Some mention the possibility that the development could result in diversion of underground streams away from where they are presently utilized. At least one objector has specifically mentioned potential effects from vibrations during turbine operation.

The recharge catchment for the Porteous Hill groundwater system coincides with the access roads that will be required as well as the foundations of the turbines and transmission structures. We have considered the potential for foundations and access roads to affect the groundwater system in this zone of recharge as follows:

- Owing to the presence of rock at shallow depth, the foundations will most likely comprise 3 concrete pads of 11m diameter, founded at 2-3m depth. The likely concrete volume is therefore minor and we consider that there is no credible possibility that this will result in any disruption to groundwater infiltration. Percolation of groundwater is unlikely to be impeded as the areas of impermeable seal are limited and where present these can be

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<sup>2</sup> Rekker, Jens, "Hydrogeology and related geological aspects of Porteous Hill, East Otago, New Zealand," PGDipsci - 1991

designed to direct flow to the adjacent recharge zones, with no net reduction in rainwater infiltration. It therefore follows that the development will have no potential to reduce current spring flow volumes because there is no significant sealing of the recharge area upslope of the springs.

- The concrete placed will have no potential to influence the perched groundwater system at depth, as rainwater that infiltrates the volcanic rock at the crest of Porteous Hill will be largely conveyed to depth by the permeability of the fractured rock. The water then perches on low permeability layers below the volcanic rocks and is then conveyed to the areas of spring flow. As no part of the proposed structures will be at such depth, there is no physical impediment to the groundwater flow at depth and hence no mechanism by which the groundwater flows can be diverted or cut off by the proposed structures.
- In terms of potential effects from vibration, the turbine foundations are designed to accommodate cyclical loading associated with wind loading (as well as earthquake loading). The design requires that the subgrade is suitably stiff to accommodate such rocking motions to prevent structural failure of the turbines. Consequently the subgrade requirements include the need to confirm adequate stiffness. The sites are predominantly volcanic rock and hence not significantly susceptible to deformation under cyclical loading. In addition, the turbine foundations are not within the saturated zone of the aquifer (i.e. they are in the zone of recharge above) and hence any vibrations would not be within the saturated zone of the aquifer at depth. Blasting is not likely to be required and hence there is no potential for vibrations sufficient to impose any credible change to the transmissivity of the aquifer soils by densification/ consolidation.
- No groundwater draw from the aquifer is required to develop or operate the wind energy development.

## 6.2 Concerns relating to groundwater contamination

Some objectors perceive that groundwater contamination could occur as a result of the development. One objector is concerned that disturbance at the top of the hill could lead to pollution of spring water.

The recharge catchment for the Porteous Hill groundwater system coincides with the access roads that will be required as well as the foundations of the turbines and transmission structures. We have considered the potential for contaminants entering the groundwater system in this zone of recharge as follows:

- Apart from the access roads and turbine foundations, the development would result in minimal change of land use (i.e. we note that the area would continue be used for similar farming activities to those currently).
- The placement of concrete (even if deep piling or grouted anchors are required) has no potential to contaminate groundwater at depth as there are generally no toxins involved in standard cured concrete.
- There is some potential that accidental spills of diesel (and possibly other contaminants) could occur during the construction phase, however such matters would be straightforward to address, readily monitored and corrected with appropriate conditions of consent. We note that construction equipment and contaminants are regularly used in the recharge zones of aquifers. We therefore conclude that standard precautions during construction are likely to provide sufficient assurance and that this aspect can be managed.
- The turbines do rely on lubricants and potentially there may be some leakage. The manufacturer is likely to have measures to mitigate such a possibility, however a straightforward contingency would be to create a simple isolation bund as part of the

concrete pad structure with sufficient volume and correct placement to contain the volume of oil that could potentially leak. We assume that if such a spill were to occur, this would result in shut-down of the turbine and any oil or other contaminants can be cleaned up from within the containment bund. We recommend that the manufacturer should comment further on the possibility of oil or other chemical leakage and standard measures to prevent ground contamination.

- A full record of the chemicals that are required for operation of the turbines as well as during construction and future maintenance should be compiled, and an appropriate management plan developed to ensure that the chemicals cannot be released to ground.

### 6.3 Concerns relating to land instability

Several objections relate to uncertainty in regard to land instability. The Porteous Hill groundwater system is a major cause of the slope instability on the flanks of Porteous Hill. The crest of the hill where the turbines would be located is not however mapped as landslide according to Council hazard maps and comprises extensive volcanic rock. However, further consideration of slope stability has been recommended for detailed design, including drilling investigations to confirm stratigraphy at depth.

Whilst movement of the major landslides that surround Porteous Hill is likely in future, it should be noted that the wind energy development would not be located on the unstable soils and therefore there is no potential for the development to directly cause such slope instability.

## 7 Conclusions

- The proposed development is located within the zone of infiltration that recharges an unconfined aquifer at considerable depth below the crest of Porteous Hill.
- The shallow foundations and limited hardstanding proposed means that the development can be constructed without creating any physical impediments to rainwater infiltration or groundwater flow. Consequently the volume of spring flows is very unlikely to be affected by this development.
- The turbines would be founded on volcanic rock and hence there are no potential vibration effects that could have an adverse effect on the groundwater at depth.
- Precautions will be required to minimise the possibility of accidental chemical spills to ground during construction and future maintenance.
- Based on engineering geological mapping, slope stability considerations are not expected to affect the sites of the proposed turbines, however further confirmatory investigations are planned for detailed design, and if any concerns remain, consent conditions could readily include submission of satisfactory geotechnical inspection reports at each stage.
- In summary, our evaluation of this site has not revealed any plausible geotechnical or geohydrological issues that could be considered to place this project at significant risk of imposing any adverse effect, if normal standards of care are used during construction.

## 8 Applicability

This report has been prepared for the benefit of Blueskin Energy Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

GeoSolve Ltd

Geotechnical Engineering Consultants

Prepared by:

A handwritten signature in black ink, appearing to read "Mark Walrond".

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Mark Walrond

Senior Engineering Geologist

Reviewed by: Dr Graham Salt, Technical Director