

**Technical Appendix 8.8: Mining Risk Assessment**



# PROPOSED RAVENGILL WIND FARM

## MINING RISK ASSESSMENT (REVISED)

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PROPOSED RAVENGILL WIND FARM

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| Drawing 003: | 413.058096.00001-003 - Solid Geology After BGS –<br>(Sheet 15E Leadhills)               | 1:32,000 |
| Drawing 004: | 413.058096.00001-004 - Mining Features & Instability Zones<br>(R-A-G) Central Site Area | 1:10,000 |
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## 1.0 INTRODUCTION

- 1.1.1 Renewco Power Limited, through an SPV (Ravengill Energy Park Limited), is proposing to develop a wind farm in South Lanarkshire, known as Ravengill Energy Park. It is located in an upland area between Leadhills village to the east and the M74 motorway to the west. The proposed wind farm comprises 21 wind turbine generators (turbines) of approximately 6MW each capacity.
- 1.1.2 Historically, the Leadhills Estate was subject to lead and gold mining activity from the 16th century through to the 20th century and evidence of disused mines and mining-related assets are visible on and adjacent to the site. Abandoned mines and their associated mining assets may represent potential sources of ground instability (through potential collapse leading to surface subsidence) and soil and water contamination and represent risks to both the integrity of the permanent engineering works and construction health and safety.
- 1.1.3 Ravengill Energy Park Limited commissioned Wardell Armstrong LLP in 2024 to undertake an assessment of likely development constraints associated with historic underground and surface mining on the proposed wind farm site. An earlier draft of this report was issued in July 2024 in order to assist in the finalising of the turbine layout such that risks from relict mining hazards were mitigated during the design process. This has resulted in a reduction in the number of turbines and the adjustment of the site layout to that shown on Drawing No. **413.058096.00001-002 - Proposed Site Layout**. This shows the location and numbering of the turbines as of April 2026 and represents the finalised layout as per the Section 36 planning application.
- 1.1.4 The results of the assessment are presented in this report, including a summary of the underlying solid geology; the identification of mineral veins of economic importance; the history of mining at the site; and the identification of conjectured zones of potential surface instability associated with former underground mining and abandoned mine entries within the site. The potential for soil and water contamination arising from the former mining activities is also assessed in the report.
- 1.1.5 Although not within the current scope of the commission, comments are given on the following aspects:
- We consider that there is potential for the relict mining assets to represent features of industrial archaeological interest and recommend that this is considered at the Planning and Environmental Impact Assessment stage;
  - Taking into account the potential presence of economic minerals within the development site area, consideration should be given to the risk that the proposed wind farm development may represent in terms of potential mineral sterilisation.



## 2.0 GEOLOGICAL AND MINING SITUATION

### 2.1 Research sources

- 2.1.1 Desk study researches were limited to those necessary to make an assessment of potential instability issues associated with former mining activities, with regards to the proposed development and its infrastructure. The following research sources were utilised in the assessment of the site:
- British Geological Survey (BGS):
    - Solid geology mapping sheets NS81SE, NS81NE NS82SE, NS91NW, NS91NE, NS91SW at 1:10,000 scale;
    - Solid geology mapping sheet 15E at 1:50,000 scale and accompanying sheet memoir 'Geology of the Leadhills District' (2003);
    - Memoir - Special Report on the Mineral Resources of Great Britain, Vol. XVII "The Lead, Zinc and Nickel Ores of Scotland" 1921 published by the Geological Survey of Scotland;
    - BGS Geoindex web page and non- coal mining plans portal;
  - National Library of Scotland (NLS) historic maps web page for historic Ordnance Survey, County and other maps dating from 1654.
  - Historic Scotland Pastmap website: Royal Commission on the Ancient and Historic Monuments in Scotland (RCAHMS), Canmore search facility;
  - Mine plans and other documentation from the Hopetoun Papers Archive, held at Hopetoun House and communication with Richard Gillanders;
  - 'The Bailgill Mining District, N.E. Leadhills' a thesis submitted by Tom Vaughan for his PhD at the University of Strathclyde (1974);
  - 'Streaming and Hushing for Scottish Gold: The Archaeology of Early Gold Working at Leadhills and Wanlockhead' by John Pickin, Mining History: The Bulletin of Peak District Mines Historical Society (2004);
  - 'The Paragenetical Mineralogy of the Leadhills and Wanlockhead Lead and Zinc Deposits' – a thesis submitted by A. K. Temple for his PhD at the University of Leeds (1954);
  - 'Lead mines and associated remains, Leadhills' - Scheduled Monument Designation SM5817, Historic Environment Scotland;
  - 'Historic gold workings, Leadhills, South Lanarkshire' - Scheduled Monument Designation SM13677, Historic Environment Scotland;
  - Previous studies and report undertaken in 2015 by Wardell Armstrong for the proposed Harryburn Wind Farm (RWE Innogy UK Limited, Proposed Harryburn Wind Farm, Mining Desk Study Report, Ref. ED11607 April 2015);





- Other Wardell Armstrong/SLR in-house archives, including the GIS mining database for the Leadhills Estate (with the permission of Hopetoun Trust which owns Leadhills Estate and this database).

## 2.2 Site layout

- 2.2.1 The proposed wind farm is located in an upland area between the village of Leadhills and the M74 motorway. The site is naturally split into central, western and eastern areas by the valleys of Glengonnar Water and Elvan Water.
- 2.2.2 The layout of the proposed site is shown on Drawing No. **413.058096.00001-002 - Proposed Site Layout**. 13 No. turbines (Nos. T9 – T21) are planned on the central area of the site. This covers land between the Glengonnar Water to the northwest and the Elvan Water to the south, over the hills of Wellgrain Dod, Coom Dod, Ravengill Dod, Harryburn Brae and Mid Hill. A further 8 No. turbines (Nos. T1 - T8) are proposed to the west of Glengonnar Water on the hills of Brown Dod, Water Head and Hunt Law. Turbines were originally proposed over the area to the east of the Elvan Water on Leadburn Rig and Glen Ea's Hill but these have subsequently been omitted from the finalised turbine layout
- 2.2.3 The upland area where the turbines are proposed generally form flat-topped hills at elevations of 400m to 555m AOD (Wellgrain Dod). The area is dissected by relatively steep sided valleys leading to the main water courses of the Glengonnar Water to the northwest of the site area and the Shortcleuch Water and Elvan Water. These valleys are elevations of c. 300m to 350m AOD.

## 2.3 Geology

### *Superficial Deposits*

- 2.3.1 The BGS 1:50,000 scale mapping for the majority of the upland areas within the site indicate that these areas are devoid of superficial deposits, with bedrock being at or near surface. Areas of peat are recorded on Bulmer Moss, Peat Hill, Dun Moss, Black Hill and between the summit of Harryburn Brae and Glencaple Burn over the central area and Hunt Law, Rake Law and Brown Law over the western area. Smaller, scattered areas of glacial till are also recorded on the upland areas and are generally exposed in the headwaters of the watercourses with very occasional deposits of alluvium.
- 2.3.2 Along the valleys of Elvan Water and Glengonnar Water, alluvium is recorded and is generally underlain by glacial till with occasional areas of other, more diverse hummocky glacial deposits (moraine). Areas of peat are also recorded at Toddle Moss, along Elvan Water and north of Elvanfoot.
- 2.3.3 There are no records of made ground over the site area, although in the vicinity of the former lead mines, there are localised deposits of waste associated with the former lead mining, crushing, and smelting processes.



### *Solid geology*

- 2.3.4 The solid geology beneath the site comprises rocks of the Ordovician age (c. 450 million years old) which have been intensively folded along a northeast to southwest fold axis. The strata are also dislocated by major geological faulting along this same axis. The majority of the site is underlain by strata of the Portpatrick Formation, comprising greywakes (a type of sandstone) and shales (fine grained rock derived from muds). The limit of this formation is bounded by the Leadhills Fault to the northwest (outcropping in a line from close to Wool Law to Ravengill Dod) and the Fardingmulloch Fault to the southeast, outcropping along White Law and Louise Wood Law. An excerpt of the 1:50,000 scale geological map Sheet 15E (Solid) is shown on Drawing No. **413.058096.00001-003 Solid Geology After BGS - (Sheet 15E Leadhills)**.
- 2.3.5 To the northwest of the Leadhills Fault, strata of the Kirkcolm Formation, comprising greywackes, together with cherts (very strong silica rich rock) of the Crawford Group and the Moffat Shales are recorded. To the southeast of the Fardingmulloch Fault, strata of the Shinnal Formation, comprising sandstones and siltstones, are recorded.
- 2.3.6 Due to the intensive folding of the strata, the rocks tend to be very steeply dipping and potentially fractured. The Leadhills Imbricate Zone is a wide belt (c. 2km across) running parallel to the Leadhills Fault of highly displaced strata.

### *Mineralisation*

- 2.3.7 The mineralisation in the Leadhills – Wanlockhead area is found in mineral veins, covering an area approximately 3km wide and stretching for approximately 8km in a NE- SW direction, orientated parallel to the strike of the country rock. The veins are vertical or very steeply dipping and the majority strike north-northwest to south-southeast, with widths generally about 1m, although in some cases mineralised veins of up to 5m have been recorded.
- 2.3.8 It is recorded that the richest portion of the veins are present within the greywacke country rock of the Portpatrick Formation, due to the more brittle nature of this type of rock causing more open fracture lines forming when the rock was folded and thereby allowing increased percolation of mineral bearing solutions.
- 2.3.9 The primary ore to be found in the area is galena (lead sulphide) although sphalerite (zinc sulphide) has also been extracted in the area but to a much more limited extent. Chalcopyrite (copper sulphide) has also been recorded to be present, but only very rarely at an economic grade. Alluvial gold has also been an important economic mineral but has not been encountered in the veins themselves.





## 2.4 Mining

### Lead

- 2.4.1 The main area of recorded mining activity in the locality is around the villages of Leadhills and Wanlockhead to the south of the site area. The mines around these villages were very rich in lead with extensive underground workings and were operated virtually continuously from the 17<sup>th</sup> Century to 1934. Subsequently, there was a short period of working during the 1950's, however this was restricted to the Glencrieff area near Wanlockhead. In total, it is estimated that the area has yielded 400,000 tonnes of lead, 10,000 tonnes of zinc, 25 tonnes of silver and several tonnes of gold.
- 2.4.2 Within the site area, lead workings are recorded to some extent over all three areas of the proposed windfarm, generally within the southern parts of the areas. Workings are most extensive in the central area around Wellgrain Dod, Bulmer Moss and Long Cleuch, however, there are mine workings within the western and eastern areas that need to be taken into consideration. The workings are discussed further below, addressing the three areas separately.
- 2.4.3 Examination of the Ordnance Survey (OS) First Edition mapping (1859) indicates that, generally, mining activities over the site area were completed by that date. Some old shafts are recorded on the OS maps indicating the present of earlier workings, however, to obtain more comprehensive information on the mining it has been necessary to examine records pre-dating this time. These earlier workings also pre-date the legal requirement for the deposition of mine plans on the abandonment of a mine. As such, a number of records from the Hopetoun Papers Archive have been examined. This included a number of plans and mine sections primarily dating back to the 18<sup>th</sup> Century. Richard Gillanders, an archivist at the Hopetoun Estate and a geologist, formerly with the BGS, has assisted with this.

### Central area

- 2.4.4 Mining over the central area is also well documented in a thesis entitled 'The Bailgill Mining District, NE Leadhills' that was submitted by Tom Vaughan in 1974 for his PhD at the University of Strathclyde. It includes archive research and ground mapping of an area stretching from Leadhills village to Glencaple and covers the majority of the central area. A 1:2,500 scale plan is included in the thesis that summarises the data collected. The thesis generally corresponds with the geological and mining situation determined from the other records but provides a greater level of detail and confirms some of the mining features that were observed on the ground.



- 2.4.5 In summary, the following main veins have been identified on and in close vicinity to the proposed turbine locations within the central area. The alignment of these veins together with the locations of particular mining features such shafts, adits and spoil tips within the central area are shown on Drawing No. **413.058096.00001-004 - Mining Features & Instability Zones (R-A-G) Central Site Area** or the wider site on Drawing No. **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site**.
- Ripping Cleuch Vein and Straight Brae Vein – these two veins extend from Shortcleuch Water north along Ripping Cleuch to the east of Broad Law. Several shafts and adits are recorded, and the veins appear to have been extensively worked during the mid to late 18<sup>th</sup> Century over a distance of approximately 600m.
  - Middle Grain Vein – this vein extends beneath the area of moor between Wool Law and Bulmer Moss around the watercourses, Middle Grain and Well Grain. It trends approximately N to S with smaller secondary veins identified as Weirs Vein and Wellgrain Vein which trend parallel with the main vein. Several shafts and adits are recorded, with the workings recorded to extend over a distance of approximately 700m. Workings within this vein are thought to have ceased around 1760s.
  - Bulmer's Vein – this vein trends parallel to, but approximately 300m east of, Middle Grain Vein from Over Cleuch, beneath Bulmer Moss and trends towards Wellgrain Dod. The most northerly workings (known as Bulmer's Works) lie to the south of Wellgrain Dod, being accessed by a number of shafts (including Whitfield's and Ramage's Shafts) and three adits (levels) driven from the Wellgrain Burn. There are fairly large spoil tips associated with the levels, indicating that the vein has been worked quite extensively in this area during the late 18<sup>th</sup> Century and to a lesser extent during the mid-19<sup>th</sup> Century. Approximately 500m south, two shafts with associated spoil are recorded (Harries Shaft and Telfer Shaft), with a further shaft and drainage adit at the head of Over Cleuch which were driven at the beginning of the 19<sup>th</sup> Century. Records indicate that there has been extensive working in the vein from head of Over Cleuch to beyond Harries Shaft (a distance of approximately 700m).
  - Gold Scaurs Vein – this vein is recorded in the south of the area, with several old trial shafts, although from the small size of the spoil heaps, any mining was probably limited.
  - Long Cleuch Vein – this vein is located on the western bank of Long Cleuch Burn adjacent to where the burn meets the Shortcleuch Water. A drainage adit and a number of shafts are recorded on the vein, and it is understood that the vein was worked for both lead and copper. Several trial adits are recorded on the eastern side of the burn, although there is no record of more extensive mining.
  - Long Cleuch Head (or Bulmer's Gold) Vein - a number of old trial shafts have been sunk higher up Long Cleuch on the eastern bank of the burn. These are thought to have been sunk on a quartz vein, and although they are shown as 'Old Lead Mines' on the OS First Edition mapping, it is likely that these were primarily trial shafts.





- 2.4.6 In addition to the named veins there are a number of additional trial shafts and adits over the site area that are recorded, but do not appear to have intersected payable mineralisation and, as such, will only have limited extent. These include an adit driven into the south-western flank of Wellgrain Dod (Airs Drift) and trial shafts and a possible trial adit to the north-east of the summit of Wellgrain Dod.

*Western area*

- 2.4.7 The western area of the site is less extensively mined than the central area, however, the Susanna Vein, one of the most productive veins in the area, does extend into the southern corner of the site as shown on Drawing No. **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site**. The vein trends in a NW- SE direction and dips to the NE at c. 50 degrees. It is marked by a large area of surface workings, known as Lady Manners Scar, to the northwest of Leadhills village. Although the surface workings lie outside the site, extensive underground workings continue to the northwest, towards Glenkip Head. A shaft accessing the workings (Boundary Shaft) can be seen close to the ridgeline and is marked on mine plans and sections for the vein (see Figures A1 and A2 of Appendix A). The underground workings continue for a distance northwest beyond the shaft, but the vein appears to be cut off by a structural geological feature before reaching Glenkip Head, as trial levels driven from the head did not encounter the vein.

- 2.4.8 There are two obvious scars to the south of Water Head, shown as Gripps on the Ordnance Survey mapping. These extend up the hillside from the Glengonnar Water and may also be associated with similar features on the western side of the hill, above Glen Kip. These are probably prospecting features, known as 'hushes' – these were primarily used for prospecting for gold, but may also have been used for lead. There is an 'old inset' halfway down one of the scars marked on a plan from 1788 but this is likely to have been only a trial and there is no indication of any other underground workings or of a vein marked on any source.

*Eastern area*

- 2.4.9 The area to the east of the Elvan Water on Leadburn Rig and Glen Ea's Hill has subsequently been omitted from the finalised turbine layout, but information relating to it has been included in the final version of the report for the sake of completeness.
- 2.4.10 Recorded mining is not extensive over the Eastern area of the site and is limited to the area to the north of Glen Ea's Hill as shown on Drawing No. **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site**. The Glen Ea's Vein trends in a SE to NW direction from near the summit of Glen Ea's Hill towards the Shortcleuch Water. The vein was worked by a series of adits in the northern flank of the hill.



- 2.4.11 To the north of these workings, there are records of trial shafts being sunk along the watercourses at two locations. These were sunk during the 1920's and the 1930's and are thought to probably be southwards extensions of the Ripping Cleuch and/or Bulmer Veins. One of these shafts is open and has been fenced by the Leadhills Estate (Figure B6).
- 2.4.12 Two trial adits driven into the western flank of Leadburn Rig from Glen Aise, are also shown on a plan from 1773, although these are not recorded on the plan from the 1974 PhD Thesis.

**Gold**

- 2.4.13 The Leadhills and Wanlockhead area is also well known for the working of gold, with mining recorded to date back to the 16<sup>th</sup> Century. Sir Bevis Bulmer was a well-known and successful mining engineer and speculator, who developed gold mining in the area during the latter part of 16<sup>th</sup> and early 17<sup>th</sup> Centuries. Bulmer Moss on the southwestern boundary of the site is named after him, and he is also reported to have erected a stamp mill in Long Cleuch.
- 2.4.14 To date, extraction of gold in the area has primarily been from the mining of the alluvial deposits with workings being found along the various watercourses. Pickin (2004) states that there are three distinctive types of working to be found in the area:
- Alluvial workings;
  - Prospection hushes; and
  - Hushed openworks.
- 2.4.15 Alluvial workings are confined to the areas of alluvial deposits in the valley bottoms where the deposits have been removed to expose deposits of alluvial gold. These can be found extensively along Shortcleuch Water, but also towards the head of Long Cleuch. It is likely that the workings date to the 16<sup>th</sup> and 17<sup>th</sup> Centuries.
- 2.4.16 Prospection hushes comprise the use of a head of water suddenly released to remove the superficial deposits over a section of hillside, thereby exposing the underlying solid strata and hopefully allowing any previously hidden mineral veins to be seen. The water was collected using extensive systems of lades and stored in hushing dams before being released. It is known that hushing was used to explore for gold veins in the study area, but it is also thought that they may also have been used for lead vein exploration.
- 2.4.17 The eroded and disturbed ground around Goldscaurs in Shortcleugh is considered by Picken to be an area of hushed openworks, where water was used more continuously for the working of gold bearing deposits. Some of these features are shown Drawing No. **413.058096.00001-004 - Mining Features & Instability Zones (R-A-G) Central Site Area**.





### Other features

- 2.4.18 In addition to the features that have been recorded in the previous sections, the research has identified a number of features that appear to be mining related, lying outwith the expected mining area. These include:
- Two small lead smelting sites at the northern end of the site on the western bank of the Glencaple Burn. These are recorded on the Canmore database;
  - A mine shaft, adit and tip further up Glencaple Burn recorded on the 1974 PhD thesis.

The recorded locations of the above features are shown on Drawing No. **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site.**

### Site walkover

- 2.4.19 A walkover of the areas described above, and shown to have been more extensively mined, was undertaken by Martin Downing (an experienced mining engineer) for Wardell Armstrong on 17<sup>th</sup> and 18<sup>th</sup> June 2024. Weather conditions were fair with good visibility, allowing the visible mining features to be identified.
- 2.4.20 The area of the walkover covered Broad Law, Wellgrain Dod, Bulmer Moss, Long Cleuch, Over Cleuch, Middle Wood and Shortcleuch within the central area; Hunt Law, Glenkip Head and Water Head within the western area; and Glen Ea's Hill in the eastern area. Recorded and suspected mining features were inspected and had their approximate positions surveyed using a hand-held GPS (lateral accuracy c. +/-5m). The surveyed positions of these features are shown on Drawings Nos. **413.058096.00001-004 - Mining Features & Instability Zones (R-A-G) Central Site Area** and **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site.** Figures B1 to B6 contained within Appendix B illustrate some of mining features encountered.
- 2.4.21 Proposed turbine locations within the highest risk areas were also inspected, in order to ascertain if any further suspected mining features were visible. Over the central area, turbine locations T17 to T21 were inspected; and over the western area turbine locations T5 and, T8 were inspected.
- 2.4.22 The confidence in identifying particular features relates to the visible evidence that remains. This varies dependent on the nature of a feature, in particular as only one open feature was found due to the age of the mining and (no doubt) the relatively weak nature of the rock strata. A collapsed shaft is easily identifiable as a depression in the ground (usually 1 to 3m deep) often surrounded with a ring of spoil material; adits are more difficult to identify, but could often be discerned by a shallow, linear depression in the vicinity of a tabular spoil tip. Notwithstanding this, the potential always remains for mining related features to exist which have either not been recorded in the various mining and historical documents reviewed and / or which are not visible at the ground surface.



## 3.0 DEVELOPMENT CONSTRAINTS

### 3.1 Ground instability from historic mining

- 3.1.1 The site area contains evidence of historic mining activities relating primarily to the exploration and extraction of lead, and potentially other metals, from steeply dipping veins. Underground mining methods have mainly been used and the potential impact on the proposed development relates to ground instability that could affect development infrastructure (permanent and temporary works) and the health and safety of the construction operations, through the collapse of abandoned mine shafts, adits and near surface underground levels and workings.
- 3.1.2 The extraction of the lead ore from the veins would have involved the sinking of vertical shafts driven on or close to the steeply dipping vein. Levels would then have been driven in the vein between the shafts and the ore extracted by hand mining (usually up dip). The workings would have been worked as close to surface as possible as long as the vein was economic, resulting in the potential for workings to be at a very shallow depth below rockhead. The age of the workings generally predates the use of efficient pumping engines, so the down dip depth of the workings would be generally limited to a horizon at which a drainage level could be driven.
- 3.1.3 As has been mentioned previously, the most intense mineralisation is limited to the greywacke strata of the Portpatrick Formation, and this will generally act as a boundary to the area of mining activities across the site. The majority of the site is underlain by these strata, with only the turbines on the western area of the development being outwith this.
- 3.1.4 Despite the age of the workings and the lack of statutory abandonment plans, the availability of mining documents from the Hopetoun Papers Archive has enabled the recording of the mining activities carried out over the site area. The interpretation of the papers has been greatly assisted by the study and compilation of the records by Tom Vaughan for his 1974 PhD thesis.
- 3.1.5 The main mining area within the site lies within the Wellgrain Dod and Bulmer Moss area. It is known that relatively extensive workings have been carried out in the Bulmer's and Middle Grain Veins to the south of the summit of Wellgrain Dod. The site layout has been amended to remove proposed turbines from within the most intensively mined area, however, turbines T20 and T21 are located close to the mining area and would require suitable mitigation. The extent of the workings appears to be defined by the presence of the known shafts, however, it is possible that workings extend to the north beneath Wellgrain Dod, although the presence of trial workings tends to suggest not.
- 3.1.6 To the east of Bulmer Vein, mining is much less extensive. Recorded mining features are limited to localised trial workings which should be more easily mitigated.





- 3.1.7 Over the western area of the site, the turbine locations appear to be outwith land that has been extensively mined; however, the alignment of access tracks still needs to be considered carefully. This is particularly the case at Glenkip Head in the western area, where underground workings in the Susanna Vein have the potential to undermine the access track to turbines T6 – T8, although the currently proposed layout avoids this critical area. Although it is recorded that the central area has been used for alluvial mining, and there is evidence of such workings, these are of a lesser ground stability risk than underground workings. There is, however, the potential for areas of unconsolidated re-worked deposits that are unlikely to be suitable as founding horizons for turbines or associated infrastructure.

### 3.2 Drainage adits

- 3.2.1 The lowest adit along a vein would act as a drainage level for the mine workings and there are a number of these over the site area. The most significant of these with regards to the proposed development is the drainage level for the Bulmer Vein that discharges into the Well Grain Burn. The adit itself has collapsed, although the increase in water flow into the burn at its most likely conjectured location indicates that the workings are likely to be flooded.
- 3.2.2 The drainage level on the Long Cleuch Vein has also collapsed near to its tail (entrance) with a considerable water flow issuing from a shaft upstream of the adit tail.
- 3.2.3 It is possible that these water discharges contain elevated levels of heavy metals, although the watercourses themselves on the site are likely to have naturally elevated levels of metals arising from the geology of the area.

### 3.3 Spoil tips and contamination

- 3.3.1 Due to the age and relatively small scale of the workings, waste material from the mining activities appears to be generally localised to the proximity of the shafts and adits. It is likely that this spoil will have arisen mainly from the excavation of the shaft or adit itself and is country rock or low-grade ore. Subsequently, the ore extracted from the vein would have been sorted initially underground and only the material that appeared to contain payable grades of lead transported to surface. Once on the surface, rich pieces of ore would have been picked out and the remainder 'dressed' by crushing and washing to remove the galena from the waste to form an ore concentrate. This concentrate would then be smelted to form lead ingots.
- 3.3.2 Notwithstanding the above it is likely that any spoil tips will have some levels of lead, and quite likely, other heavy metal contamination. As mentioned above, dressing of the lead ore is also likely to have been undertaken in the vicinity of the shafts and adits resulting in areas of soil contamination. Due to the proximity of the mining areas to watercourses, it is possible that the tips are contributing to elevated levels of heavy metals within the watercourses.



- 3.3.3 The smelting of the lead concentrate was generally carried out at the smelter in Glengonnar, particularly during the later years of the mining operations. It is possible, and this would seem to be confirmed by the presence of the smelting sites recorded in Glencaple, that small smelting sites associated with early mining, or more remote veins could be present on the site. These are, however, likely to be very small in area and are not considered to be a significant development constraint.





## 4.0 CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Ground instability

4.1.1 Based on the available information, a preliminary ground instability risk assessment has been carried out and is presented in accordance with a Black – Red – Amber – Green system ('BRAG map'). Due to the localised nature of individual features, the approximate extent of zones has been specified along veins and general areas of known mining. The potential risk zones have been categorised as follows:

- Green – the presence of mineralisation is not expected and there is a very low likelihood of mining having taken place. There is a negligible to low risk of ground instability due to former mining activities.
- Amber – there is the potential for mineralisation and localised exploration features are present but more extensive mining is not recorded and not expected. There is a low to medium risk of ground instability from former mining activities.
- Red – mining and/or exploration features are recorded in the vicinity with a high likelihood of additional features being present. There is a medium to high risk of ground instability from former mining activities.
- Black – extensive mining recorded, and numerous mining features present are recorded and visible on site. There is a high to very high risk of ground instability from former mining activities.

4.1.2 The approximate extents of the above zones are shown on Drawings Nos. **413.058096.00001-004 - Mining Features & Instability Zones (R-A-G) Central Site Area** and **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site** and have been defined based on the presence of the recorded mining features identified in Section 2 of this report and an assessment of the geological and mining situation of the area. Standoff zones around the features have also been included within the zones, dependent on the level of activity (mining/exploration) within the zone.

4.1.3 Due to the steeply dipping nature of the veins and of the workings, any treatment of more extensive workings by infilling or grouting is likely to be impractical (without excessive cost) and may result in contamination of groundwater discharges flowing from the former drainage levels. It is possible that treatment by infilling or excavation may be practicable for individual mining features such as trial shafts or adits that are not connected to further workings.

4.1.4 It is recommended that the following mitigation measures are considered for each of the risk categories identified:

- Green – no mining specific investigation or mitigation is required. The ground investigation should be designed to confirm the soil and rock bearing characteristics at turbine locations and provide data for earthworks design etc. During construction, all excavations for the turbine bases and infrastructure should be inspected by an experienced mining engineer/engineering geologist

with experience in relict mining hazards to ensure that no unrecorded mining related features are present. Construction health and safety plan and methods of works to consider relict mining hazards.

- Amber – a site-specific assessment of the mining setting should be allowed for in the site investigation to confirm the geological and mining situation beneath the proposed turbine or infrastructure. This may include targeted intrusive site investigations such as trial trenching and/or rotary drilling to ensure relict mining features are not present at surface or underground that could cause ground instability. The recommendations for inspection by an experienced mining engineer/engineering geologist with experience in relict mining hazards during construction (as identified in the Green category), should also be allowed for. Construction health and safety plan and methods of works to consider relict mining hazards.
- Red – wherever possible, turbine installations and infrastructure should be avoided and relocated outwith the Red zone. If relocation is not possible, comprehensive targeted intrusive site investigations should be undertaken to ensure relict mining features are not present at surface or underground that could cause ground instability. Inspection by an experienced mining engineer/engineering geologist with experience in relict mining hazards during construction (as identified in the Green category), should also be allowed for. Construction health and safety plan and methods of works to consider relict mining hazards.
- Black – turbine installations and infrastructure should be avoided in these areas

4.1.5 Based on the above general recommendations and Drawings Nos. **413.058096.00001-004 - Mining Features & Instability Zones (R-A-G) Central Site Area** and **413.058096.00001-005 - Mining Features & Instability Zones (R-A-G) Whole Site**, Table 4.1 provides a summary of the mining risk for the individual turbine locations and associated infrastructure together with specific mitigation. Further to the re-design of the turbine layout, no turbine is currently proposed within the Red or Black risk zones.

**Table 4.1: Preliminary Risk Assessment for Turbine Locations and Infrastructure**

| Turbine No. | Recorded mining features                      | Site walkover summary findings<br>(N/A – area not inspected during walkover) | Preliminary 'BRAG' Assessment |        | Specific mitigation recommendations         |
|-------------|-----------------------------------------------|------------------------------------------------------------------------------|-------------------------------|--------|---------------------------------------------|
|             |                                               |                                                                              | Turbine                       | Access |                                             |
| T1          | None                                          | N/A                                                                          | GREEN                         | GREEN  | N/A                                         |
| T2          | None                                          | N/A                                                                          | GREEN                         | GREEN  | N/A                                         |
| T3          | None                                          | N/A                                                                          | GREEN                         | GREEN  | N/A                                         |
| T4          | None                                          | N/A                                                                          | GREEN                         | GREEN  | N/A                                         |
| T5          | Potential surface workings (Gripps) recorded. | Extensive potential surface workings to S and                                | AMBER                         | AMBER  | Site specific mining assessment for turbine |





| Turbine No. | Recorded mining features                                       | Site walkover summary findings<br>(N/A – area not inspected during walkover) | Preliminary 'BRAG' Assessment |        | Specific mitigation recommendations                                    |
|-------------|----------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------|--------|------------------------------------------------------------------------|
|             |                                                                |                                                                              | Turbine                       | Access |                                                                        |
|             |                                                                | E of turbine location.                                                       |                               |        | location and access track.                                             |
| T6          | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T7          | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T8          | Trials for Susanna Vein c. 500m E at Glenkip Head and 300m SW. | No obvious visual mining features at turbine location.                       | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T9          | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T10         | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T11         | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T12         | Trial workings c. 400m to SW.                                  | N/A                                                                          | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T13         | None                                                           | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                    |
| T14         | Trial workings c.500m to SW.                                   | N/A                                                                          | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T15         | Trial workings c.200m to E.                                    | N/A                                                                          | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T16         | Trial workings c.250m to SE.                                   | N/A                                                                          | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T17         | Long Cleuch Head trial workings c. 300m to SE.                 | No obvious visual mining features at turbine location.                       | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T18         | Long Cleuch Head trial workings c. 300m to W.                  | No obvious visual mining features at turbine location.                       | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. |
| T19         | Long Cleuch trial workings c. 300m to N.                       | No obvious visual mining features at turbine location.                       | AMBER                         | AMBER  | Site specific mining assessment for turbine                            |



| Turbine No. | Recorded mining features                               | Site walkover summary findings<br>(N/A – area not inspected during walkover) | Preliminary 'BRAG' Assessment |        | Specific mitigation recommendations                                                                                   |
|-------------|--------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------|
|             |                                                        |                                                                              | Turbine                       | Access |                                                                                                                       |
|             |                                                        |                                                                              |                               |        | location and access track.                                                                                            |
| T20         | Within area of trials for Bulmer Vein (pits and adits) | N/A                                                                          | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track. Likely to require targeted site investigation. |
| T21         | Bulmer East Vein c. 200m to W.                         | No obvious visual mining features at turbine location.                       | AMBER                         | AMBER  | Site specific mining assessment for turbine location and access track.                                                |
| Met mast    | Long Cleuch trial workings c. 500m W                   | No obvious visual mining features at met mast location                       | AMBER                         | AMBER  | Site specific mining assessment completed and mast erected (Nov 2025)                                                 |
| Sub-station | None                                                   | N/A                                                                          | GREEN                         | GREEN  | N/A                                                                                                                   |

- 4.1.6 It should be noted that the mining risk assessment is specific to the turbine and infrastructure locations detailed in this report layout and any changes to this will require additional assessment. It is also possible that any required improvements to adopted highways may also impact on recorded or unrecorded mining features and that specific mitigation measures may be necessary.

## 4.2 Contamination

- 4.2.1 As stated in Section 3 of this report, it is likely that spoil tips and other areas of contamination will be associated with the main areas of mining and, as such, are likely to be avoided due to the potential ground instability risk. Notwithstanding this, areas of spoil and other made ground are not suitable for providing suitable founding formations and would require removal with the subsequent handling and waste licensing implications.
- 4.2.2 Any disturbance of the material may also cause re-activation of the contaminants and increased levels of pollution. Any change to the drainage of the site, due to access track construction etc. should consider areas of mining wastes, as increased runoff could cause exacerbation of existing pollution of the watercourses.

