

17.0 GEODIVERSITY: NEW CHAPTER

17.1 INTRODUCTION AND METHODOLOGY

- 17.1.1 Leicestershire County Council, as the Minerals Planning Authority, or MPA, has identified concerns over the proposals at Lubbesthorpe in relation to geodiversity (see section 17.2 below). In consideration of its concerns, this section has utilised literature published by the British Geological Survey (BGS) and the County Council themselves, as well as observations made on site, to characterise the site in a geodiversity context and assess the scope for impact associated with the proposals.
- 17.1.2 It is considered at the outset that the area to the north of the wider site holds no interest in a geological or geodiversity context. It should be noted therefore that, for the purposes of this section, only the development area envisaged to the south of the M69 is referred to as the 'Subject Area' in this Chapter.
- 17.1.3 This assessment is qualitative only as there has been no need to identify and calculate any mineral resources that could potentially be sterilised by the proposals. Assessment has not required technical input; merely a sound understanding of the geology of the area and the characteristics of the formations therein.

Assessment Methodology

- 17.1.4 This section has made use of Good Practice guidance provided by Natural England in the form of their research report into the production of Local Geodiversity Action Plans (reference R560).
- 17.1.5 In short, the geology present on site has been described and characterised to identify its potential importance in a geodiversity context.

17.2 PLANNING CONTEXT

- 17.2.1 The safeguarding and assessment of geological assets is identified in Planning Policy Statement 9: Biodiversity and Geological Conservation. The PPS was published with a number of objectives, which included:-
- *“to promote sustainable development by ensuring that ... geological diversity sites are conserved and enhanced ...; and*
 - *to conserve, enhance and restore the value of England’s wildlife and geology ...”*
- 17.2.2 The protection of assets is mainly achieved by a national designation i.e. a Site of Special Scientific Interest (SSSI), or a regional designation in the form of a Regionally Important Geological Site (RIGS). PPS9 confirms that the latter sites should be afforded further policy protection, which should be articulated in regional and local planning policies. This position is reaffirmed in Minerals Policy Statement 1.
- 17.2.3 The Regional Spatial Strategy is not considered to be relevant under the provisions of this section, as its scope is too wide ranging.
- 17.2.4 At a more local level, Leicestershire County Council adopted Minerals Core Strategy and Development Control Policies document during October 2005. Policy protection for local and

regional sites is afforded in Policy MCA4, whilst national sites are safeguarded via PPS9 as a statutory designation.

- 17.2.5 The planning application (ref 2011/0100/01) has been subject to public consultation and consultation with statutory consultees, one of which is Leicestershire County Council ('the Council'). The Council has provided a 95 page report to the LPA addressing a range of issues.
- 17.2.6 In addition to ongoing concerns regarding the potential mineral resource on the site, the County Council identified concerns over geodiversity, stating:-

"The Environmental Statement is incomplete as it makes no reference to the Geodiversity interest of the Lubbesthorpe area. Although geological sites may appear robust they can be damaged and destroyed by inappropriate development or activities. There is a geological Site of Special Scientific Interest to the west of the area referred to as Parcel 2. This important geological site has been infilled but there are plans (by Natural England) to re-excavate the site in the future. It is important that any development does not impact on the planned future excavation of the SSSI (paragraph 128).

The important geodiversity features at the site include rare palygorskite mineralisation at the boundary between Ordovician South Leicestershire Diorite and the overlying Triassic sediments. It is likely that the South Leicestershire Diorite extends into the area 'Parcel 2' beneath Triassic sediments. The 'buried landscape' is often undulating and contains ancient stream beds known as 'wadis'. The wadis often contain sand horizons which often act as aquifers which may affect the drainage of the area. The relationship of the proposed development site to the prehistoric River Bytham deserves more consideration. If any geologically interesting sites are used or exposed then consideration should be given to retaining some key features of interest, and the sites possible future as a new interpreted RIGS (paragraph 129)."

- 17.2.7 Refer to Chapter 3: Planning Policy for a more detailed summary of the current local planning policy position in relation to geodiversity.

17.3 BASELINE CONDITIONS

Site Setting

- 17.3.1 The wider site is located directly to the west of the M1 motorway, and either side of the M69 motorway as indicated at Appendix 17A, Figure 17.1. The site is currently accessible via the Lubbesthorpe Bridle Road which originates east of the M1 and bisects the landholding to Beggar's Lane at the site's western boundary.
- 17.3.2 The site is split into two distinct areas being separated by the M69 motorway; Area 1 is located to the north of the M69, and Area 2, the Subject Area, which is located to the south of the M69.
- 17.3.3 The Subject Area comprises primarily of agriculture and woodland, the following residential properties are located within the proposed development area:-
- Warren Farm; and
 - Warren Cottages.

- 17.3.4 The field compartments are irregular in size, and are constrained by the presence of small woodland copses and the parkland area associated with Enderby Hall to the south and west as shown at Appendix 17A, Figure 17.2. The parkland comprises open grassland with isolated mature trees.
- 17.3.5 There is a hillock/rise in the east of the Subject Area adjacent to the M1, which is of potential relevance in the context of the geology.
- 17.3.6 Access into the Subject Area can be derived off Leicester Lane to the south and Warren End Lane to the north although it is noted that, as part of the Project, the Subject Area would ultimately be linked into Area 1 via a bridge crossing the M69 as illustrated at Appendix 2A, Figure 2.3A.
- 17.3.7 Adjoining land uses to the subject area include established highway networks on the northern, eastern and southern perimeters, with the aforementioned Enderby Hall and parkland to the west. In addition to Enderby Hall, the north-western perimeter of the subject area is located next to the former Enderby Warren Quarry and Landfill Site as indicated at Appendix 17A, Figure 17.2.

Regional Geology

- 17.3.8 The geology for Leicester and the surrounding area is illustrated on the British Geological Survey (BGS) Map No. 156. The accompanying sheet description was written by J N Carney et al, and published in 2009.
- 17.3.9 This section of the Chapter also uses the Coalville Memoir (published 1988), the Coventry Memoir (published in 1998) and the Mineral Resource Information (MRI) report for the county of Leicestershire as published by the BGS in 2002.
- 17.3.10 The information published in the MRI report provides an approximate indication of the lateral extent of mineral resources within the county. It is of note that the subject area is located in close proximity to an identified igneous rock intrusion, which forms part of the larger South Leicestershire Diorite.
- 17.3.11 The MRI report confirms the development of the geology in the area over a 340 million year period, and confirms the mineral resources available in each of the identified formations. Leicestershire has a rich history associated with the recovery of mineral resource in particular coal, clay and sand and gravel, as well as igneous resources including the former Enderby Warren Quarry which is located adjacent to the subject area. It is the latter resource that now forms the bulk of the county's mineral resource output.
- 17.3.12 The memoir and sheet descriptions indicated above provides a more detailed commentary on the geology present.

Local Geology

- 17.3.13 The geology of the immediate area around the site is better defined on the 1:10,000 sheets for grid SK50SW and SP59NW, a combined extract of which is reproduced at Appendix 17A, Figure 17.3.

Solid Geology

- 17.3.14 The surface geology of the area is mainly dominated by Triassic geology deposited circa 220 million years ago. The other time-period of significance is the Pre-Cambrian – Ordovician period, some 600 to 400 million years ago. The latter is represented by a number of isolated outcrops in the county of igneous geology, comprising basalts, diorites and gabbro complexes.
- 17.3.15 The closest of these complexes is the South Leicestershire Diorite exposure located north of Enderby and just west of the subject area as shown at Appendix 17A, Figure 17.3. These rocks comprise a quartz diorite. The same diorite can be traced back to the south-west of Enderby at Croft Quarry. The exposure at Enderby Warren Quarry has been subject to mineral extraction, and is now concealed by landfill deposits and subsequent built development, although a single exposure remains partially buried adjacent to the site and has been designated as a SSSI for its geological content; this is considered at section 17.5 below).
- 17.3.16 The remainder of the area in the vicinity of the subject area is covered by deposits of the Mercia Mudstone Group, specifically the Edwalton Formation, which generally comprises a reddy-brown mudstone with a sandstone basal unit and some interbedded sandstones. The whole formation is commonly 40m to 50m thick, with some lateral variation. Based on local borehole information it is understood the thickness of the formation in the vicinity of the site is circa 22m.
- 17.3.17 The Mercia mudstone formations are understood to unconformably overlie the South Leicestershire diorite; this is evidenced by local deep boreholes particularly at Leicester Forest East Services.
- 17.3.18 The Leicester memoir produced by the BGS (paragraph 17.3.8 above) provides an indication of the structure of the igneous rocks at Figure 12. This is reproduced at Appendix 17B and shows the structure contours on the top of the igneous rock in dashed light blue lines. The location of the Subject Area is illustrated by the “E” notation which is Enderby.

Drift Geology

- 17.3.19 Drift geology, i.e. unconsolidated deposits generally overlies the solid deposits of the Edwalton Formation. These deposits comprise the following named formations:-
- Thrussington Till
 - Oadby Till;
 - Glaciofluvial Sand and Gravel; and
 - Alluvium and Colluvium.
- 17.3.20 These formations are resultant of glacial and post-glacial deposition processes and the development and erosion/re-working of the older Bytham River (a massive ancient former drainage channel located to the south-east of the site).
- 17.3.21 In a lithological context, the undifferentiated glaciofluvial deposits comprise a heterogeneous mix of sand, gravel, silt and clay. These deposits are localised, and can be deep, and are generally considered to be outwash from the post-glacial erosion of the Thrussington and

Oadby Till formations. With reference to the geological map extract included at Appendix 17A, Figure 17.3, such deposits are present within the subject area.

17.3.22 The Alluvium and Colluvium deposits are also low in terms of stratigraphy, and are defined on a narrow width along the course of the current unnamed streams on site. These are not present in the subject area.

Site Specific Geology

17.3.23 This subsection concentrates specifically on the distribution and depth of geology in the Subject Area, relying on the interpretation of borehole logs obtained from the BGS and data from site investigation exercises. Copies of the borehole logs sourced from the BGS are reproduced at Appendix 17C. Their distribution, relative to the subject area, is illustrated on a plan which is forms part of the Appendix.

17.3.24 A summary of the logs is set out as follows:-

Table 17a: Summary Table of Boreholes (logs and location plan included at Appendix 17C)

Plan Ref	Borehole Ref	Grid Ref	Depth Drilled	Description
BH1	SK50SW31	454210, 300410	5 m	Red sandy clay of the Mercia Mudstone Group
BH2	SK50SW45	454221, 300740	14.6 m	Gravel underlain by sandy clay of the Mercia Mudstone Group.
BH3	SK50SW42	457007, 300700	18.0 m	Gravel underlain by sandy clay of the Mercia Mudstone Group.
BH4	SK50SW43	454042, 300727	10.6 m	Silty Clays and Gravels underlain by sandy clay of the Mercia Mudstone Group
BH5	SK50SW50	454510, 300729	9.25 m	Boulder Clay
BH6	SK59NW17	454610, 290700	9.14 m	Boulder Clay
BH7	SK59NW18	454620, 299950	12.19 m	Boulder clay with sand and gravel underlain by sandy clay of the Mercia Mudstone Group

17.3.25 There is a relative scarcity of data with boreholes. Data that has been obtained mainly results from investigation activity around the M1 and M69 motorway corridors. However it is notable that, without exception, the borehole data that is present does not identify the presence of the diorite structure. This has also been verified by trial trench investigations undertaken across the Subject Area to a maximum depth of 4.5m on site.

- 17.3.26 With reference to Appendix 17B, the Leicester Forest East Borehole indicates the tip of the igneous rock to be at 152 m below Ordnance Datum, which is actually 250 m beneath ground level. The distance from the borehole to the outcrop of the diorite is 3,000 m which, if the diorite has a consistent gradient outfall at outcrop, means that the outer edge falls at a gradient of circa 1:12. However this is clearly not the case, as the borehole evidence above shows.
- 17.3.27 Trial pit investigations undertaken in the subject area have verified the presence of the Thrussington Till and a smaller outcrop of glacial sand and gravel than indicated on BGS mapping. The investigations also confirmed the presence of the Edwalton Formation, with deposits in the south of the area in particular located lower down in the succession as interbedded sandstones, indicative of the lower part of this formation, being identified.
- 17.3.28 The site investigations did identify the top of the solid geology in most cases and did not identify the presence of clean economic sand and gravel underneath the Till deposits.

Safeguarded Geodiversity

- 17.3.29 As set out in section 17.2 above, the Subject Area is located adjacent to the former Enderby Warren Quarry which extracted the diorite resources from the South Leicestershire Diorite for use as an aggregate in roadstone production. The quarry has now been landfilled; however exposures of the diorite remained and have been designated as a Site of Special Scientific Interest (SSSI). A copy of the citation and map for this site is reproduced at Appendix 17D.
- 17.3.30 The exposure has been designated due to palygorskite mineralisation, a weathered clay mineral with high magnesium and aluminium content, found at the unconformable junction of the diorite with the overlying Mercia Mudstone Formation. The extent of the SSSI is confined to the south-east corner of the wider quarry as indicated at Appendix 17A, Figure 17.2. The mineralisation was formed by the movement of mineral rich meteoric fluids through the overlying Triassic strata.
- 17.3.31 The mineralisation is noted in the BGS memoirs to occur in joints and fractures within the diorite and it is therefore notable that it is not widely disseminated in the host rock and thus magmatic in source.
- 17.3.32 In a slightly wider context, it is notable that other geologically related SSSIs at Croft Quarry and Huncote Quarry are designated due to a different form of mineralisation and the presence of Triassic wadi sediments. These Triassic wadis can form deeply incised features into the diorite deposits, which is particularly the case at Croft. The presence of such features at the Subject Area cannot be discounted at this time.
- 17.3.33 The drift geology in the area does not generally have much scientific interest. The most interesting of the fluvial glacial features are deposits associated with the Bytham River, which pre-dates the Till and Glacial Sand and Gravel and are therefore commonly found buried under these features. Mapping work previously undertaken by the BGS inferred that the route of the Bytham River passes in close proximity or possibly within the south-east corner of the subject area. However the aforementioned trial pit investigations, which reached at least 4 m in depth, did not come across any deposits that could be representative of this period of time.

17.4 PROJECT DESIGN

Potential Effects

- 17.4.1 The Project design is set out at ES Volume 1, Chapter 2: Development Proposals, Supplementary Chapter 2 contained within this Further Information Document and on the revised Parameters Plans included at Appendix 2A. The Project encompasses an area of 394 ha. The Subject Area detailed in this subsection relates solely to areas designated for employment or open space land uses covering an area of 71 ha. The Masterplan has evolved in full knowledge of the presence of both drift and solid geology, with no known geotechnical constraints.
- 17.4.2 The design paid due regard to the presence of the SSSI in Enderby Warren Quarry by providing an open space land use on all relevant perimeters of the former mineral workings. Further standoffs from other potential exposures are afforded by the topography of the site.

Mitigation

- 17.4.3 Aside from the appropriate standoffs from the Enderby Warren SSSI, no specific safeguarding measures were identified as being necessary at the Masterplan stage of this proposal.
- 17.4.4 At this stage it is difficult to predict what mitigation measures would be required, as the detailed layout of the Strategic Employment Site (SES) has not yet been determined.
- 17.4.5 Generalised mitigation measures for the protection of the SSSI and the attendant palygorskite mineralisation can simply be provided by the use of a 10 m stand-off from all perimeters of the Enderby Warren Quarry as shown at Appendix 17A, Figure 17.3. This would ensure that any shallower occurrences of the mineral remain undisturbed.
- 17.4.6 In respect of the potential for Triassic wadis, these can only be revealed by large scale earth moving operations such as mineral extraction which, in any event, would need to penetrate to depths in excess of 20m. This is unlikely to be the case in support of these proposals, meaning the underlying Triassic sediments would remain undisturbed.
- 17.4.7 Any disturbance of the overlying strata could open up a new pathway to the Triassic receptor; however, given the constrained nature of the sandstone horizons, a direct pathway is considered unlikely to be established. There should be no derogation of flow or groundwater quality and no mitigation measures are considered to be necessary in this instance.
- 17.4.8 Finally, in the context of the Bytham River, BGS borehole and site investigations have indicated that these deposits, if present on site, are concealed beneath considerable depths of glacial sand, gravel and till deposits. It is highly unlikely that these would be exposed during any cut and fill element of the proposals and again therefore mitigation would appear unnecessary.
- 17.4.9 Nevertheless, in the event of the following features being exposed, the BGS would be contacted to ascertain the potential importance of the exposure and scope for its retention determined:-
- (i) the South Leicestershire diorite;
 - (ii) any palygorskite mineralisation; and/or

(iii) clean sand and gravel of the Bytham River deposits.

17.5 ASSESSMENT OF EFFECTS

Introduction

17.5.1 The consultation response from the County Council required the consideration of four separate elements:-

- (i) the presence of the Enderby Warren SSSI;
- (ii) the potential presence of palygorskite mineralisation beneath the subject area;
- (iii) the potential presence of Triassic wadis beneath the subject area; and
- (iv) the relationship of the subject area to the River Bytham.

17.5.2 Each element is considered below.

Construction and Operation

Enderby Warren Quarry SSSI

17.5.3 The SSSI is located on the north-western boundary of the Subject Area and relates to a specific part of the wider Enderby Warren quarry.

17.5.4 With reference to the Masterplan, Appendix 2A, Figure 2.3A, it is noted that the southern limit of the SSSI is the only perimeter which directly abuts the wider Lubbesthorpe development site. This area is envisaged to be retained in its current condition and would not impact on the existing condition of the SSSI or any proposals to enhance its condition in the future.

17.5.5 Access into the SSSI would remain and, owing to the development layout, there is no potential for the development proposals to impinge on the SSSI. It is therefore assessed that the impact on the SSSI during any stage of the Project would be negligible, with no net effect overall.

Palygorskite Mineralisation

17.5.6 It is notable that palygorskite mineralisation is rare in concentrated occurrence, evident in only three locations in Leicestershire, and can only be found in hydrothermal deposits, i.e. in close proximity to an igneous intrusion, potentially along fault lines within or in proximity to an intrusion or within weathered rock in proximity to an intrusion.

17.5.7 At Enderby Warren Quarry the mineralisation is found in both the Triassic sediments, i.e. the Edwalton Formation, and Ordovician South Leicestershire diorite. Its extent, however, is confined and is not readily apparent across the wider deposits. The Edwalton Formation has a clay content of illite, chlorite and smectite, with other lesser assemblages of sepiolite and corrensite. It takes the presence of igneous intrusion and the metal content within, in order to precipitate out the palygorskite.

17.5.8 With reference to the Masterplan and Parameters Plans at Appendix 2A, there are only three areas that could encounter this mineralisation, namely the employment areas designated as

E2 - E4 respectively. Although much will depend upon the layout of specific structures within each of these areas, given that the area of mineralisation extends to less than 3 m from the contact between the two formations, the exposure in any foundation work associated with the Lubbesthorpe development is considered to be very remote. Deeper deposits will remain unexposed, meaning no change from the current situation. It is therefore assessed that the impact on the palygorskite mineralisation during any stage of the Project would be negligible, with no significant adverse effect overall.

Triassic Wadis

- 17.5.9 There is extensive evidence to suggest that the Ordovician igneous intrusions of the South Leicestershire Diorite were largely buried beneath aeolian (wind blown) deposits and riparian (river based) deposits which cut into the diorite where shelter belts or fault zones weakened the diorite. The best evidence for this is at the nearby Croft and Mountsorrel Quarries.
- 17.5.10 The features at Mountsorrel are understood to have a different origin to those at Croft due to the later intrusion of the diorite at Mountsorrel than at Croft. The diorite at Croft is of the same magmatic body as at Enderby Warren Quarry and it is therefore reasonable to assume that the same type conditions (topographical and climatic) prevailed during the Triassic era. However, the wadi type features are not widely mapped and without extensive drilling it is not possible to predict if they are present beneath the subject area, or indeed the wider site.
- 17.5.11 The BGS mapping at Appendix 17B does have an area where the Edwalton Formation appears to penetrate into the plutonic structure of the Enderby Warren deposit, this being shown by a curved chunk being taken out of the north-east area of the quarry. The full depth of the Edwalton Formation is not proven in the vicinity of the site apart from at the Leicester Forest East borehole where it is recorded as being 22 m thick.
- 17.5.12 However, it is known that significant deposits of boulder clay and mudstones in the Edwalton Formation underlie the Subject Area, these would confine any deep aquifer deposits within any potential wadi areas. This would mean that the potential for the development to affect the flow or quality characteristics of any deeper aquifer strata is minimal. There is a slight/minor scope for the sandstone within the Edwalton Formation to outcrop within the employment area, in particular within E2. Specific measures may therefore need to be put in place to safeguard the quality of any waters within this unit.

Bytham River

- 17.5.13 The Bytham River was a massive ancient river developed prior to the glacial periods in the Pleistocene era. The river is understood to have run through the Midlands, rising in the vicinity of Stratford on Avon, running up through Leicester and east into East Anglia to flow into the North Sea.
- 17.5.14 Subsequent glacial events have led to the erosion and/or the concealment of this feature over time. However its presence is noted in the vicinity of Leicester, in particular along the alignment of the current River Soar. In addition, there are areas where it crops at the surface, particularly at Huncote to the west and Alyester Park to the east.
- 17.5.15 Within the context of the subject area, the channel of the river may be present in the south-west corner of the site. The sand and gravel should be readily identifiable by low clay content

and as having a yellowy orange appearance, this being opposite to the glacial sand and gravel deposits noted on site which have relatively high clay content and are brownish grey in colour. The trial pit investigations undertaken across the subject area have confirmed that if the river channel is present it is concealed by the glacial sand and gravel and the Thrissington Till to at least a depth of 4 m.

17.5.16 Evidence presented in the archaeological records appear to verify this position, as finds should be readily available from the Bytham River deposits, as is the case elsewhere, but are not present immediately to the south-west of Leicester. This suggests the structure is buried and has not been reworked by post deposition glacial events.

17.5.17 It is therefore considered that there is no scope for the Project to uncover these sediments, if they are indeed present on site, and therefore a negligible effect is anticipated.

Cumulative Effects

17.5.18 This section assesses the likely significant effects of the Project when considered in the context of other future projects.

17.5.19 Whilst the overall effect of the Project upon geology local to the Lubbesthorpe area would be negligible, cumulative effects involving proposed Sustainable Urban Extensions at both Barwell and Earl Shilton, within Hinckley and Bosworth Borough, may lead to cumulative losses or exposure of geological assets. Although the exact scope of this potential effect is unknown at present it is known that the SUEs at Barwell and Earl Shilton are located on an outcrop of the Mercia Mudstone Group specifically the Gunthorpe Formation which exhibits similar characteristics to the Edwalton Formation which underlies the site at Lubbesthorpe. Drift deposits are mainly glacial and post-date the development of the Bytham River. Whilst there is scope (albeit limited) for the exposure of strata overlying Triassic Wadi's, and therefore potential cumulative effects upon the deep aquifer systems, there is no scope for cumulative effects under any of the headings discussed above.

Residual Effects

17.5.20 There would be no residual effects associated with the proposals. The existing concealed geology would remain so in perpetuity. Residual effects could occur should the drift deposits be removed to expose the Triassic groundwater system. However, standard mitigation measures, such as the use of SuDS or bypass separators, can be used to prevent any adverse impact.

17.6 STATEMENT OF EFFECTS

17.6.1 The geodiversity assessment confirms that the likelihood of the presence of the Enderby Warren SSSI, palygorskite mineralisation, Triassic wadis or the Bytham River within the site is minimal and, if present, would not be disturbed by the proposals due to their concealment at depth. Therefore the impact of the Project upon these features would be negligible.

17.6.2 Nevertheless, a scheme of mitigation measures has been detailed which would result in any exposure of potentially important geology being reviewed by an appropriately trained geologist who would be present in situ as necessary. Therefore the Project affords potential for a slight

beneficial effect in respect of geodiversity in the longer term with any new deposits revealed during the implementation phase potentially being preserved in situ.