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INTRODUCTION

This chapter describes and evaluates the current geological interest of the Carlton Main Quarry (the Quarry) and the application site.

- 9.1 This chapter considers the potential effects of the proposed development on important geological aspects. Where necessary, it also describes proposed mitigation measures to safeguard features of geological importance.

SCOPING

- 9.2 As noted in Chapter 4 a formal scoping process has been undertaken with the LPA. This was set out in the 'Scoping Report' submitted to the LPA on 16th October 2019, which described the proposed scope of the EIA, and was accompanied by a request for a 'Scoping Opinion'. The LPA issued their Scoping Opinion on 3rd January 2020, attached as Appendix 4/1 to Chapter 4.
- 9.3 From the scoping opinion, the following comments were provided in relation to geology.

Table 9-1
Scoping Opinions

Consultee	Scoping Comment
Barnsley Metropolitan Borough Council / Sheffield Area Geology Trust	As the site is a geological SSSI it is the Council's view, and that of the Sheffield Area Geology Trust that a detailed assessment of this and the impact of the proposed on it will be required.
Barnsley Metropolitan Borough Council Biodiversity Officer	No attempt seems to have been made to gain data on non-statutory Ancient Woodlands or Local Sites – i.e. Local Wildlife Sites and RIGS/ Local Geology Sites – this should be done.
Sheffield Area Geology Trust	Given the sensitivity of the geological environment and the presence of the SSSI the geological chapter needs to be robust and should include: • a detailed geology map • clear reference to the target clay horizon they are planning to excavate • an impact assessment on the marine band, not only in the existing section (where we are assured there will be no effect) but also in the new section (where the depth of excavation is not clarified) if the target horizon lies close to or below the marine band.

BASELINE CONDITIONS

Geological Setting

Regional Geology

- 9.4 The geology of the area around Grimethorpe comprises late Carboniferous (Westphalian) strata of the Middle and Upper Pennine Coal Measures. The geology of the area is shown on the British Geological Survey 1:50,000 scale map no. 87 (Barnsley) and documented in the associated memoir. A detailed geological map of the site is presented on **Drawing 02** (superficial) and **Drawing 03** (bedrock) in Appendix 8/3, Chapter 8 above.
- 9.5 The Coal Measures strata dip gently to the east-north-east at around 3° and, whilst largely unaffected by folding, are intersected by a large number of normal faults typical of the extensional tectonic setting in the Pennine Basin.
- 9.6 The strata comprise cyclical sequences of clastic sedimentary rocks (mudstones, sandstones and conglomerates) interspersed with coal seams and ironstones. The sequence of Coal Measures strata beneath Grimethorpe attains a thickness of 1,200m, beneath which are found the Millstone Grit series and deeper still the Carboniferous Limestone series.
- 9.7 Argillaceous rocks predominate throughout the Coal Measures.
- 9.8 The Westphalian strata are strongly dislocated by faults, typically with a northwest-southeast trend, and a system of WNW-ESE-trending fold¹.
- 9.9 The BGS specify that *'Within the Coal Measures thinner sandstones are generally lenticular, passing laterally as well as vertically into siltstones and mudstones.'*¹
- 9.10 Superficial deposits are largely absent regionally with the exception of localised alluvial channels along the route of watercourses and some localised areas of Till, Head and Glaciofluvial deposits. These typically have limited geographical extent and form isolated pockets of superficial deposits.

Local Geology

- 9.11 According to the online BGS Geindex mapping service, the proposed extension area is underlain by mudstones, siltstones and sandstones of the Pennine Upper Coal Measures Formation. The BGS Lexicon² describes this formation as *"interbedded grey mudstone, siltstone and pale grey sandstone, commonly with coal seams, but no mudstones containing marine fossils are present". The BGS3 further state that rocks of the Pennine Upper Coal Measures Formation 'are largely*

¹ Morris B.L. (2005) Hydrogeological notes for the Sheffield District (sheet 100) British Geological Survey Internal Report, IR/05/045. 21pp.

² British Geological Survey Lexicon of Named Rock Units: Pennine Upper Coal Measures Formation, available at: <https://www.bgs.ac.uk/lexicon/lexicon.cfm?pub=PUCM> (accessed 28th August 2020)

³ British Geological Survey Earthwise Website: Westphalian Coal Measures, Carboniferous, Northern England, available at: http://earthwise.bgs.ac.uk/index.php/Westphalian_Coal_Measures,_Carboniferous,_Northern_England (accessed 28th August 2020)

sandstone and mudstone, mostly reddened to some degree, with a few thin coals and claystone seatearths."

- 9.12 The mapping indicates that the Newstead Rock outcrops immediately to the east of the proposed extension area (and the existing quarry). This is a sandstone unit within the Pennine Upper Coal Measures Formation. The presence and extent of this sandstone horizon has been assessed further by site investigation across the development area.
- 9.13 Borehole logs within and surrounding the proposed extension area indicate that there are numerous mudstone, siltstone and sandstone bands of variable thickness. These borehole logs are provided in Appendix 8/1 and locations shown on **Drawing 06** (Appendix 8/3, Chapter 8).
- 9.14 A review of the available borehole logs across the extension area (specifically Borehole GNP19, GNP220 and GNP221 located in and around the proposed extension area) indicates the following:
- GNP219 (in the east of the extension area) is dominated within the proposed quarrying depth by mudstone strata interspersed with two coal seams (at 53.80 – 54.11m AOD and 42.98 – 43.26m AOD) and two thin sandstone bands (at 50.13 – 50.93m AOD and 43.76 – 43.99m AOD);
 - The proposed base of the workings (at c.35m AOD) is underlain by a c. 3m thickness of siltstone overlying an extensive thickness of sandstone (proven to a thickness of at least 17.4m) which is considered to represent the Newstead Rock formation;
 - GNP220 (located to the south of the proposed extension area) indicates a similar sequence dominated by mudstone, although this is overlain by approximately 5.6m of made ground. This log does not record any coal seams or thin sandstone bands, although it does identify the top of the underlying sandstone at an elevation of approximately 38.31m AOD, which is proven to a thickness of 47.85m;
 - GNP221 (located to the west of the proposed extension) also indicates a similar sequence dominated by mudstones and siltstones in the upper part of the log (the proposed quarry extent) and by sandstones below approximately 36m AOD.
- 9.15 The above boreholes, alongside further previous site investigations in the current main quarry area including the borehole IMCBH4A (which predominantly logs varying bands of mudstone and sandstone from 61.16m AOD to 10.66m AOD) indicate that there are bands of sandstone underlying the base and adjacent to the sidewalls of the proposed extension area. The thickest band of sandstone (Newstead Rock) is recorded at up to 29.85m in thickness and as its top is encountered at 38.31m AOD would directly underlie the proposed extension area in the south of the site, but appears to dip beneath the proposed base of quarry (c.35m AOD) in the north. It is noted that a potential fault runs roughly through the north of the site, between the existing quarry and southern extension, the sandstone bands beneath and adjacent to the existing quarry do not appear to be as thick as beneath the existing quarry.
- 9.16 Bands of sandstone logged in previous site investigations that would likely be adjacent to the sidewalls and above the proposed base of excavations are no more than a metre in thickness.

Coal Mining

9.17 There is a long history of coal mining across the region with numerous historic shafts and collieries throughout Yorkshire. The main coal mining areas in the vicinity of the application site are outlined below:

- The Grimethorpe Colliery (centred at SE 40871 08327⁴), is the closest historic colliery to the Site and worked numerous seams. The deepest shaft at Grimethorpe Colliery was at a depth of over 840m. Grimethorpe Colliery closed in August 1993. Shafts and surface drifts associated with the former Grimethorpe Colliery are located to the west of the site and brickworks premises. In 1915, Ferrymoor Colliery was sunk immediately to the west of Grimethorpe Colliery by Hodroyd Colliery Company to work the Shafton Seam at a depth of c.51m (56 yards)⁵.
- The Shafton Coal Seam and the Highgate Coal Seam have been identified as previously targeted coal deposits in the vicinity of the Site. The Shafton Coal Seam (c.1500mm in thickness) and the Highgate Coal Seam (c.350mm in thickness) crop out farther to the west and south of the quarry respectively and dip eastward under the quarry site. The Shafton Seam was worked beneath the quarry at a depth of at least 75m during the 1920s.
- Further historic mine workings of eight coal seams have occurred within the local vicinity the Site at depths ranging from 400m to 810m. The most recent operations took place in the Fenton Coal Seam (at a depth of c.740m) in 1989.
- The Hodroyd Shaft is located approximately 2.5km north of the Site in the vicinity of Brierly (centred on SE 40978 10770 for location purposes⁶). The Shafton seam was targeted here, with shafts sunk to the seam at a depth of c.205m (224 yards) in 19107. In 1947 mining ceased at Brierley and the colliery became a training centre.
- The Dearne Valley Colliery/Shaft is located c.1.5km to the southeast of the Site (centred on SE 43200 07500). According to the Durham Mining Museum '*Surface drift established 1903 on the outcrop with subsequent development following the Shafton seam*'⁸.

9.18 All of the highlighted coal seams are located well below the base of the quarry and it is not anticipated that the quarry site would intercept any previously worked coal seams, although it is noted that there are potentially former mine working present at depth beneath the Site.

⁴ Durham Mining Museum: Grimethorpe Colliery, Available at: <http://www.dmm.org.uk/collnear/g204.htm> (Accessed 18th September 2020)

⁵ Jones, M (n.d) Grimethorpe Colliery – A Profile and History, On: Yorkshire Magazine. Available at: <https://www.on-magazine.co.uk/yorkshire/history/grimethorpe-colliery/> (Accessed 18th September 2020)

⁶ Durham Mining Museum: Hodroyd Colliery, available at: <http://www.dmm.org.uk/colliery/h210.htm> (Accessed 18th September 2020)

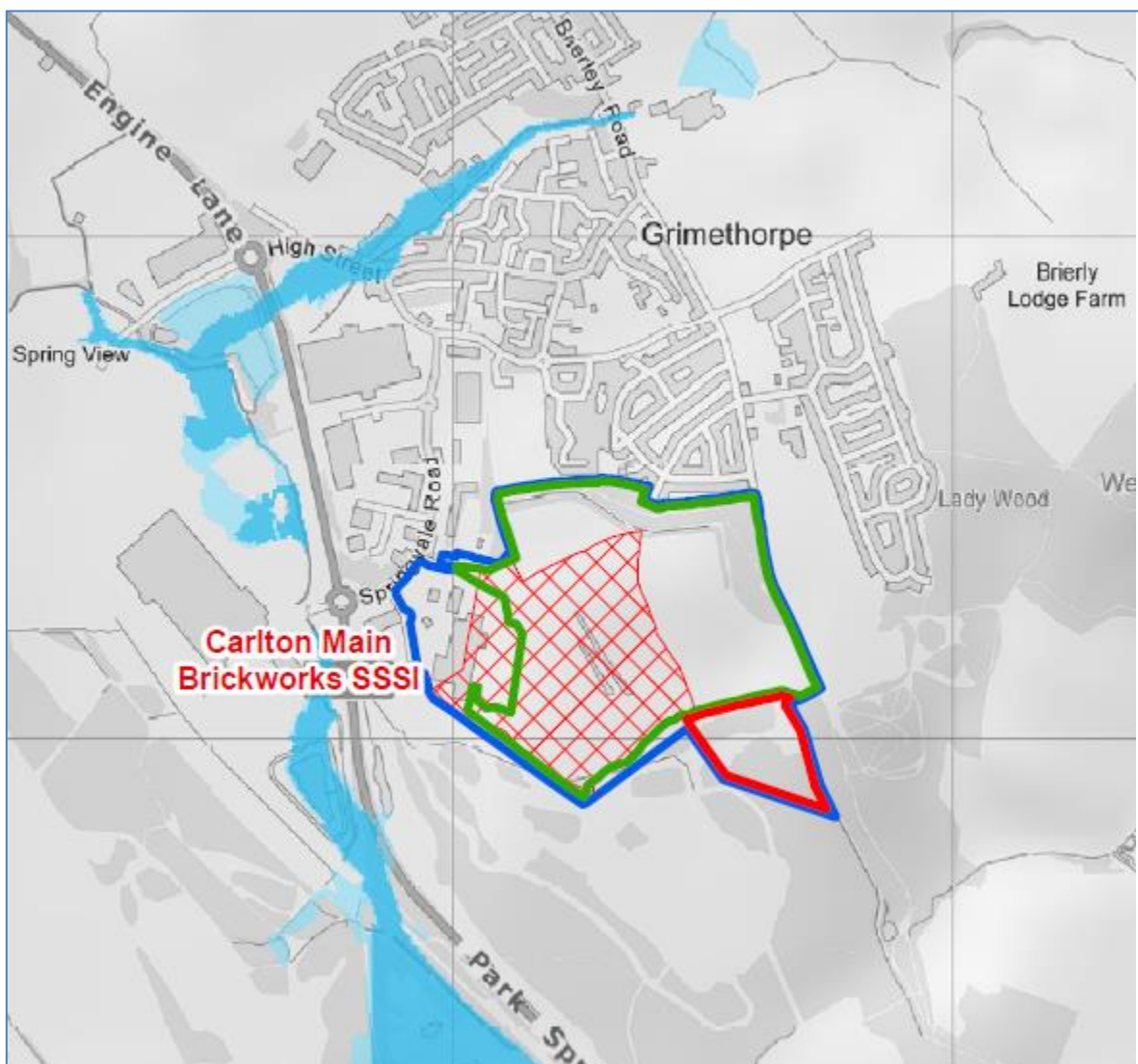
⁷ Brierly Village Website: Brierly Colliery (Hodroyd Coal Company), Available at: <http://www.brierleyvillage.co.uk/PHOTOGRAPHS/PHOTOGRAPHSONLINE/BUILDINGS/buildings29.htm> (Accessed 18th September 2020)

⁸ Durham Mining Museum: Dearne Valley Colliery, available at: <http://www.dmm.org.uk/colliery/d208.htm> (Accessed 18th September 2020)

Geological SSSI

- 9.19 The central and western parts of the Quarry excavation are designated as a geological Site of Special Scientific Interest (SSSI), which extends across 15.5 ha of the existing quarry site.
- 9.20 The particular interest is a horizon which is the highest Coal Measures marine band (the Westphalian C Top Marine Band, also known as the Cambriense Marine Band in more recent publications) in Britain, which is the latest evidence of normal marine conditions in this country during the Carboniferous period.

Figure 9-1
Location of Carlton Main Brickworks SSSI

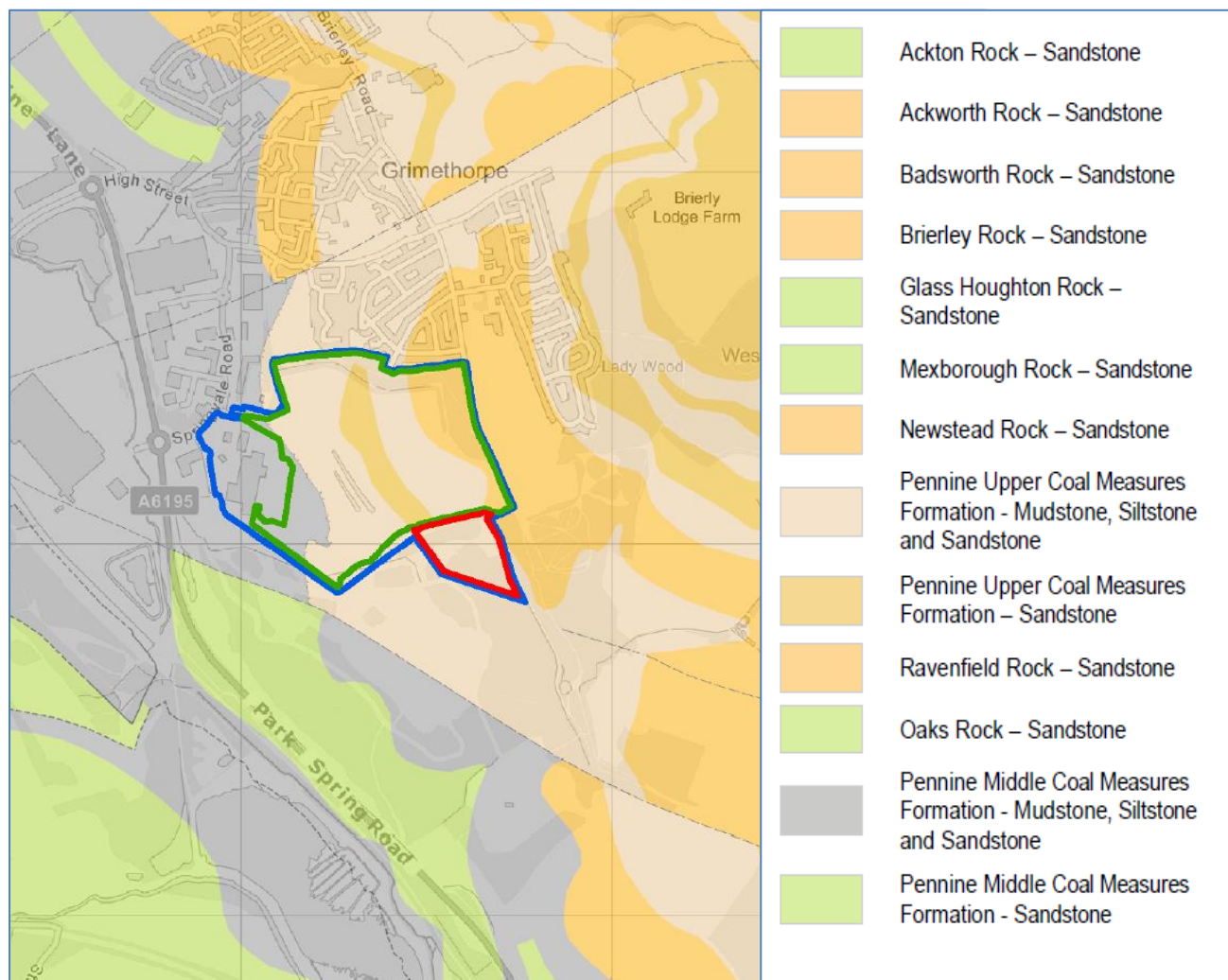


ASSESSMENT OF EFFECTS

Setting and Significance

- 9.21 The 'Carlton Main Brickworks' SSSI was designated in 1989, is centred at National Grid Reference (NGR) SE 412 081 and extends across 15.5 ha of the existing quarry site (Figure 9-1). The SSSI boundary does not currently cover the eastern part of the existing quarry nor the proposed Southern extension area.
- 9.22 The Carlton Main Brickworks has been notified as a geological SSSI for the Coal Measures strata exposed by the extraction of clay within the quarry. The SSSI is currently identified as 'favourable' condition, the last field survey and assessment of the SSSI was undertaken in 2010 by Natural England.
- 9.23 As noted above, the geology of the area around Grimethorpe comprises late Carboniferous strata of the Middle and Upper Pennine Coal Measures. The Pennine Coal Measures were deposited during a geological time called the Westphalian Stage. The site is located within the Pennine Basin; a sedimentary basin active during this time.
- 9.24 The Coal Measures strata were deposited between 313 and 304 million years ago in deltaic and near shore conditions in a subtropical environment. The sequence of Coal Measures strata beneath Grimethorpe has a thickness of 1.2km, beneath which are found the Millstone Grit series and deeper still the Carboniferous Limestone series. The geological strata facies comprise markedly cyclic successions, with each facies having different characteristics (Figure 2). During the Westphalian the Pennine basin was frequently flooded by the sea. These beds are called marine bands and are recognised by the marine fossils they contain.
- 9.25 The particular interest of the SSSI is a horizon of the Coal Measures known as the Westphalian C, Top Marine Band, also known as the Cambriense (Top) Marine Band in more recent publications. This horizon is the highest Coal Measures marine found band in Britain and is the latest evidence of normal marine conditions in this country during the Carboniferous period.

Figure 9-1
Bedrock Geology around Grimethorpe



- 9.26 The fossil assemblage found within the Cambriense (Top) Marine Band suggests it is the *Myalina* Facies “as described by Calver, represented only in very shallow marine conditions, and contrasts with other occurrences of this marine band,...”. There are also records of non-marine bivalves which are thought to represent the first sign of return to non-marine conditions.
- 9.27 The extraction of clay at the quarry has created what is considered as one of the best exposures of the Cambriense (Top) Marine Band in the Pennine Coalfields.

Operational Phase Effects

- 9.28 As noted above, the Coal Measures strata dip gently to the east north-east at around 3° and, whilst largely unaffected by folding, are intersected by a large number of normal faults typical of the extensional tectonic setting in the Pennine Basin. The Cambriense (Top) Marine Band at Carlton

Main quarry will dip gently to the east, becoming progressively deeper in the excavation as it is worked to the east.

- 9.29 The boreholes drilled in the vicinity of the Southern Extension show a slightly different sequence to that of the existing quarry working area, with a thick (20m+) sandstone bed beneath 15m to 25m of mudstone. The sandstone and mudstone are overlain by approximately 2m of overburden comprising made ground, soil, and weathered clay. This difference suggests a fault between this area and the main excavation, although no evidence for a fault has been observed, nor is a fault recorded on the geological maps.
- 9.30 The quarry works generally eastwards and has been developed in a series of low faces, ranging from 3m to 5m in height separating intermediate benches used for accessing different strata.
- 9.31 In 2004 Natural England produced a document on their views about the management of the SSSI. It notes two reasons quarries are an important part of the geological resource in England. Firstly, that many quarries are in location where geological units of scientific interest are not naturally exposed or exposures are rare. Secondly that quarried sites often provide a much better exposure of the geological feature than if often found in natural exposures. The vertical nature of quarried faces are rarely found in the natural occurrences of exposures.
- 9.32 The two management principles of the SSSI are noted to be the maintenance of the exposed geological feature throughout the quarry working life and to ensure that representative sections of this important geological feature are retained once quarry works have ceased.
- 9.33 If the 'Cambriense (Top) Marine Band' is present in the proposed extension area to be quarried, then quarrying would expose the sequence within some of the quarry faces to be developed. The proposed development would therefore potentially result in a net increase in the extent of the marine band visible within the quarry walls compared to the existing quarry. The proposals would therefore potentially result in a minor improvement in relation to the geological SSSI. This is considered further below under within the 'Mitigation' section.

Restoration Phase Effects

- 9.34 The proposed restoration has been revised to remove the requirement to infill the quarry void with non-hazardous biodegradable wastes and create a lower level scheme using inert wastes. Although the eastern part of the quarry is not within the SSSI, as the Cambriense (Top) Marine Band becomes progressively deeper towards the east it is likely that even low level restoration would cover the unit of geological interest in this part of the quarry.
- 9.35 The proposed restoration scheme would include the retention of quarry faces along the eastern and northern boundaries. Should the future development of the quarry expose new sections of the Cambriense (Top) Marine Band, it may be possible, subject to safe access and suitable restoration, to retain an exposure of the unit for recording and future research. The restoration of the Site to amenity grassland with associated public footpaths would also improve the access to the features of interest in comparison to the existing situation and the currently approved restoration scheme which would have resulted in the ultimate loss of these features. The proposed revised restoration

scheme would therefore provide a net minor improvement compared to the current approved scheme.

PROPOSED MITIGATION

- 9.36 It could be possible identify an accessible exposure in the western part of the site or northern face of the quarry that could be retained in the longer term for access and research. In these parts of the quarry the horizon of interest is likely to be higher up in the quarry faces due to the dip of the beds.
- 9.37 There is a possibility that if faulting is present between the existing quarry and south-east extension, the faulting may have uplifted the Top Marine Band in the south-east extension. The unit of interest may not be present if the tectonics and subsequent glaciations of the landscape have caused erosion and weathering of the unit of interest.
- 9.38 Subject to safe access a geologist could periodically map and record the exposed faces in the south-east extension to determine the presence or absence of the Cambriense (Top) Marine Band. Should the future development of the quarry expose new sections of the unit, it may be possible, subject to safe access and suitable restoration, to retain an exposure of the unit for recording and future research. Further discussion would be required with the relevant stakeholders to determine the scope of any access and future research and mapping

CONCLUSIONS

- 9.39 The geology of the area around Grimethorpe comprises late Carboniferous (Westphalian) strata of the Middle and Upper Pennine Coal Measures. The strata comprise cyclical sequences of clastic sedimentary rocks (mudstones, sandstones and conglomerates) interspersed with coal seams and ironstones. The sequence of Coal Measures strata beneath Grimethorpe attains a thickness of 1,200m, beneath which are found the Millstone Grit series and deeper still the Carboniferous Limestone series.
- 9.40 The central and western parts of the Quarry excavation are designated as a geological Site of Special Scientific Interest (SSSI), which extends across 15.5 ha of the existing quarry site. The particular interest is a horizon which is the highest Coal Measures marine band (the Westphalian C Top Marine Band, also known as the Cambriense Marine Band in more recent publications) in Britain, which is the latest evidence of normal marine conditions in this country during the Carboniferous period. The SSSI boundary does not currently cover the eastern part of the existing quarry nor the proposed Southern Extension.
- 9.41 Boreholes drilled in the vicinity of the Southern Extension show a slightly different sequence to that of the existing quarry working area, with a thick (20m+) sandstone bed beneath 15m to 25m of mudstone. This difference suggests a fault between this area and the main excavation, although no evidence for a fault has been observed, nor is a fault recorded on the geological maps.
- 9.42 If the 'Cambriense (Top) Marine Band' is present in the proposed extension, then quarrying would expose the sequence within some of the quarry faces to be developed. The proposed development would therefore potentially result in a net increase in the extent of the marine band visible within

the quarry walls compared to the existing quarry. The proposals would therefore potentially result in a minor improvement in relation to the geological SSSI.

- 9.43 The proposed restoration scheme would include the retention of quarry faces along the eastern and northern boundaries. Should the future development of the quarry expose new sections of the Cambriense (Top) Marine Band, it may be possible, subject to safe access and suitable restoration, to retain an exposure of the unit for recording and future research. The restoration to amenity grassland with associated public footpaths would also improve the access to the features of interest in comparison to the existing situation and the currently approved restoration scheme which would have resulted in the ultimate loss of these features. The proposed revised restoration scheme would therefore provide a net minor improvement compared to the current approved scheme.

Appendix 9/1

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