Natural Area: 14. Southern Magnesian Limestone	**Geological Significance:** Considerable **(provisional)**

General geological character: This Natural Area is characterised by the easterly dipping Magnesian Limestone escarpment of the Yorkshire Province. The Permian Magnesian Limestone was deposited on the western edge of the shallow, tropical, Zechstein Sea some 255 million years ago and forms a continuous belt from the south of Sheffield to the Durham Coast. Yellow desert sands (reworked by the rising Zechstein Sea) mark the base of the Permian succession. Three distinct cycles are recognised within the overlying Magnesian Limestone; these cycles consist of interbedded evaporites, marls, siltstones and (dolomitic) limestones and relate to large scale palaeoenvironmnetal changes often culminating in the evaporation of marine waters in arid climates and the resultant formation of evaporite (salt) deposits. Zechstein-aged sediments in the Southern Magnesian Limestone Natural Area are dominated by the first cycle, characterised by the Cadeby Formation. This is a dolomitised shelf carbonate, similar to modern tropical carbonates such as the Bahamas, and contains a number of fossiliferous patch reefs in the Weatherby Member. Superficial Pleistocene deposits are not abundant occurring mainly in isolated patches on high ground. The area was affected by glacial advance on at least two occasions. An early glaciation (approximately 128,000 years BP) covered the area in ice while during the Devensian (approximately 12,000 years BP) the area was affected by periglacial (tundra-like) erosion. Gorge and cave deposits (eg. at Creswell Crags) contain extensive vertebrate remains, including evidence of human occupation, making this a key locality for interpreting the Pleistocene evolution of the British Isles.

Key geological features:

- Permian Magnesian Limestone of the Yorkshire Province
- Pleistocene stratigraphy
- Pleistocene vertebrates
- Early settlement by palaeolithic man

Number of GCR sites:

Marine Permian: 9 Pleistocene/Quaternary of Eastern England: 1 Pleistocene Vertebrata: 1
Palaeozoic Palaeobotany: 1

Geological/geomorphological SSSI coverage: There are 12 (P)SSSI in the Natural Area containing 12 GCR SILs representing 4 different GCR networks. The majority of sites are notified for their Marine Permian interests. These sites are mainly quarries, active and disused, and lie largely within the Cadeby Formation of Zechstein Cycle 1. Cadeby Quarry is the type locality for the Cadeby Formation and contains the most comprehensive sections through the Sprotborough and Weatherby Members. Patch reefs of the Weatherby Member are also particularly well exposed at Newsome Bridge Quarry and South Elmsall while lowermost Permian Yellow Sands are exposed at Bilham Sand Pits. The River Ure Cliff exposes Zechstein Cycles 2 and 3 (Edlington Formation and Brotherton Formation). Kimberley Railway Cutting contains well preserved plant remains, in particular, extinct fern-like plants that dominated the Permian and following Triassic. Creswell Crags is of international importance and is currently nominated for World Heritage Status. This is a reflection of the diverse fauna and flora (including evidence of hominid occupation) found in the cave and gorge deposits allowing the detailed interpretation of the evolution over the last 100,000 years.

Key geological management issues:

- Maintain and enhance existing exposures
- Agree conservation sections in working quarries
- Assess new sites (temporary or permanent)
- Promote the educational value of the geological resource

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures (agreed conservation in working quarries such as Cadeby, site clearance in disused quarries such as Bilham Sand Pits), b) development of local conservation strategies that include geology, c) continued assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. Promotion of geological resource through a) assessment and promotion of site educational value (particularly relevant with the urban setting of the Natural Area), b) on-site interpretation (e.g. sign boarding, trail guides, leaflets), c) promotion of initiatives that link geology and local habitats, scenery and the industrial development of the Natural Area (eg. The Creswell Initiative).

Useful guides/references:

SMITH, D.B. 1994: Marine Permian of England. Geological Conservation Review Series 8. Chapman & Hall.

EDEN, R.A., STEVENSON, I.P. & EDWARDS, W. 1957: Geology of the Country around Sheffield. Memoir of the Geological Survey of Great Britain.

EDWARDS, W. & TROTTER, F.M. 1954: British Regional Geology, the Pennines and adjacent areas. Institute of Geological Sciences. HMSO, London.

MITCHELL, G.H. *et al.* 1947: Geology of the Country around Barnsley. Memoir of the Geological Survey of Great Britain.

RAYNER, D.H. & HEMMINGWAY, J.E., 1974: The geology and mineral resources of Yorkshire. Yorkshire Geological Society.

SMITH, E.G., RHYS, G.H. & EDEN, R.A., 1967: Geology of the Country around Chesterfield, Matlock and Mansfield. Memoir of the Geological Survey of Great Britain.

WRAY, D.A. & MITCHELL, G.H. 1940: Geology of the Country around Wakefield. Memoir of the Geological Survey of Great Britain

Earth science (P)SSSIs in the Natural Area:

- Ashfield Brickpits
- Bilham Sand Pits
- Cadeby Quarry
- Creswell Crags
- River Ure Bank, Ripon Parks
- Micklefield Quarry
- New Edlington Brickpits
- Newsome Bridge Quarry
- South Elmsall Quarry
- Wood Lee Common
- Kimberley Railway Cutting
- Quarrymoor, Ripon

Natural Area: 15. Humberhead Levels	Geological Significance: Some (provisional)

General geological character: The Humberhead Levels Natural Area is essentially a low lying southern extension of the Vale of York, bounded to the west by the Permian Magnesian Limestone escarpment and to the east by the Jurassic limestones of Lincolnshire. The area is underlain by the Triassic Sherwood Sandstone Group (245-241 Ma) in the west and Mercian Mudstone Group (241-223 Ma) in the east. Triassic rocks are underlain by the Carboniferous East Pennines Coalfield. Throughout the Natural Area is capped by clays, sands and gravels of Pleistocene origin. Today the area is dominated by rivers (notably the Derwent, Ouse, Aire, Went, Don, Tourne, Idle and Trent) within which the drainage of 1/5 of England flows into the Humber.

During Carboniferous times (approximately 350 to 305 Ma) the area was first covered by a tropical sea and then by a fluvially dominated coastal plain on which the coal forming swamps of the Upper Carboniferous were deposited (East Pennines Coalfield). During Permian and Triassic times the area was situated on the SW margin of an intra-continental depression dominated by a Saharan-like climate. The Triassic saw the area covered by fluvial sands (Sherwood Sandstone Group) superseded by lagoonal and peritidal mudstones (Mercia Mudstone Group). Subsequently, there is no depositional evidence until the Quaternary when the area was covered by an ice sheet (Anglian glaciation, approximately 500,000 years BP) cutting glacial channels which were filled with sand and gravel. During the last glaciation (Devensian; approximately 12,000 years BP) the Humber was blocked by ice leading to the formation of Lake Humber across the Vale of York. The Flandrian (from 10,000 years BP onwards) saw sea level rise to present levels and the accumulation of peat in areas such as Thorn Moors documenting the most recent vegetational changes in the Natural Area.

Key geological features:

- Economic resource; concealed East Pennines Coalfield and UK's only inland gas field
- Triassic stratigraphy and palaeogeography
- Pleistocene stratigraphy and palaeogeography
- Flandrian peat deposits
- Present-day drainage pattern

Number of GCR sites:

None

Geological/geomorphological SSSI coverage: There are no geological/geomorphological (P)SSSIs in this Natural Area. The subsurface geology has been proved through extensive borehole investigation associated with the economic exploitation of the concealed East Pennines Coalfield. Scattered surface exposures include brick pits, sand and gravel pits, occasional quarries and cuttings and natural river exposures.

Key geological management issues:

- Improvement of the limited surface exposure
- Improvement of awareness of the geological resource

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures (especially RIGS), b) development of local conservation strategies that include geology, c) assessment of educational/research value of new sites (eg. quarries and cuttings, temporary or permanent).

2. Promotion of geological resource through a) assessment and promotion of site educational value, b) on-site interpretation (eg. sign boarding, trail guides, leaflets), c) promotion of the link between geology and local habitats, scenery and the industrial development of the Natural Area (eg. concealed East Pennines Coalfield).

Useful guides/references:

GAUNT, G.D. 1994: Geology of the country around Goole, Doncaster and the Isle of Axholme. Memoir of the British Geological Survey, Sheets 79 & 88.

Earth Science (P)SSSIs in the Natural Area:

None

Natural Area: 16. Coversands	**Geological Significance:** Some **(provisional)**

General geological character: The solid geology of the Coversands Natural Area is dominated by rocks of Lower and Middle Jurassic age (208-157 Ma). These consist of limestones deposited on the floor of a tropical sea in warm, clear water during this time. Of particular importance are the deposits of Lower Jurassic age (Liassic), especially the formerly economically important Frodingham Ironstone. This deposit is rich in fossil remains including internationally famous ammonites.

Later in the Jurassic, the deposition of limestones gave way to marine clays deposited when the waters contained higher sediment concentrations. The overlying clay-dominated sequence culminates in limestones of the Middle Jurassic. The Jurassic limestones and clays are overlain by Quaternary (the last 2 million years) deposits including the coversands which give the Natural Area its name. The coversands are a more or less continuous sheet of wind blown sands which indicate very dry and cold (periglacial) conditions existed prior to the onset of glaciation in the area. The coversands probably accumulated over a permafrost terrain beyond the margin of an ice sheet less and are believed to have been derived from proglacial outwash in the North Sea Basin. They are most likely Late Devensian in age (approximately 30,000 years BP). There is evidence that some of these coversands have moved within historical time, suggesting that they may be susceptible to environmental change.

Key geological features:

- Ironstone workings with remarkably complete liassic sequences.
- Economically and palaeontologically important ironstone.
- Quaternary wind blown sands (coversands).

Number of GCR sites:

Quaternary of North East England: 2 Hettangian-Pliensbachian: 1 Aalenian-Bajocian: 1

Geological/geomorphological SSSI coverage: There are 4 (P)SSSIs in the Natural Area containing 4 GCR SILs and representing 3 different GCR blocks. The Jurassic sites include a famous representative of the Frodingham Ironstone at Conesby Quarry SSSI, and one site showing the stratigraphy of the Middle Jurassic limestones at Manton Stone Quarry SSSI. Two sites represent the Quaternary history of the area. Risby Warren SSSI is a site noted for the development of coversands, whilst at Castlethorpe Tufas SSSI a sequence of calcareous tufa (redeposited calcium carbonate derived from spring waters) records the environmental and climatic changes which have affected the area during the Quaternary.

Key geological management issues:

- Potential conflict between fossil collecting and conservation at sites such as Conesby Quarry
- Loss of geological resource (including Jurassic rocks) through large scale infilling of former ironstone quarries.

Key geological objectives:

1. **Continue scientific assessment and recording** of the geological resource
2. **Encourage responsible fossil collecting** at sensitive or vulnerable sites
3. **Safeguard important geological sites from landfill threat**
4. **Encourage projects aimed at integrating geological and biological conservation**

Useful guides/references:

KENT, P. 1980: British Regional Geology. Eastern England from the Tees to the Wash. Institute of Geological Sciences, HMSO, London.

JONES, R.L. & KEEN, D.H. 1993: Pleistocene Environments in the British Isles. Chapman and Hall, London.

KNELL, S. J. 1988: The natural history of the Frodingham Ironstone. Scunthorpe Museum.

Earth science (P)SSSIs in the Natural Area:

- Conesby Quarry
- Risby Warren
- Castlethorpe Tufas
- Manton Stone Quarry

Natural Area: 17. Sherwood Forest	**Geological Significance:** Some **(provisional)**

General geological character: The Sherwood Forest Natural Area is characterised by the low N-S escarpment of the Triassic Sherwood Sandstone Group (bounded to the west by the Permian Magnesian Limestone escarpment and to the east by the Triassic Mercia Mudstone Group). Underlying much of the Natural Area is the concealed Upper Carboniferous East Pennine Coalfield. Pleistocene deposits include clays, sands and gravels capping hills and filling valleys.

The Sherwood Sandstone Group is fluvial in origin, deposited by rivers that flowed northwards across the area. Uplift and erosion have removed Jurassic, Cretaceous and Tertiary sediments. During Pleistocene times the area was covered by at least one glaciation (pre-Devensian, earlier than 100,000 years BP) which left behind glacial clays, sands and gravels and outwash plains. Subsequently, the area has undergone general denudation and down cutting of rivers such as the Trent. The concealed East Pennines Coalfield has in the past been economically important, associated exploration and mining providing much of our current geological knowledge of the area. Carboniferous strata have also yielded oil (eg. Bothamsall Oilfield). The Sherwood Sandstone forms an important aquifer supplying cities such as Nottingham.

Key geological features:

- Sherwood Sandstone Group; palaeoenvironments
- Economic resource; East Pennine Coalfield and Sherwood Sandstone aquifer

Number of GCR sites:

Permian - Triassic: 2

Geological/geomorphological SSSI coverage: There are 2 (P)SSSIs in the Natural Area containing 2 GCR SILs representing 1 GCR network. Both the sites are key locations for understanding the detailed sedimentology and palaeoenvironments of the Sherwood Sandstone Group (Nottingham Castle Formation). Scrooby Top Quarry (active) has faces cut parallel to palaeocurrent directions and Styrrup Quarry (disused) has complimentary sections transverse to palaeocurrent direction.

Key geological management issues:

- Conservation in active and disused quarries
- Assessment of the geological resource (e.g. RIGS)
- Promotion of the educational and scientific value of geological resource

Key geological objectives:

1. Maintenance and enhancement of the geological resource through a) enhancement of existing exposures and agreed conservation sections in active and disused quarries , b) development of local conservation strategies that include geology, c) assessment of educational/research value of new sites (e.g. quarries and cuttings, temporary or permanent, potential RIGS).

2. Promotion of geological resource through a) assessment and promotion of site educational value, b) on-site interpretation (e.g. sign boarding, trail guides, leaflets), c) promotion of the link between geology and local habitats, scenery and the industrial development of the Natural Area (e.g. concealed East Pennines Coalfield, Sherwood Sandstone aquifer).

Useful guides/references:

EDWARDS, W.N., 1967: Geology of the Country around Ollerton. Memoir of the Geological Survey of Great Britain.

SMITH, E.G., RHYS, G.H. & GOOSTENS, R.F. 1973: Geology of the country around East Retford. Memoir of the Geological Survey of Great Britain.

Earth science (P)SSSIs in the Natural Area:

- Scrooby Top Quarry
- Styrrup Quarry

Natural Area: 18. Trent Valley and Levels	**Geological Significance:** Considerable **(provisional)**

General geological character: The Trent Valley and Levels Natural Area is a broad expanse of Triassic rocks (around 240 Ma) draped over the older Precambrian and Ordovician rocks of Charnwood Forest (between 600 and 400 Ma). The Precambrian rocks are some of the oldest rocks in England and consist of a series (the 'Charnian') of igneous grits, lavas and volcanic ashes. The Ordovician rocks were intruded into the area 150-200 million years after the Charnian rocks and consist mainly of igneous granites and granodiorites. They are exposed around the Nuneaton area where they are worked in quarries. An economically important mineral resource, the Carboniferous Coal Measures, also underlie this area and crop out around Ashby de la Zouch.

The later Triassic rocks (approximately 245 to 210 Ma) represent a period of mountainous desert conditions and consist of Bunter Sandstones and Keuper Sandstones (now known collectively as the Sherwood Sandstone Group) and Keuper Marls (now known as the Mercia Mudstone Group). These rocks are the product of the migration of desert dunes across the area: the Sherwood Sandstones are composed of coarse grained desert sands and the Mercia Mudstones are a thick sequence of calcareous clays laid down in ephemeral lakes on the floor of the desert. The Mercia Mudstones are both the thickest and most extensive of the Triassic deposits in the area, giving rise to a subdued and generally low lying landscape. This thick blanket of mudstone is broken only by the inliers of the more resistant Precambrian rocks at Charnwood Forest and by the Leicestershire coalfield. The River Trent follows the gentle eastern dip of the Triassic rocks to form a broad lowland, partly infilled with glacial sands, gravels and clays deposited during the Quaternary 'Ice Ages' (the last 2 million years). The soils derived from these glacial deposits are rich in clay and often impermeable so that the Trent occupies a wide and open floodplain over much of its course. The present day floodplain lies at the bottom of a staircase of river terraces deposited by the Trent over the Quaternary sediments. These terraces are composed of fluvial sands and gravels and are often fossiliferous, containing the remains of Quaternary mammals.

Key geological features:

- Precambrian rocks, Caledonian igneous rocks and associated mineral veins
- Exposures of Triassic rocks
- River Trent terraces and associated river gravels and fossils

Number of GCR sites:

Mineralogy of the Peak District, Leicestershire and Cheshire: 5 Caledonian Igneous: 3 Cambrian: 2
Dinantian of North England and North Wales: 2 Hettangian-Pliensbachian: 1
Pleistocene/Quaternary of the Midlands: 1

Geological/geomorphological SSSI coverage: There are 12 (P)SSSIs in the Natural Area containing 14 GCR SILs representing 6 different GCR networks. The site selection is dominated by those showing the nature of the Caledonian igneous activity and associated mineralisation. There are relatively few exposures of the Triassic rocks in the area. This is because the harder and more resistant Precambrian rocks have been quarried for stone, whilst the softer Triassic sandstones and marls are not economically important. The exposures at Boon's Quarry SSSI show the important Precambrian/Cambrian unconformity, whilst Gipsy Lane Pit SSSI demonstrates the sedimentary structures and mineralogy of the Mercia Mudstone Group. The site at Enderby Warren illustrates post-Triassic mineralisation in the rocks of the area. Boulton Moor SSSI is an important site showing both glacial and fluvial sedimentation and the environmental changes over the Quaternary.

Key geological management issues:

- Management of existing geological sites to safeguard exposures of Precambrian, Cambrian, Triassic and Quaternary sediments
- Lack of exposures in Triassic sandstones and marls
- Potential conflict between mineral extraction industry, landfill and geological conservation
- Management of the River Trent and its floodplain to maintain natural processes within the Natural Area

Key geological objectives:

1. Maintain and where possible enhance the existing geological exposures by agreeing management plans with owners and occupiers

2. Negotiating long-term conservation of exposures with mineral extraction companies at key geological sites

3. Encourage the creation and recording of both temporary and permanent exposures in the poorly-exposed Triassic sediments of the area as part of road schemes and other developments

Useful guides/references:

AUDLEY-CHARLES, M.G. 1992: Triassic *in* DUFF, P.McL.D. and SMITH, A.J. (eds.). Geology of England and Wales. The Geological Society, London.

SYLVESTER-BRADLEY, P.C. & FORD, T.D. 1968: The Geology of the East Midlands. Leicester University Press.

Earth Science (P)SSSIs in the Natural Area:

- Boulton Moor
- Breedon Cloud Wood and Quarry
- Buddon Wood and Swithland Reservoir
- Dimminsdale
- Enderby Warren Quarry
- Gipsy Lane Pit
- Tilton Cutting
- Boon's Quarry
- Croft and Huncote Quarry
- Colwick Cutting
- Ticknall Quarries
- Woodlands Quarry

Natural Area: 19. Charnwood Forest	**Geological Significance:** Outstanding **(provisional)**

General geological character: The upland peaks of the Charnwood Forest Natural Area are formed by some of the oldest rocks in England. The late Precambrian age (600 Ma) slates, grits, lavas and volcanic ashes are partly buried by more recent rocks, but still form the summits of Charnwood reaching 278 m AOD at Bardon Hill. The Precambrian rocks are famous for their soft-body trace fossils ('sea-pens' and possible medusoids) which are the earliest known evidence of life recorded in England. The Precambrian "Charnian" rocks have been deformed giving them a slaty appearance, and were subsequently intruded by great masses of molten rock. These molten rocks now form the many diorites in the area which are the basis of the important Leicestershire quarrying industry. The ancient Charnian rocks were eroded to form a mountainous desert landscape during the Triassic Period (about 240 million years ago). The sands, salt pans and wadis of this desert now form the red Triassic rocks between the Charnian peaks. Several of the Charnwood summits are capped by tors, adding to the upland nature of the area. The whole area has been lowered by recent river erosion, and many narrow gorges such as that of Bradgate Park follow Triassic wadis in the resistant Precambrian rocks.

Key geological features:

- Precambrian fossils
- Precambrian rocks, Caledonian igneous rocks and associated mineralveins
- Precambrian hills and associated summit tors
- Deep river gorges

Number of GCR sites:

Precambrian of England and Wales: 7 Mineralogy of the Peak District, Leicester and Cheshire : 4
Precambrian Palaeontology: 4 Caledonian Igneous: 3 Quaternary of Midlands/Avon: 2
Dinantian of Northern England and Wales: 1

Geological/geomorphological SSSI coverage: There are 12 (P)SSSIs in the Charnwood Forest Natural Area containing 21 GCR SILs representing 6 different GCR networks. The sites are selected predominantly for the Precambrian rocks, and their associated minerals and fossils. Many of these sites are naturally occurring outcrops, but some are located in quarries or around reservoirs. Charnwood is internationally famous for the soft-body trace fossils present in the Precambrian rocks. These are the earliest evidence of multicellular life reported in Britain, prior to the explosion of life in the suceeding Cambrian Period. These rocks are amongst only a handful known throughout the world and hold a high significance (potential World Heritage Site) in our understanding of life on earth. Other Precambrian and igneous sites within the Natural Area are nationally important in providing rare opportunities to study rocks which are mostly buried beneath many miles of younger rocks across the remainder of the country.

Key geological management issues:

- Management of existing natural geological sites to safeguard the Charnian stratigraphy and fossil localities, summit tors and other important geological sites.
- Potential conflict between mineral extraction industry, landfill and geological conservation
- Maintain natural processes such as river flow within the Natural Area.

Key geological objectives:

1. Maintain and where possible enhance the existing natural geological exposures, fossil localities and landforms in the Natural Area by agreeing management plans with owners and occupiers

2. Negotiating long-term conservation of exposures with mineral extraction companies in key geological sites

3. Encourage initiatives aimed at increasing public enjoyment and interpretation of the Charnwood Forest Natural Area such as signboarding and geological trail opportunities.

4. Maintain the operation of natural processes in the area, such as the hydrological regimes of rivers.

5. Promote responsible fossil collecting at sensitive sites

Useful guides/references:

SYLVESTER-BRADLEY, P.C. & FORD, T.D. 1968: The Geology of the East Midlands. Leicester University Press.

MOSELY, J. & FORD, T.D. 1985. A stratigraphic revision of the Late Precambrian rocks of Charnwood Forest, Leicestershire. Mercian Geologist 10

Earth science (P)SSSIs in the Natural Area:

- Bradgate Park and Cropston Resevoir
- Buddon Wood and Swithland Resevoir
- Charnwood Lodge
- Cliffe Hill Quarry
- Grace Dieu and High Sharpley
- One Barrow Plantation
- Bardon Hill Quarry
- Beacon Hill, Hangingstone and Outwoods
- Main Quarry, Mountsorrel
- Newhurst Quarry
- Swithland Wood and the Brand
- Dimmimsdale

Natural Area: 20. Lincolnshire Limestone	**Geological Significance:** Notable **(provisional)**

General geological character: The Lincolnshire Limestone Natural Area is dominated by Middle Jurassic (178-166 Ma) limestones which are assigned to the Lincolnshire Limestone 'Formation'. Earlier Jurassic deposits exposed include the northern limits of the Northampton Sand Ironstone which was formerly of high economic importance. This is overlain by the Lincolnshire Limestone, which probably represents the northern most occurrence of the Middle Jurassic carbonate platform in Europe, with shallow water deposits typical of tropical shallow seas. It is also a very important building stone in eastern England and has been exploited since Roman times. Similarly, the thinly laminated Collyweston 'slate', actually a calcareous sandstone here, has long been exploited as a roofing material.

Key geological features:

- Northern most developments of economically important Northampton Sand Ironstone
- Some of the northernmost developments of a Middle Jurassic carbonate platform in Europe
- Collyweston Slate, a fissile calcareous sandstone, historically used for roofing slates.

Number of GCR sites:

Aalenian-Bajocian: 9 Bathonian: 1

Geological/geomorphological SSSI coverage: There are 9 (P)SSSI in the Natural Area containing 10 GCR SILs which represent 2 different GCR networks. The site coverage includes key exposures within the Lincolnshire Limestone representing Lower, Middle and Upper units. Greetwell Hollow Quarry is historically very important with a near-complete sequence exposed. Similarly, Ketton Quarries exposes the complete Limestone sequence type sections (Rutland Formation) in the overlying Bathonian Estuarine Series. Sproxton exposes Lower Lincolnshire Limestone and the Northampton Sand Formation which were both formerly quarried at this site. Many of these sites are building stone quarries, notably old mine workings at Collyweston, the origin of the famous 'Collyweston Slate'.

Key geological management issues:

- Threat to disused quarries by infill
- Deterioration of sites due to vegetation encroachment.

Key geological objectives:

1. **Ensure sites safeguarded against damaging infill**

2. **Establishment of appropriate management of sites** to promote educational/recreational use and **agreement of conservation sections** in working quarries

3. **Adoption of geological conservation policies** in local plans

Useful guides/references:

ASHTON, M. 1980: The stratigraphy of the Lincolnshire Limestone Formation (Bajocian) in Lincolnshire and Rutland (Leicestershire). Proceedings of the Geologists' Association, 91, 203-223.

KENT, P. 1980: British Regional Geology, Eastern England, the Tees to the Wash. Institute of Geological Sciences, HMSO, London

SYLVESTER-BRADLEY, P.C. & FORD, T.D. 1968: The Geology of the East Midlands. Leicester University Press

TAYLOR, J.H. 1963: Geology of the area around Kettering, Corby and Oundle (Sheet 171). Memoir of the Geological Survey of Great Britain. HMSO, London.

Earth science (P)SSSIs in the Natural Area:

- Castle Bytham Quarry
- Clipsham Old Quarry & Pickworth Great Wood
- Collyweston Slate Mine
- Ketton Quarries
- Sproxton Quarries
- Cliff Farm Pit
- Copper Hill
- Greetwell Hollow Quarry
- Metheringham Heath Quarry

Natural Area: 21. Lincolnshire Clay Vales	**Geological Significance:** Some **(provisional)**

General geological character: The Lincolnshire Clay Vales Natural Area is underlain by Middle Jurassic (178-161 Ma) clays with some thin bands of limestones (including the highly fossiliferous Abbotsbury Cornbrash Formation). Overlying these is a thick sequence of mainly Upper Jurassic clays - the Oxford, Ampthill and Kimmeridge clays (approximately 161-152 Ma). The Middle Jurassic deposits were laid down in a complex system of rivers and swamps. The Upper Jurassic clays were laid down in relatively deep tropical seas. These clays sometimes yield good fossil faunas including ammonites of national/international importance for dating rocks. Unfortunately few exposures now exist as most sites have been filled in or otherwise lost.

The area was on the southern limit of the last glaciation (Devensian) and though not covered by the Devensian ice sheet was affected by tundra-like periglacial erosion. Ice-damming of the Wash is believed to have created lakes which covered the southern part of the area.

Key geological features:

- Middle Jurassic clays and limestones
- Upper Jurassic clays some with historically famous faunas (eg. the ammonite *Rasenia* from Market Rasen)

Number of GCR sites: None.

Geological/geomorphological SSSI coverage: Although there are no GCR sites in the Natural Area, the following GCR blocks may have relevance in the future if any revisions are undertaken: the Oxfordian, Callovian, Bathonian and Pleistocene/Quaternary of Eastern England.

Key geological management issues:

- Lack of exposure.

Key geological objectives:

1. Enhance the geological resource by (a) identifying sites for conservation, (b) re-excavate of former sites of important, c) recording of new exposures, temporary or permanent.

2. Ensure RIGs system identifies and conserves sites not (yet) determined to be of SSSI status.

Useful guides/references:

KENT, P. 1980: British Regional Geology, Eastern England; from the Tees to the Wash. Institute Of Geological Sciences. HMSO. London

SWINNERTON, H.H. & KENT, P.E. 1976. The Geology of Lincolnshire. Lincolnshire Naturalists Union, 2nd Edition.

Earth science (P)SSSIs in the Natural Area:

None

Natural Area: 22. Lincolnshire Wolds	**Geological Significance:** Notable **(provisional)**

General geological character: The solid geology of the Lincolnshire Wolds Natural Area is dominated by the succession of Cretaceous rocks including a great thickness of Upper Cretaceous Chalk (deposited around 97-74 Ma) which forms the Wolds themselves. This chalk is a very pure limestone deposited on the floor of clear and warm tropical sea. Of particular importance within the Natural Area, however, is the sequence of Lower Cretaceous sandstones, ironstones and subordinate clays deposited prior to the chalk (around 145-97 Ma). These deposits often yield a fossil fauna of bivalves and ammonites showing Arctic affinities which allow international correlation with similar deposits on the Russian Platform, Greenland and Arctic Canada.

During the Quaternary (the last 2 million years), the area was glaciated on several occasions and as a result local areas of glacial deposits are present, representing an unknown number of glacial ('Ice Age') and interglacial phases. The glacial deposits consist mainly of sands, gravels and clays in variable thicknesses. These are derived primarily from the erosion of surrounding bedrock and therefore tend to have similar lithological characteristics, usually with a high chalk content. The glacial deposits are particularly important because of the controversy surrounding their correlation with the timing and sequence in other parts of England, especially East Anglia.

Key geological features:

- Exposures of the Lower Cretaceous deposits and associated Arctic fossil faunas
- Chalk Wolds
- Exposures of the glacial deposits

Number of GCR sites:

Berriasian-Barremian: 6 Quaternary of Eastern England: 2 Aptian-Albian: 1

Geological/geomorphological SSSI coverage: There are 8 (P)SSSIs in the Natural Area covering 9 GCR SILs representing 3 different GCR networks. The site coverage emphasises the importance of the Cretaceous deposits (eg. at Benniworth Haven, Hundleby, etc) for the understanding of Lower Cretaceaous lithostratigraphy, biostratigraphy, and the palaeogeography of Cretaceous north-eastern England. Welton le Wold Old Gravel Pits is a key site for Quaternary stratigraphy and for studying the relationship between glacial events in England.

Key geological management issues:

- Threats to geological sites from disuse or neglect
- Possible threat to important localities from fossil collecting at sensitive or vulnerable sites

Key geological objectives:

1. **Encourage program of site clearance** to enhance disused Lower Cretaceous sites

2. **Develop educational use and interpretational value of geological sites** in the Natural Area

Useful guides/references:

KENT, P. 1980: British Regional Geology Eastern England, Tees to the Wash. Institute of Geological Sciences, HMSO. London.

JONES, R.L. & KEEN, D.H. 1993: Pleistocene Environments in the British Isles Chapman and Hall, London

Earth science (P)SSSIs in the Natural Area:

- Winceby Rectory Pit
- Kirmington Pit
- Benniworth Haven Cuttings
- Dalby Hill
- Harrington Hall Sandpit
- Hundleby Clay Pit
- Nettleton Chalk Pit
- Welton le Wold Old Gravel Pits