



Technical Appendix 8.6: Mining Stability Report including Past Mining Risk Assessment

Dalfad Wind Farm

Brockwell Energy Limited

The Eagle Building, Third Floor, 19 Rose Street, Edinburgh, EH2 2PR

SLR Project No.: 413.057968.00001

Proposed Windfarm Development, Glenmuir, East Ayrshire

Mining Stability Report Including Past Mining Risk Assessment

August 2023



JWHROSS

CONTROL SHEET

CLIENT: Brockwell Renewable Solutions Ltd
PROJECT TITLE: Proposed Windfarm Development, Glenmuir, East Ayrshire
REPORT TITLE: Mining Stability Report including Past Mining Risk Assessment
PROJECT REFERENCE: 156227/GL/J/R1

Original Issue	Issue 1 Final	Name		Signature		Date
	Prepared by	Stuart Tennant Mining Engineer		Signed copy held on file		24/08/2023
	Checked by	Dave Milne Principal Mining Engineer		Signed copy held on file		24/08/2023
	Approved by	Alan Blair Partner		Signed copy held on file		24/08/2023
Update Record	Issue	Date	Status	Description	Signature	
	2				Prepared By	
					Checked	
					Approved	
	3				Prepared By	
					Checked	
					Approved	
	4				Prepared By	
					Checked	
					Approved	

This document has been prepared in accordance with the Fairhurst Quality and Environmental Management System and in accordance with the instructions of the client, Brockwell Renewable Solutions Ltd, for the client's sole and specific use. Any other persons who use any information contained herein do so at their own risk. Any information provided by third parties and referred to herein has not been checked or verified by Fairhurst unless otherwise expressly stated within this report.

Unless otherwise agreed in writing, all intellectual property rights in, or arising out of, or in connection with this report, are owned by Fairhurst. The client named above has a licence to copy and use this report only for the purposes for which it was provided. The licence to use and copy this report is subject to other terms and conditions agreed between Fairhurst and the client.

JWH Ross is the trading name of Fairhurst Group LLP, a limited liability partnership registered in Scotland with the registered number SO307306 and registered office at 43 George Street, Edinburgh EH2 2HT.

CONTENTS

1.0	Title.....	1
2.0	Instructions	1
3.0	Limitations	1
4.0	Subjects.....	1
5.0	Researches	2
6.0	Background Geology.....	2
7.0	Past Mining.....	4
7.1	Underground workings	4
7.2	Opencast (Surface) Workings	6
8.0	JWH Ross Past Mining Risk Assessment.....	6
8.1	Definition	6
8.2	Recorded Mine workings.....	7
8.3	Unrecorded Mine Workings.....	7
8.4	JWH Ross Risk Rating	8
9.0	Results of Research	8
9.1	Area 1.....	8
9.2	Area 2.....	9
9.3	Area 3.....	9
9.4	Area 4.....	10
10.0	Future Mining	11
11.0	Old Pit Shafts/Adits	11
12.0	Concluding Remarks.....	14

Appendices

Appendix 1 – Drawing No. 156227/9001 – Site Location Plan

Appendix 2 – Drawing No. 156227/9002 – Composite Geological Plan

Appendix 3 – Drawing No. 156227/9003 – Composite Site Plan – Area 2

Appendix 4 – Drawing No. 156227/9004 – Composite Site Plan – Area 3

Appendix 5 – Drawing No. 156227/9005 – Composite Site Plan – Area 4

Appendix 6 – Drawing No. 156227/9006 – Mine Entry Location Plan

Appendix 7 – Drawing No. 156227/9007 – Mineral Stability Risk Plan

1.0 Title

Report relative to the mining stability under and adjacent to the site of a proposed windfarm development at Glenmuir, East Ayrshire (including Past Mining Risk Assessment).

2.0 Instructions

This Report has been prepared by JWH Ross as instructed by the Client, Brockwell Renewable Solutions Ltd; email instruction dated 20th July 2023 refers.

The extent of past mining in minerals other than coal, e.g., ironstone, fireclay and limestone, within Central Scotland is considerable, and often overlooked. This report addresses mining stability in relation to all mineral extraction. It is particularly noted that subsidence damage caused by the extraction of minerals other than coal is not covered by the Coal Mining (Subsidence) Act 1991.

This Report includes a Past Mining Risk Assessment, as may be required under the Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008, where a project is located within a Coal Mining Development Referral Area.

3.0 Limitations

This Report is for the private and confidential use of the Client(s) for whom the Report is undertaken and should not be reproduced in whole or in part, or relied upon by third parties for any use whatsoever. JWH Ross accepts no duty or responsibility (including negligence) to any party other than the stated Client(s) and disclaims all liability of any nature whatsoever to any such party in respect of this Report.

The Report is based on the geological and mining records at present available. The contents of the Report are believed to be accurate but since mining records and information for this District may be incomplete, we cannot accept responsibility for any insufficiency or inaccuracy in the information provided.

We must advise that this Report only examines the solid geology and associated minerals; it is not to be construed as inferring that the engineering or chemical properties of the natural or man-made superficial deposits are satisfactory or otherwise, since these latter matters are outwith the scope of our Brief.

4.0 Subjects

The Subjects comprise approximately 720 hectares of land at Glenmuir to the immediate east of Lugar, East Ayrshire. The site is bound to the north and west by the A70 Muirkirk Road, the south by the Glenmuir Water and east by forestry and agricultural land. The site predominantly comprises the former Duncanziemere, Dalfad and Gasswater opencast Collieries. The site area is shown outlined in red on appended Drawing No. 156227/9001 and is approximately centred on National Grid co-ordinates NS 62320 21566. At the time of reporting, we understand that the current proposals relate to the development of a new windfarm including turbines, working areas and associated access roads.

For the purposes of this assessment we have considered the Subjects in several discrete areas as indicated on appended Drawing Number 156227/9001 and 9007. These areas have been determined based the risk attributable to factors including the underlying geology, evidence of past mineral extraction and likelihood of unrecorded extraction which may affect the future surface stability.

5.0 Researches

In connection with this investigation we have researched and taken into account information from the undernoted sources:-

- Published geological maps, including:
 - County Series Ayrshire XXX SW, Ayrshire XXXVI NW Ayrshire XXXVI SW
 - National Grid Series NS 61 NW and NS 62 SW.
- Historical Ordnance Survey topographical maps prepared to scales of 1:2500 and 1:10560
- Memoirs of the Economic Geology of the Ayrshire Coalfields Area III, published in 1930 and Memoirs of the Economic Geology of the Ayrshire Coalfields Area IV, published in 1932
- Abandonment plan catalogues, mine plan records and previous mineral investigation Reports held in the mining Archives of JWH Ross
- Non-confidential borehole data held by the British Geological Survey
- Previous Mineral Investigation Reports and borehole records held in the Archives of JWH Ross.

6.0 Background Geology

According to published geological information, the Subjects are underlain by solid strata belonging to several rock formations passing from the oldest unit, namely the Strathclyde Group of the Calciferous Sandstone Series, through the Carboniferous Limestone Series, The Passage Formation (Millstone Grit) and into the Lower Coal Measures or the Carboniferous Period. The sedimentary strata generally dip towards the west with the younger rock formations at the western side of the site. The aforementioned published records also infer that areas of the site are underlain by later igneous rocks, which have been intruded into the surrounding sedimentary strata.

We have shown the Geological setting and outcrop positions of principal mineral seams as derived from the National Grid Series Geological Plans (NS 61 NW and NS 62 SW) on appended Drawing No, 156227/9002. A general description of each of these rock formations and mining operations undertaken within them is given below as derived from the Economic Memoirs for the District, mining records and the published geological mapping, with detailed findings in each of the separate areas of the site described in section 8 of this report.

The aforementioned geological plans infer that the continuity of the strata across the site has been considerably disrupted due to a number of geological faults that traverse through the area under review. We have shown the line of these faults as derived from the National Grid Series Geological Plans on appended Drawing No. 156227/9002.

We should explain the nature of geological faults and the uncertainties which attend their precise position underground and at the surface. Faults are planes of movement about which adjacent blocks of rock strata have moved relative to each other. They are seldom vertical and commonly consist of zones, perhaps up to several tens of metres wide, containing several fractures. The portrayal of faults as a straight line is therefore a generalisation.

In order that the geological setting underlying the site may be better appreciated, we have explained below the nature of each of the geological formations as derived from available published mapping and the Economic Memoirs for the District.

Lower Coal Measures

The rocks of the Lower Coal Measures are sedimentary in nature and comprise cycles of sandstones, mudstones and siltstones with numerous seams of coal. Particular to the subjects, only the lower part of the sequence of the Lower Coal Measures are inferred to be present beneath the northernmost corner of the site near Welltrees. The lowest significant mineral horizon of the Lower Coal Measures, namely the Lugar Blackband Ironstone is inferred to outcrop in the north of the site on an approximate north to south trend before being truncated against a fault.

Passage Formation (Millstone Grit)

The Passage Formation lies between the Lower Coal Measures and the Upper Limestone Formation and generally does not contain any economically important seams. The formation comprises mainly sandstones with fireclays, blaes and subsidiary seams of Coal and Ironstone. According to the Economic Memoir for the District, the Passage Formation in the Gasswater area is estimated to be in the region of 60 fathoms (110 metres) in thickness. The memoir notes *"With regard to coal seams, none has recorded a thickness of exceeding 2 feet. The Ironstones are also thin. The economic possibilities of both of these must be rated as poor"*. This eludes to the lack of development of any mineral horizons within the sequence and therefor the lack of economic prospects.

Upper Limestone Formation

The Upper Limestone Group is inferred to be present in a band trending north-east to south-west through the central area of the site. Throughout Scotland, the formation is known to contain economically significant mineral horizons however, published geological records suggest that the group is devoid of coal seams at this locality. The Economic Memoir for the District notes that in the Gass Water District *"No coal seams of economic importance have been proved in the Upper Limestone Group of this area. Limestones are exposed in several streams, these do not seem to be worked to any great extent"*.

The lack of significant mineral horizons explained in the Memoir is reflected on published geological plans with no outcrop positions recorded.

Limestone Coal Formation

The Limestone Coal Formation outcrops on the east of the Upper Limestone Formation on a similar trend. This sequence of rocks contains sandstones, siltstones, mudstones, marine limestones and coal seams. In order that the relationships between each mineral horizon in the Limestone Coal Formation may be better appreciated, we have shown below, in tabular form, the general succession together with the approximate depth to the principal seams as identified in the Gass water area. The Index limestone, which defines the boundary between the Upper Limestone Formation and Limestone Coal Group, has been taken as a convenient datum. This section is given as a rough guide only since the thickness of the seams and strata intervals can vary considerably over distance.

Seam	Approx. Depth (m)
<i>Index Limestone</i>	<i>0 - relevant datum</i>
<i>Main Gasswater Coal</i>	<i>11</i>
<i>Lower Gasswater Coal</i>	<i>27</i>
<i>Thirty Inch Coal</i>	<i>36</i>
<i>Six Foot Coal</i>	<i>40</i>
<i>Mc Donald Limestone</i>	<i>49</i>

Notably, the sequence of the Limestone Coal Formation is significantly thinner in the Gass water District than elsewhere in the Ayrshire area. The Economic Memoir for the District notes *“The limestone Coal Group as a whole and the individual coal seams are much reduced in thickness (than in the wider area)”*.

Only two of the abovementioned horizons attain any significant thickness in this area. The Main Gasswater coal is a group of several coals interbedded with sedimentary strata and totals approximately 4.0 metres in thickness.

The underlying Lower Gasswater Coal is also split into leaves with three coals present over a total thickness of 3.2 metres. We have shown the outcrop positions of the Main and Lower Gasswater Coals as derived from the National Grid Geological Plans on Appended Drawing No. 156227/9002.

Lower Limestone Formation

Underlying the Limestone Coal Formation, the Lower Limestone Formation attains a thickness of approximately 13 metres in the Gass water area. This formation is again less developed in this locality than in the wider Ayrshire mineral field with the Economic Memoir for the District noting no significant coal seams having been recorded. At the base of the formation there is a 6 metre thick group of limestones known as the Hawthorn limestones which is the only notable mineral horizon hereabouts.

Strathclyde Group and Inverclyde Group (Calciferous Sandstone Series)

These formations are formed mainly of yellow sandstones, siltstones and mudstones with occasional volcanic intrusions and are not known to contain any significant mineral horizons of past economic importance within the District.

Igneous Rocks

In addition to the sedimentary strata underlying the site, the area around Duncanziemere is inferred to be underlain by Intrusive igneous rocks of the Western Midland Valley Westphalian to Early Permian Sills. These rocks are noted to be composed of Quartz-microgabbro and were intruded into the surrounding sedimentary strata. We have shown by means of green shading on appended Drawing No. 156227/9002, the recorded extent of these igneous rocks as derived from the National Grid Series Geological Plans.

Under such circumstances, where intruded igneous rock is juxtaposed against much older sedimentary strata, it commonly results in the surrounding rock becoming heat affected and its mineralogy altered. Where this strata contains coal seams and other workable minerals, the resultant effect of the foregoing alters their characteristics, often reducing their quality and leaving them largely uneconomical to extract.

7.0 Past Mining

7.1 Underground workings

This section of the report gives an overview of past underground and surface (opencast) mining in the area under review. Detailed findings for each area of the site are given in section 9 below.

Past underground mining has been undertaken in the District within mineral seams belonging to the Scottish Lower Coal Measures and Limestone Coal Formation from the nearby Welltrees, Hillhead Moss, Gasswater, Stonebriggs and Cairnhill Collieries. The workings took place during various periods of time dating from the mid 1800s. Particular to the site, exploitation of the seams thereunder was conducted using both the stoop and room and longwall methods of mining.

We should explain that where the Stoop and Room system of mining is employed, passageways, or rooms as they are called, are driven more or less at right angles to each other through the seam,

which is thus formed into square or rectangular blocks or stoops. At a later stage as much as possible of the seam in the stoops is normally removed, but because the removal of a stoop in its entirety is an extremely difficult and dangerous procedure, part of the seam was generally left intact to support the roof at the time and safeguard the workmen. While these remaining stoops can continue to perform this function for an indefinite period, their edges may ultimately break down, resulting in collapse of the adjacent bridging strata and causing varying degrees of subsidence movement of the ground surface. The magnitude of surface effects diminishes with increasing depth and eventually ceases to reach the surface due to bulking of the collapsed strata.

Where the Longwall method is utilised the seam is completely extracted and the strata overlying the mined area is allowed to collapse. As a result thereof, subsidence of the ground surface is usually complete shortly after the extraction of the seam. Access roadways are provided and maintained through the worked out area, but these roadways quickly collapse after maintenance of them ceases, except in the case of workings at shallow depths where, depending on the nature of the superincumbent strata, they may remain intact for a considerable period after the cessation of workings. In such cases when the old underground roadways eventually collapse, isolated plump holes or sits may appear on the surface ground.

Our search of Abandoned Mine Plan Catalogues, "Unsigned" Mining Plans held by the Coal Authority and records held within the Archives of JWH Ross has revealed plan records pertaining to workings extending under or within influencing distance of the Subjects in two mineral horizons, namely, the Lugar Blackband Ironstone and the Main Gasswater Coal.

We have shown the recorded extent of the shallow workings in the abovementioned seams on appended Drawing Nos. 156277/9003 to 156227/9005.

We should point out, however, that the winning and working of the minerals in this District commenced an extremely long time ago, before it became a statutory requirement to keep plans of mines (1850) and to lodge with the Secretary of State all plans of abandoned mines (1872). Consequently, the plan record information at our disposal may be incomplete and the possibility that early uncharted workings may have taken place must be fully considered.

In this regard, the Economic Memoir for the District notes of the Lugar Blackband Ironstone "*In this area (Old Cummnock, Lugar, Cronberry and Darncorner) the Ironstone has now been totally worked out, or proved unworkable*". The foregoing suggests that where present, the aforementioned seam will have been explored as a workable prospect.

Nevertheless, published geological plans suggest that the seam is only present in a limited area in the north of the site and there are recorded workings within the horizon at this locality. As such, we consider the probability of workings beyond the limit of that which is recorded in the Lugar Blackband Ironstone underlying the Subjects is unlikely.

In reference to the Main Gasswater Coal, the aforementioned Memoir, published in 1930, states "*In the past, the coals were exploited at their outcrops in the Gass Water and south therefrom. Most of these workings were abandoned over fifty years ago and no plan of them are known to us, so that their extent is impossible to estimate. It is most probable, however, that the majority of the pits were shallow, and the workings of small extent*". Given this evidence, the possibility that the Main Gasswater Coal has been worked by early uncharted means beyond the recorded limit of extraction towards its outcrop position remains likely.

The Memoir suggests that the other coals in the Limestone Coal Group were found to be of limited thickness in the area and as such efforts to extract them may be unlikely.

7.2 Opencast (Surface) Workings

In addition to the abovementioned underground workings, we are aware that the minerals beneath the site have been worked by opencast extraction methods until as recently as the early 2010s. The operations were conducted via the former Duncanziemere, Dalfad, Gasswater and Powharnal opencast sites. The sites of the opencast operations have subsequently undergone a programme of restoration, resulting in the current topography.

We have been unable to obtain full completion records for these workings and limited plans have been obtained from the Coal Authority. We understand that the opencast workings excavated the seams of the Limestone Coal Formation, passing through the old workings in the Main Gasswater Coal before extracting the Lower Gasswater Coal and underlying Thirty Inch, Six Foot and Mc Donald Coals.

We have shown the approximate plan extent of these opencast works on appended Drawing Nos. 156227/9003 to 156227/9005 as derived from the available plans and information currently at our disposal. We note that much of the shallow underground workings recorded in the Main Gasswater Coal are indicated to have been excavated by the opencast operations.

In addition to the abovementioned opencast workings, historical topographical and Geological Plans infer that surface quarries exist in the eastern part of the site. These small scale surface workings are understood to have excavated the Hawthorn Limestone. Additionally, the Economic Memoir for the District notes *“The upper worked part (of the Limestone) is not now visible here, but commencing a short distance south of the Gass Water, and continuing to the Glenmuir Burn, an extensive Limestone working existed in it”*. We have shown the approximate line of outcrop of the Hawthorn Limestone on appended Drawing No. 156227/9004.

As a general comment, in the context of mineral stability, the presence of opencast workings is, in many regards, a more favourable process of extraction with regard to later development. The total extraction of the underlying coal seams from surface removes all of the coal and with it, the possibility of any residual instability mining risk relating to underground workings. The potential for settlement in areas of former opencast is therefore predominantly related to the characteristics of the backfill material or restoration works rather than the upward migration of belated mineral subsidence from mineworkings at depth.

While we have records of the extent of extraction we don't have any records or documentation in respect to the subsequent reclamation works and are not in a position to comment on the suitability thereof or otherwise.

8.0 JWH Ross Past Mining Risk Assessment

8.1 Definition

“Risk” is a combination of the likelihood of an “occurrence” and the assessment of the severity of the consequences. This can be discussed with reference to a variety of scenarios, i.e., risk to life, risk to property and risk of financial loss.

The magnitude of risk relative to each scenario will depend on a number of factors (such as accessibility to personnel, existence of structures or the interruption of services). In addition the perception of risk will depend on such considerations as the background knowledge of the persons involved and the degree of their involvement.

The assessment of risk to proposed or existing surface development from subsidence effects due to historic mining is a difficult process requiring significant professional judgement and experience. This

process is complicated by the fact that the information needed to make an assessment with a high degree of confidence is incomplete and involves uncertainty.

Unless otherwise stated, the JWH Ross risk rating of potential mining subsidence makes the following presumptions that the risk:

- is derived from underground mineral workings (including coal)
- excludes the risk of mine entries (covered separately in our separate section on old shafts and adits)
- relates to typical residential development
- excludes likelihood of occurrence within a timeframe

8.2 Recorded Mine workings

Where “Abandonment” or “Unsigned” mine plan record information exists, the principal contributing factors that influence the assessment of potential future mining subsidence are:

- The thickness of the mineral
- The inclination of the strata
- The extraction height of the workings
- The number of seams worked and any interaction between them
- The mining technique utilised
- The extraction ratio
- Roof conditions
- The date of the workings
- The extent of mine workings and the perceived accuracy thereof
- The layout of the workings in relation to the proposed development
- The thickness and nature of overlying rock strata
- The thickness and nature of overlying superficial deposits
- The condition of the working (void, collapsed, partially collapsed)
- The influence of geological faults and igneous intrusions
- Information obtained from boreholes

8.3 Unrecorded Mine Workings

Early mining was somewhat secretive due to lack of legislation regarding the keeping of plan records and rivalry between mining companies. Early mining was also generally at shallow depth in the best and thickest seams.

Under the “Past Mining” section of the Coal Authority Report may be/is contained the sentence *“However you may wish to know that the property is in an area where coal is believed to exist at or close to the surface that may have been worked at some time in the past”*. This is a direct reference to

the possible presence of unrecorded extraction, i.e., workings that may have taken place prior to the time that it became a statutory requirement to keep or lodge Abandonment Plans.

An assessment of the potential for shallow unrecorded workings to exist must take into account additional wider ranging information sources and factors, including but not limited to:

- The degree of economic importance of the relevant seams to the early mineral operators
- Local thickness and quality of the seam(s) in question
- Evidence that may be obtained from plan record information in the wider surrounding area, e.g., did the up-dip recorded workings encounter “old waste”?
- The position of known old pit shafts and adits in the locality in relation to geological structure and recorded/unrecorded mining
- Borehole data on a wider basis providing information on the thickness and quality of the seam

8.4 JWH Ross Risk Rating

For the specific purposes of this Report, we have adopted the categories of high, moderate and low, to represent a simplified risk assessment of potential instability due to past mining activity. The sections of the site to which these categories apply are shown by means of red hatching (high risk), blue hatching (moderate risk) and green hatching (low risk) on the appended Drawings. Sections with negligible or no risk are unhatched.

These categories are based on:

- a) a scale of likelihood of an abandoned underground mine working (recorded or unrecorded) being present within critical depth, beneath or within lateral influencing distance of the route. Critical depth is normally taken to equate to overlying rock strata being 10 times the extraction height, however, this can vary considerably due to the influence of other factors, e.g., the method of extraction.
- b) the estimated depth range expressed as the thickness of overlying rock strata in relation to the extraction height.

9.0 Results of Research

Our account of past mining and interpretation of the geological structure pertaining to the principal seams that influence the assessment of mineral stability is set out below. To facilitate our description of underlying conditions, we have considered the Subjects in several discrete areas numbered 1 - 4 as indicated on appended Drawing Nos. 156227/9001 and 9007. These areas have been determined based on the risk attributable to factors including the underlying geology, evidence of past mineral extraction and likelihood of unrecorded extraction which may affect the future surface stability.

9.1 Area 1

Area 1 is located in the southern part of the site and forms a large triangular shape extending to the north-west, bound by the conjectured lines of two faults which are indicated to displace the strata down to either side of Area 1. We have shown the approximate locations of these faults on appended Drawings No. 156227/9002

Published geological plans infer that Area 1 is underlain by the Strathclyde Group, which is not known to contain any economically significant mineral horizons. We have found no plan records of any mineral extraction having taken place beneath this area and have no evidence to suggest that any early unrecorded mining will have taken place.

In line with the foregoing, Area 1 is considered to have negligible risk from a mineral stability aspect.

9.2 Area 2

Area 2 is located in the westernmost part of the site and is bound to the east by one of the aforementioned faults leading to Area 1, and to the north by the extension of the fault which displaces the strata down on the northern side.

The strata in this area are inferred to dip to the north-west at a gradient of approximately 1 in 5. Published geological plans suggest that the area is underlain by the Strathclyde Group, through the Lower Limestone Formation, Limestone Coal Formation and Upper Limestone Formation. The aforementioned Rock formations being mapped at rockhead from east to west respectively. According to the National Grid Geological Plan, the Main Gasswater Coal outcrops through Area 2 on an approximate north-east to south-west trend at the approximate position shown on appended Drawing Nos. 156227/9002 and 9003.

In addition to the sedimentary strata, Area 2 is inferred to be underlain by intrusive igneous rocks, covering large parts of the area. We have shown the extents of the igneous rocks as derived from the National Grid Series Geological Map on appended Drawing Nos. 156227/9002 and.

We have found no plan record of any underground workings within area 2. The area has however been subject to surface workings related to the Duncanziemere Opencast Mine. We have shown on Drawing No. 156227/9003 the recorded extent of the opencast operations as derived from plan No. 18356. We understand that the opencast pit extended from the south, gaining depth to the north with the highwall adjacent to Dancanziemere Farm.

The area of the open cast appears to extend from the inferred outcrop position of the Main Gasswater Coal which would suggest that this was the mineral seam targeted for extraction.

We understand that the opencast site has since undergone backfilling and restoration, resulting in the current topography and loch. We have no records as to the restoration process and as such cannot comment on the make-up or suitability of the backfill.

In terms of mineral stability risk, with the lack of underground workings, we have placed Area 2 in the category of negligible. The hazards posed by the restored opencast site are of a geotechnical nature and require separate consideration.

9.3 Area 3

Area 3 occupies the central part of the site and is characterised by numerous geological faults on approximate east to west trends. Similarly to Area 2, the strata underlying Area 3 pass through the Strathclyde and Inverclyde formations, Lower Limestone Formation, Limestone Coal Formation, Upper Limestone Formation and Passage Formation, from east to west respectively. The strata hereabouts are indicated to dip to the north-west at an approximate gradient of 1 in 4.

The National Grid Series Geological Plan infers that Main Gasswater Coal will outcrop through the centre of Area 3 on an approximate north to south trend at the approximate positions shown on appended Drawing Nos. 156227/9002 and 9004. Given the general succession of strata in the District, we would anticipate that this is underlain by the Lower Gasswater Coal, however this is only mapped to

a limited extent, again shown on the aforementioned drawings. Considering the prevailing strata dip towards the north-west, we would expect that the aforementioned seams will be present beneath the Subjects at their outcrop positions and to the north-west thereof.

Extensive recorded underground workings have taken place in Area 3 to extract the Main Gasswater Coal, we have shown the recorded limit of shallow workings within the seam on appended drawing No. 156227/9004. Coal Authority records indicate that recorded workings in the Main Gasswater Coal are known to extend deeper further to the west, however plans at our disposal only detail the shallow workings shown.

Our research has revealed no plan records of any other mineral horizons having been extracted from beneath area 3. As mentioned in section 7 however, the Economic Memoir for the District suggests that operations to extract the Main Gasswater Coal may extend beyond the recorded limit of extraction in early unrecorded shallow workings to its outcrop position.

In addition to the abovementioned underground workings, Area 3 has also been subject to subsequent opencast operations from the Dalfad and Gasswater opencast sites. Plans pertaining to the opencast workings infer that the operations passed through much of the shallow workings in the Main Gasswater Coal and also excavated coals including the Lower Gasswater Coal and underlying Thirty Inch, Six Foot and Mc Donald Coals. We have shown on appended Drawing No. 156227/9004 the understood limit of the opencast operations in Area 3.

Similarly to Area 2, we understand that the opencast site has since undergone a programme of restoration works, resulting in the current topography. We have no records as to the restoration process and as such cannot comment on the make-up or suitability of the backfill.

The National Grid Geological Plan suggests that historic quarrying of the Hawthorn Limestone has taken place along the eastern part of Area 3 as outlined in section 7 of this report. We have shown the approximate location of these quarries as derived from the aforementioned geological plan on appended Drawing No. 156227/9004.

In terms of mineral stability risk, we have placed parts of Area 3 where we anticipate recorded or unrecorded shallow workings in the Main Gasswater Coal to remain present outwith the extents of the opencast operations or at the edges thereof in the Category of High. Where opencast operations have been undertaken, with the removal of underground workings, we have placed these areas in in the category of negligible. As previously mentioned, the hazards posed by the restored opencast site are of a geotechnical nature and require separate consideration.

To the immediate west of the opencast operations, we are apprehensive that where the workings in the Main Gasswater coal extend westward beyond the limit of opencast extraction, there may be an insufficient thickness of superincumbent strata intervening between the roof of any workings, and the base of superficial deposits to prevent the effects of any belated mineral subsidence from manifesting at surface level. We have placed these areas in the category of Moderate Risk, lowering to Low risk towards the west as the seam attains depth in accordance with the prevailing strata dip.

We have shown these designated risk areas on appended Drawing No 156227/9007.

9.4 Area 4

Area 4 is located at the far north of the site and is again inferred to be underlain by a number of geological faults, which are shown on the National Grid Geological Plan to trend in a north-west to south-east direction. The strata in this area are inferred to dip towards the north-west.

Published geological records suggest that solid strata underlying Area 4 predominantly belong to the Limestone Coal Formation in the east of the Area, through the Upper Limestone Formation and The Passage Formation, with the western part of the Area underlain by the Scottish Lower Coal Measures.

The Main Gasswater Coal is shown to outcrop in the north-eastern corner of the Area with the conjectured outcrop truncated against geological faults. Considering the prevailing strata dip to the north-west, it follows that the Main Gasswater Coal will be present to the north-west of these outcrop positions within the block of strata.

The Lugar Blackband Ironstone is inferred to outcrop in the west of the area on an approximate north-south trend, as shown on appended Drawing No. 156227/9005. Again, considering the prevailing strata dip towards the north-west, it follows that the aforementioned seam will be present at shallow depth to the west of the indicated outcrop position.

Our search of Mine Plan Records has revealed that the Lugar Blackband Ironstone has been worked up to its corresponding outcrop position from the former Welltrees Colliery, using the longwall method of mining. We have shown the recorded extent of these workings on appended Drawing No. 156227/9005. Where workings in the Lugar Blackband Ironstone underlie the site, we are apprehensive that there may be an insufficient thickness of superjacent strata intervening between the roof of any workings, and the base of superficial deposits to prevent the effects of any belated mineral subsidence from manifesting at surface level. In line with the foregoing, we have designated this area as High Risk.

We have found no plan record of underground workings in the Main Gasswater Coal in Area 4 and have seen no evidence of unrecorded extraction in this area. The limited presence of the seam and prevalence of faulting in this area may have hindered any attempts to extract the Main Gasswater Coal at this locality, however a lack of site specific borehole data prevents us from completely ruling out unrecorded workings, albeit the prevalence of faulting in this area may have been prohibitive to local opportunistic workings. In line with the foregoing, the areas indicated to be underlain by the Main Gasswater Coal at shallow depth have been designated as Low Risk.

We have shown the designated risk areas on appended Drawing No. 156227/9007.

10.0 Future Mining

It is our understanding that there is no underground mining presently taking place under or in proximity to the routes. On the basis of current economics, available technology and planning regulations, we consider that the possibility of underground mining can be ruled out in the foreseeable future

11.0 Old Pit Shafts/Adits

Our research in respect to the Subjects has identified the position of some 27 no. mine entries indicated to lie within or within influencing distance of the site boundary. The mine entries comprise a combination of both shafts and adits, and many are noted to correspond with the recorded underground workings referenced in Sections 7.0 and 9.0.

The Coal Authority identifies these mine entries within the site, assigning them a reference number corresponding with their internal archive system. We have shown by means of crossed brown circles (shafts) and brown arrows (adits), the approximate locations of these mine entries as derived from the relevant mine plans and at positions as indicated by the Coal Authority using the reference numbers provided by the Coal Authority, on appended drawing No. 156227/9006. It should be noted that where adits are shown, the orientation of the corresponding symbol indicates the approximate azimuth of the roadway from surface.

A list of mine entries indicated to be positioned within or within influencing distance of the site, together with their approximately coordinated location, is detailed within the table below:

<u>CA Reference</u>	<u>Type</u>	<u>Name</u>	<u>Orientation/ Azimuth</u>	<u>Approx. Coordinates</u>
262623-005	Adit	Old Mine	212	262780, 623410
*262623-014	Adit	Cairnhill No. 2 Mine	291	262645, 623077
*262623-015	Adit	Cairnhill No. 1 Mine	293	262656, 623045
262621-001	Shaft	Hillhead Moss Old Shaft	Vertical	262308, 621929
262621-002	Shaft	Hillhead Moss Old Shaft	Vertical	262633, 621540
*262622-001	Shaft	Gaswater Old Shaft	Vertical	262699, 622971
*262622-002	Shaft	Gaswater No. 9 Shaft	Vertical	262632, 622863
*262622-003	Shaft	Gaswater Old Shaft	Vertical	262785, 622878
*262622-004	Shaft	Gaswater no. 6 Shaft	Vertical	262722, 622802
*262622-005	Shaft	Gaswater Old Shaft	Vertical	262804, 622826
*262622-006	Shaft	Gaswater Old Shaft	Vertical	262807, 622857
*262622-007	Shaft	Gaswater Old Shaft	Vertical	262812, 622820
*262622-008	Shaft	Gaswater No. 26 Shaft	Vertical	262616, 622548
*262622-009	Shaft	Gaswater No. 27 Shaft (Dalfid Pit)	Vertical	262419, 622355
262623-002	Shaft	No 2 Shaft	Vertical	262918, 623778
*262623-003	Shaft	No 1 Shaft	Vertical	262910, 623540
262623-004	Shaft	Old Shaft	Vertical	262812, 623413
262623-006	Shaft	Old Shaft	Vertical	262841, 623312
262623-007	Shaft	Old Shaft	Vertical	262860, 623297
262623-008	Shaft	Old Shaft	Vertical	262865, 623289

<u>CA Reference</u>	<u>Type</u>	<u>Name</u>	<u>Orientation/ Azimuth</u>	<u>Approx. Coordinates</u>
*262623-009	Shaft	Old Shaft	Vertical	262637, 62327
*262623-010	Shaft	Old shaft	Vertical	262611, 623207
*262623-011	Shaft	No 13 Shaft	Vertical	262545, 623228
*262623-012	Shaft	No 2 Shaft	Vertical	262442, 623249
262623-013	Shaft	Old Shaft	Vertical	262117, 623347
262624-008	Shaft	Air Pit	Vertical	262889, 624278
262624-009	Shaft	Air Pit	Vertical	262817, 624138

*Mine entries marked with an asterisk fall within the subsequently opencast areas.

We have insufficient information to comment on the actual ground position or the present integrity of any of the mine entries listed above. Consequently, we consider that the approximate position of each shaft or adit shown on appended Drawing No. 156227/9003 and its immediate environs should be regarded as a potential source of instability.

We would note that 10 of the inferred mine entry positions fall within the extents of subsequent opencast mining. While we have no confirmation, we consider it likely that these may have been partially or wholly excavated during the opencast mining.

We have no knowledge of any measures taken to secure any of the shafts referenced in the table above at the time of abandonment, however we should advise that it was not uncommon to only partially infill such features when mining operations ceased. Subsequently, the filling in the shaft may collapse as the superficial deposits gain entry thereto, often taking the form of a large cone shaped depression, with the shaft itself positioned at its centre. The final diameter of this cone of collapse (zone of influence) is dictated by a number of factors, but predominantly by the nature of the superficial deposits and the depth to rockhead at the individual shaft's locus.

While an adit does not conform to the same collapse mechanisms as a shaft, the surface subsidence effects are often broadly similar. The surface area affected by such a feature is restricted to the position of the mine mouth, extending along the direction of the corresponding roadway as it increases in depth until a sufficient thickness of superincumbent strata is present atop to prevent a collapse manifesting at surface. The potential zone of influence attributable to such a feature begins at the recorded position of the adit and traverses laterally across the site in the direction of its recorded azimuth.

In order to make more specific comment on the possibility of movement arising from a possible collapse of any of the mine entries referenced above, we would recommend that, in the first instance, a further and more extensive search be undertaken to determine the originating plan source of the feature; this in an attempt to confirm the correctness of the plotted position.

Thereafter, and in normal course of events, site investigations are usually required to prove the exact ground position of the mine entry; such investigations comprising either probing or trenching of the

ground surface to locate the feature and possibly followed by drilling to prove both the thickness and nature of the superficial deposits thereat together with the method of treatment (if any) adopted at the time of abandonment.

In the context of any proposed development, we would recommend in the first instance that roads and structures are positioned to avoid the areas suspected to be underlain by mine entries.

12.0 Concluding Remarks

Our overall past mining assessment has placed areas of the site in the relative risk categories of Low, Moderate and High. Our research in respect to the past mining history at the site has revealed that the minerals hereabout have been subject to extraction by both underground and surface mining methods.

In the context of mineral stability, cognisance need be taken of the potential presence of shallow mineworkings occurring within influencing depth of the surface. In this regard, we should advise that the upward transmission, nature and extent of subsidence movement is directly related, amongst other factors, to the extraction height, inclination of the strata, method of mining, percentage extraction, degree of natural consolidation of the wastes and the thickness, nature and bulking factor of the overlying deposits.

The information at our disposal infers that the Lugar Blackband Ironstone has been worked at shallow depth up to its outcrop position in the north of the site in Area 4, as shown on appended Drawing No. 156227/9005. In this area, we are apprehensive that the thickness of superincumbent rock strata intervening between the roof of the underground workings in the aforementioned seams and rockhead will be insufficient to preclude the risk of belated mineral subsidence manifesting at surface. In line with the foregoing, the area of the Subjects underlain by these workings has been designated High Risk.

Published geological plans also infer two areas that may be underlain by the Main Gasswater Coal at shallow depth in Area 4. While we have no evidence of the seam being worked here, a lack of confirmatory boreholes in this area prevent us from ruling out unrecorded workings, albeit the prevalence of faulting here may have been prohibitive to localised opportunistic workings. These areas, as shown on appended Drawing 156227/9007, have been designated Low Risk.

Mine plans and records also indicate that the Main Gasswater Coal was subject to underground workings throughout Area 3, with workings likely to extend up to the corresponding outcrop position as shown on Appended Drawing No 196227/9002.

In addition to the foregoing, information at our disposal indicates that there has been extensive opencast workings undertaken throughout Area 2 and Area 3 as shown on Drawing Nos. 157226/9003 to 9005. This is indicated to have excavated much of the shallow remnant workings in the Main Gasswater Coal through Area 3 and strata understood to have been previously unworked in Areas 2.

Again, in the context of mineral stability, the presence of opencast workings is, in many regards, a more favourable process of extraction with regard to later development. The total extraction of the underlying coal seams from surface removes all of the coal and with it, the possibility of any residual instability mining risk relating to underground workings. The potential for settlement in areas of former opencast is therefore predominantly related to the characteristics of the backfill material rather than the upward migration of belated mineral subsidence from mineworkings at depth.

Areas inferred to be underlain by the Main Gasswater Coal, outwith the indicated extent of the Opencast workings, have been designated High Risk. Areas on the western fringes of the opencast workings in Area 3 have been designated moderate risk, transitioning to low risk as the seam gains

depth towards the west in accordance with the prevailing strata dip. This is due to uncertainty surrounding the exact extent to which the Main Gasswater Coal was excavated, and the possibility of underground workings being present with insufficient intact rock cover to prevent belated mineral subsidence from manifesting at ground level.

Belated mining subsidence takes many forms and depends on a number of factors (see previous Section 8.0). Generally, where workings are present at, or close to the seam outcrop, subsidence at the surface may manifest itself in the form of plump-holes or deep depressions. With an increase in rock cover above the workings, subsidence takes the form of wider and shallower saucer-shaped depressions, accompanied by compressive and tensile strains.

Our assessment of the past mining history at the Subjects and corresponding stability risk have been informed by the information available at present which is notably lacking in site specific borehole records to confirm conditions are as inferred.

In the context of any proposed development, given the size of the study area and the complexity of the geological structure at the site locus, we recommend that in the first instance, development proposals should look to avoid areas identified as being at risk. Where development is proposed in areas with an identified risk, the mineral position beneath the Subjects be confirmed by means of boreholes.

Such investigations should be designed in recognition with any development proposals and seek to establish, where applicable;

- The limit and condition of recorded underground mineworkings, and cover thickness of intact strata overlying them,
- The limits of opencast extraction with particular reference to the location of the high walls and the transition from in-situ rock strata to opencast backfill.
- Confirmation of the absence of unrecorded mineworkings within areas of shallow coal that are beyond the limit of recorded extraction.
- The surface position of any mine entries deemed to occur within influencing distance of the development proposals, the depth to rockhead at the entry locus and the condition and nature of any infilling. (See section 11.0 – Old Pit Shafts/Adits)

Any such mineral investigation proposals should be developed in accordance with existing information and undertaken under the design and supervision of an appropriately qualified mining engineer.

As previously mentioned, we are unaware of the nature and efficacy of the restoration undertaken at the opencast site and cannot comment on the suitability of the backfill materials. A geotechnical assessment of these areas should be undertaken ahead of any development.

N.B. for Old Pit Shafts see Section 11.

Appendix 1

Drawing No. 156227/9001 – Site Location Plan



Do not scale from this drawing.

Rev.	Date	Description	Drawn	Checked	Approved
------	------	-------------	-------	---------	----------

Client: _____ Project Title: _____



**PROPOSED WINDFARM
DEVELOPMENT, GLENMUIR,
EAST AYRSHIRE**

Drawing Title:
SITE LOCATION PLAN

This plan is based on the Ordnance Survey map with the permission of the controller of His Majesty's Stationary Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings.

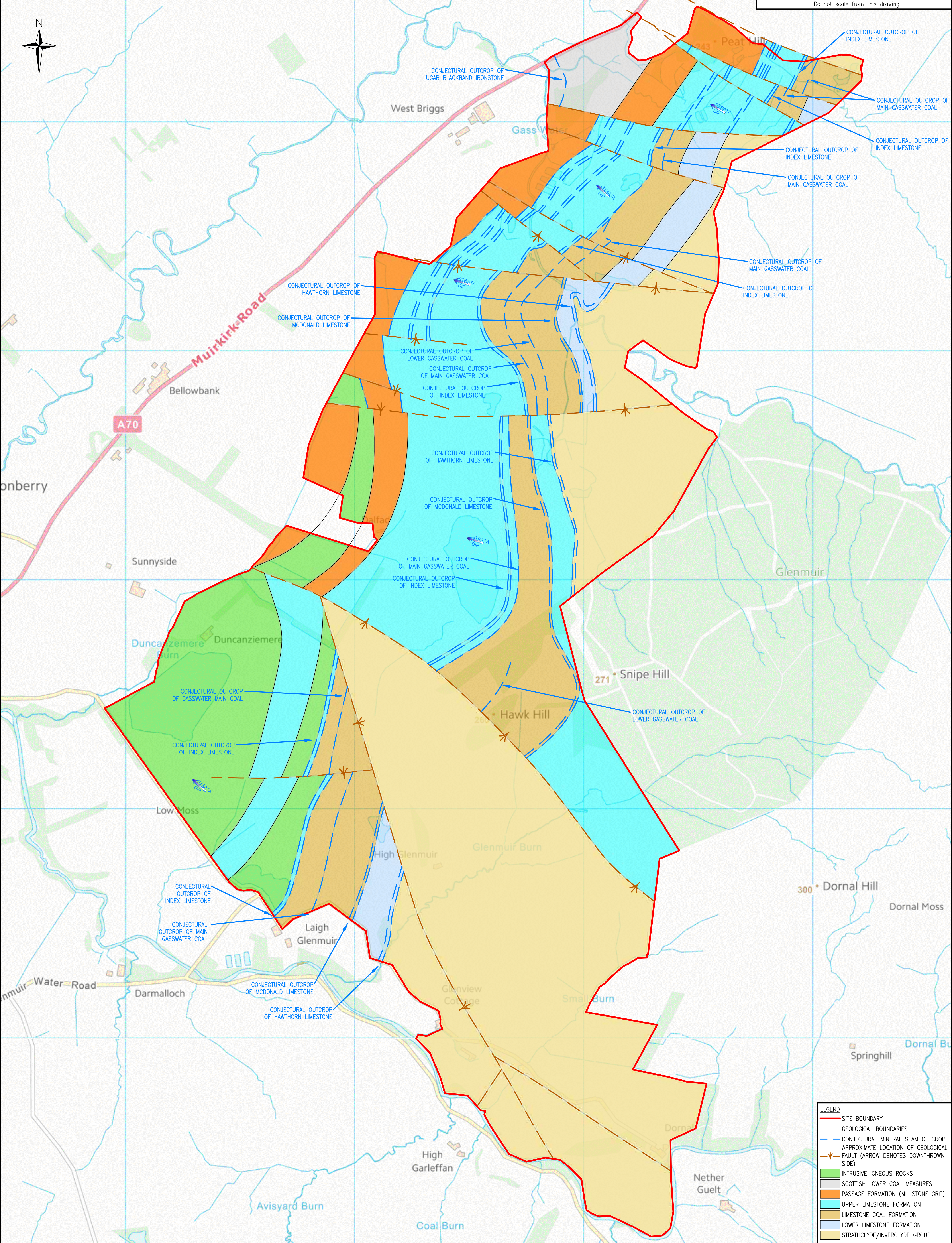


4th Floor, Toy House, 300 Bath Street,
GLASGOW, G2 4JR
Tel: 0141 285 8700

Scale at A4: NTS		Status: For Report	
Drawn: CMCC	Checked: ST	Approved: DM	
Date: 15/08/23	Date: 15/08/23	Date: 15/08/23	
Drawing No.: 156227/9001			Revision: —

Appendix 2

Drawing No. 156227/9002 – Composite Geological Plan



LEGEND

- SITE BOUNDARY
- GEOLOGICAL BOUNDARIES
- CONJECTURAL MINERAL SEAM OUTCROP
- APPROXIMATE LOCATION OF GEOLOGICAL FAULT (ARROW DENOTES DOWNTHROWN SIDE)
- INTRUSIVE IGNEOUS ROCKS
- SCOTTISH LOWER COAL MEASURES
- PASSAGE FORMATION (MILLSTONE GRIT)
- UPPER LIMESTONE FORMATION
- LIMESTONE COAL FORMATION
- LOWER LIMESTONE FORMATION
- STRATHCLYDE/INVERCLYDE GROUP

Rev.	Date	Description	Drawn	Checked	Approved				

Notes:

Client:

 **brockwell energy**

Project Title:

PROPOSED WINDFARM DEVELOPMENT, GLENMUIR, EAST AYRSHIRE

Drawing Title:

COMPOSITE GEOLOGICAL PLAN

JWHROSS

4th Floor, Tay House, 300 Bath Street,
GLASGOW, G2 4JP
Tel: 0141 285 8700

Scale at A1:
1:7500

Status:
For Report

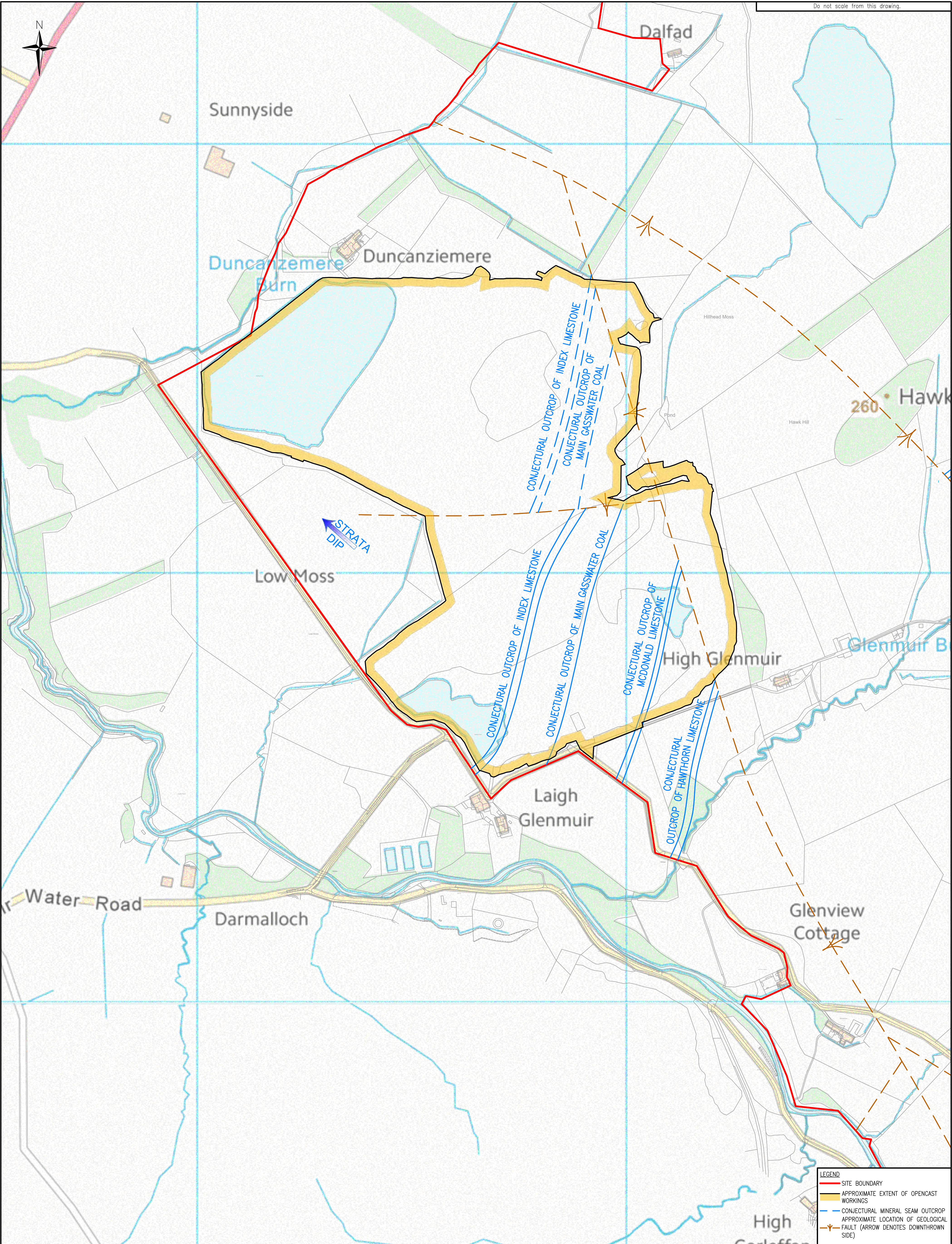
Drawn: CMCC	Checked: ST	Approved: DM
Date: 15/08/23	Date: 15/08/23	Date: 15/08/23

Drawing No.: 156227/9002

Revision: —

Appendix 3

Drawing No. 156227/9003 – Composite Site Plan – Area 2



Rev.	Date	Description	Drawn	Checked	Approved

Notes:

Client:



Project Title:
PROPOSED WINDFARM
DEVELOPMENT, GLENMUIR,
EAST AYRSHIRE

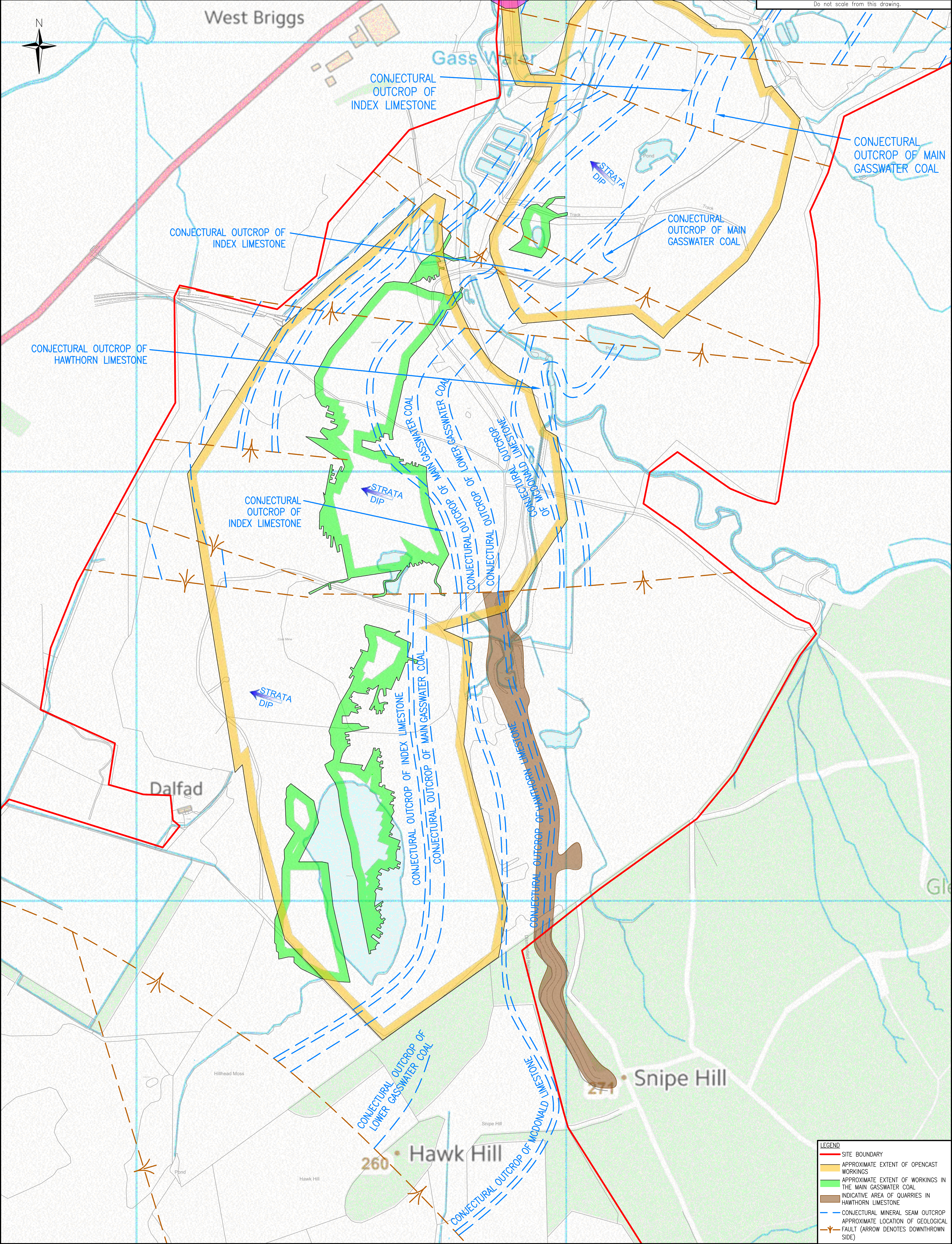
Drawing Title:
COMPOSITE SITE PLAN
– AREA 2

JWHROSS
4th Floor, Toy House, 300 Bath Street,
GLASGOW, G2 4JR
Tel: 0141 285 8700

Scale at A1: 1:4000	Status: For Report	
Drawn: CMCC	Checked: ST	Approved: DM
Date: 15/08/23	Date: 15/08/23	Date: 15/08/23
Drawing No.: 156227/9003		Revision: –

Appendix 4

Drawing No. 156227/9004 – Composite Site Plan – Area 3



Rev.	Date	Description	Drawn	Checked	Approved

Notes:

Client: 

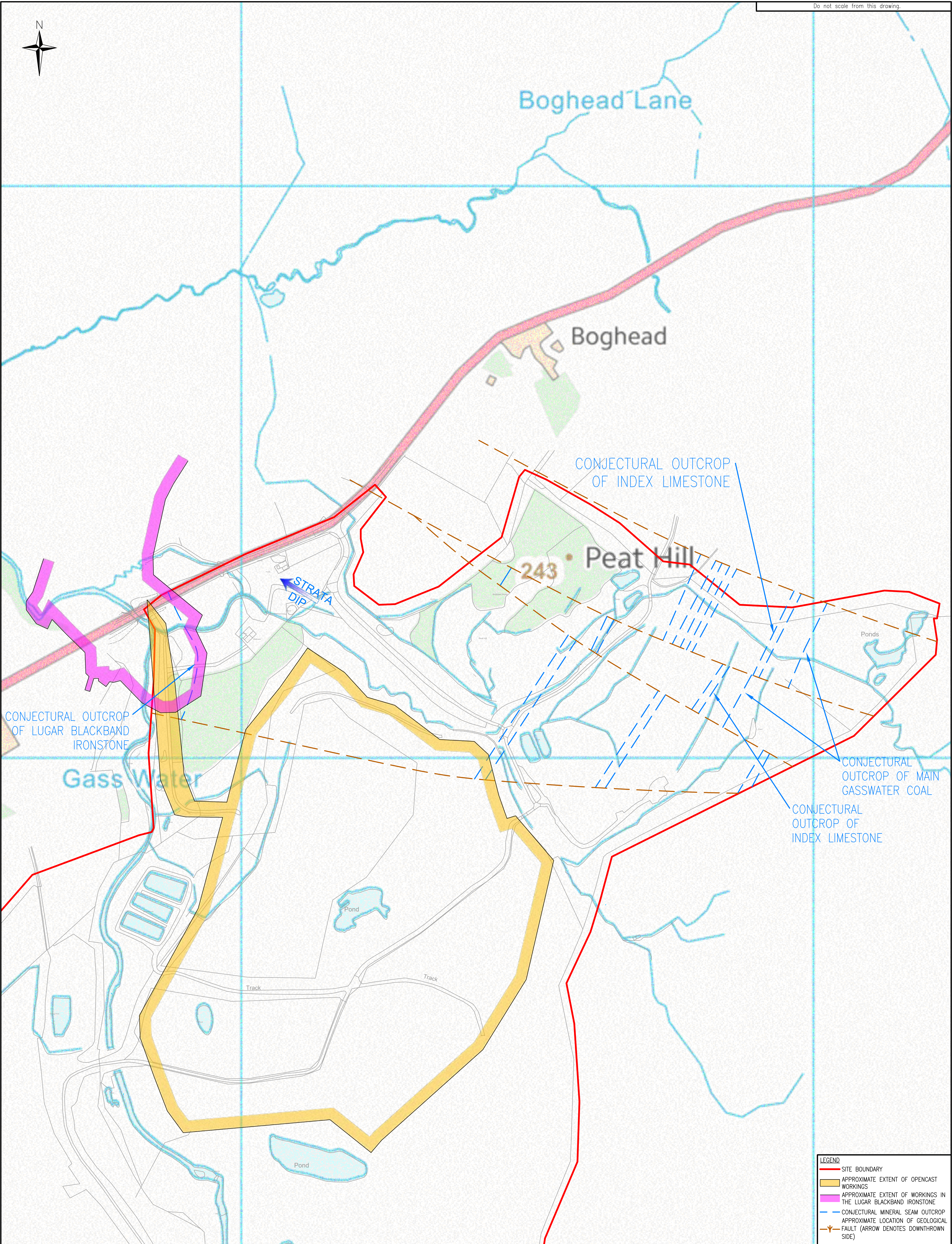
Project Title: PROPOSED WINDFARM DEVELOPMENT, GLENMUIR, EAST AYRSHIRE
COMPOSITE SITE PLAN – AREA 3


4th Floor, Tay House, 300 Bath Street,
GLASGOW, G2 4JP
Tel: 0141 285 8700

Scale at A1: 1:4000
Status: For Report
Drawn: CMCC
Checked: ST
Approved: DM
Date: 15/08/23
Date: 15/08/23
Date: 15/08/23
Drawing No.: 156227/9004
Revision: –

Appendix 5

Drawing No. 156227/9005 – Composite Site Plan – Area 4



Rev.	Date	Description	Drawn	Checked	Approved

Notes:

Client:



Project Title:
PROPOSED WINDFARM
DEVELOPMENT, GLENMUIR,
EAST AYRSHIRE

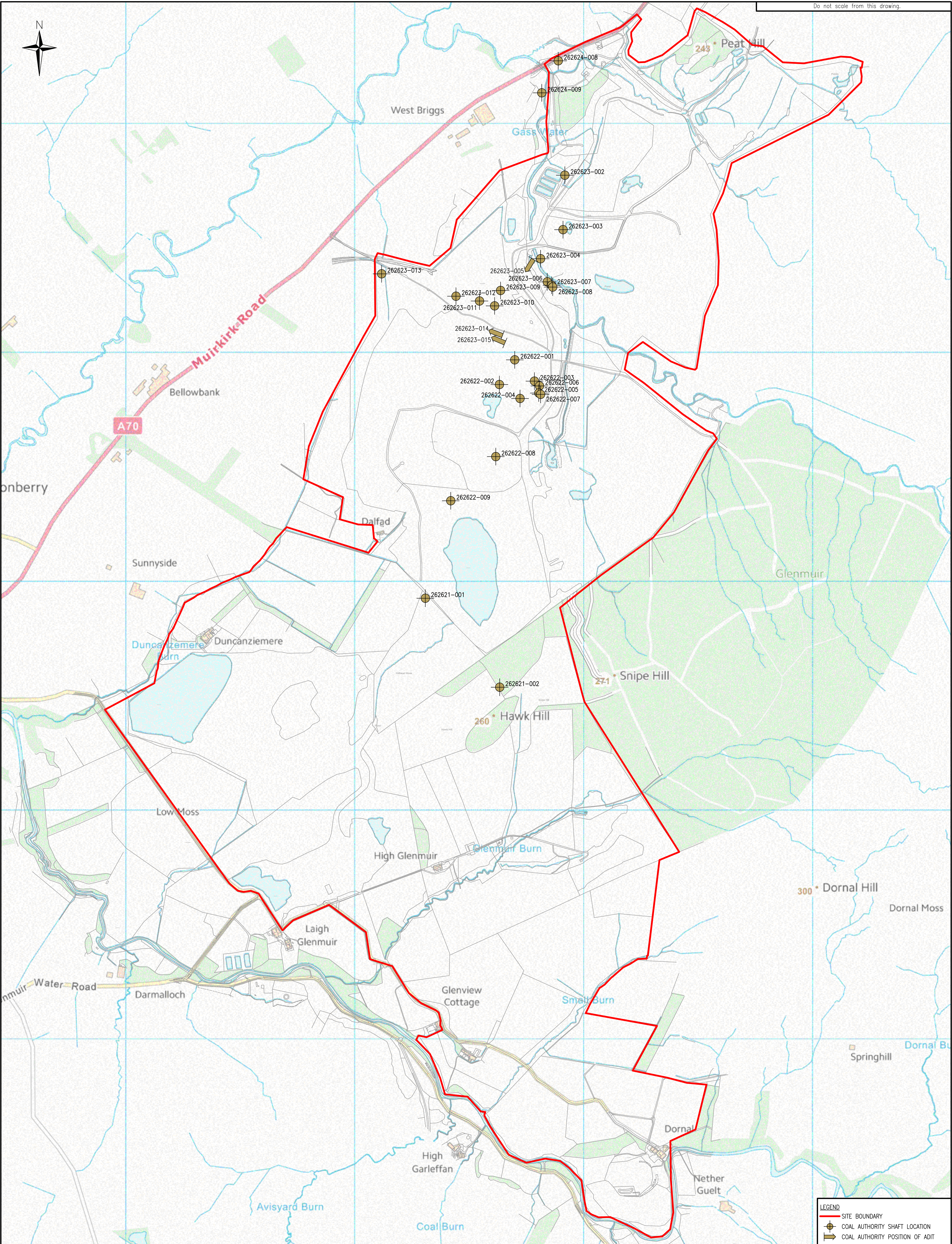
Drawing Title:
COMPOSITE SITE PLAN
– AREA 4

JWHROSS
4th Floor, Toy House, 300 Bath Street,
GLASGOW, G2 4JR
Tel: 0141 285 8700

Scale at A1: 1:3000	Status: For Report	
Drawn: CMCC	Checked: ST	Approved: DM
Date: 15/08/23	Date: 15/08/23	Date: 15/08/23
Drawing No.: 156227/9005		Revision: –

Appendix 6

Drawing No. 156227/9006 – Mine Entry Location Plan



LEGEND

SITE BOUNDARY

COAL AUTHORITY SHAFT LOCATION

COAL AUTHORITY POSITION OF ADIT

JWHROSS

4th Floor, Toy House, 300 Bath Street,
GLASGOW, G2 4JR
Tel: 0141 285 8700

Scale at A1:
1:7500

Status:
For Report

Drawn:
CMCC

Checked:
ST

Approved:
DM

Date:
15/08/23

Date:
15/08/23

Date:
15/08/23

Drawing No.:

156227/9006

Revision:

—

Rev.	Date	Description	Drawn	Checked	Approved

Notes:

Client:

BE

brockwell
energy

Project Title:

PROPOSED WINDFARM
DEVELOPMENT, GLENMUIR,
EAST AYRSHIRE

Drawing Title:

MINE ENTRY LOCATION PLAN

Appendix 7

Drawing No. 156227/9007 – Mineral Stability Risk Plan

MINING & MINERAL STABILITY ASSESSMENT • GROUND STABILISATION • MINERAL RESERVE
APPRAISAL • MINERAL & WASTE PLANNING • MINERAL ESTATES MANAGEMENT & VALUATION •
SURVEYING SERVICES

www.jwhross.co.uk

4th Floor, Tay House
300 Bath Street
Glasgow
G2 4JR
Tel: 0141 285 8700
Fax: 0844 381 4412
E: info@jwhross.co.uk

JWHROSS