Common Standards Monitoring Guidance

for

Earth Science Sites

Version February 2004

ISSN 1743-8160 (online)

Common Standards Monitoring guidance for Earth science sites

1 OVERVIEW

1.1 This document aims to provide general guidelines and a framework for common standards for monitoring Earth science (geological and geomorphological) sites. It is not intended to provide a universal template for recording sites in the field, nor does it supersede detailed guidance being issued by statutory nature conservation agencies in the UK to monitoring personnel. Its purpose is to demonstrate the rationale and summarise the common principles that underpin Earth science SSSI and ASSI site monitoring work in the UK.

1.2 Although geology and geomorphology have a fundamental role in determining habitat type, the monitoring of types of habitat that are strongly dependent on underlying geology/geomorphology – e.g. chalk grassland, sand dunes as a coastal habitat feature, or karst as a habitat – is covered by separate guidance. However, 'mixed' interest sites – containing both biological and geological features of interest will need to be reported on separately (e.g. Bempton Cliffs, Yorkshire, will be monitored for its geology and independently for its breeding seabird colonies).

2 INTRODUCTION: GEOLOGICAL SIGNIFICANCE OF THE UK

2.1 The comparatively small, but complex, part of the Earth's crust we call the 'United Kingdom' contains an unusually diverse assemblage of rocks, mineral and fossil deposits, landforms and superficial deposits that provide a natural record much of the long physical and biological history of the Earth. In fact, this geological 'record' in the UK spans over three billion years, with every geological 'system' being represented by rocks in the UK. Such a rich *Earth heritage* in such a small area is highly unusual, and it reflects a particularly dynamic geological history. Sites of importance to the study of Earth sciences are a fundamental part of our Earth heritage, the latter term embracing a wider perspective that includes aesthetic and cultural aspects of the geological and geomorphological significance of the UK.

2.2 It is perhaps because of this unusual diversity, coupled with the scientific awakening that began over two hundred years ago, that the UK is frequently referred to as the 'cradle of geology' – the place where study of rocks, sediments, fossils and the features of the landscape led to the development of geological science itself. Generations of leading geologists have studied – and continue to study – the geology and geomorphology of the UK, and sites here continue to contribute to the development and testing of theories, and to the unravelling of the geological history of the islands.

2.3 This founding position in the development of the Earth sciences not only gives the UK a historical, and ongoing, significance in the study of geology, geomorphology and Earth history, but also has led to the establishment here of formally recognised sedimentary rock successions that are used internationally as comparative standards ('stratotypes'). In fact, many of the divisions of geological time used throughout the world are named after British sites or areas, for instance the Cambrian, Ordovician and Devonian systems, the Ludlow Series and the Kimmeridgian and Portlandian stages.

2.4 Further importance in UK sites is as renowned, archetypal, 'textbook' features (e.g. the Giant's Causeway, County Antrim – columnar basalt jointing, and Chesil Beach, Dorset – gravel barrier beach/tombolo). Also, there are sites that are widely recognised as playing a key role in the development of the Earth sciences (e.g. earth movements at Hutton's Unconformity, Siccar Point, Berwickshire; cauldron subsidence in Glencoe, Argyll, and ancient glaciation at Agassiz Rock in Edinburgh). There are also internationally famous

'type' sites – yielding definitive fossil, rock or mineral material – some sites even lending their names to minerals and fossils, such as Cayton Bay, Yorkshire – the fossil tree *Caytonia*, and Angelsey (Ynys Mon) – the mineral anglesite). Furthermore, many fossil and mineral names originate from eponymous geologists from the UK studying specimens recovered from rocks here – for example, Geikielite after Sir Archibald Geikie and *Megalosaurus bucklandi* after William Buckland.

2.5 *Earth science site conservation – rationale*

2.5.1 Much of the information that allowed us to build up a picture of Britain's Earth history and understand the underground arrangement of rock formations relies upon the availability of field sites for study and interpretation. To piece together the geological history of Britain stretching back hundreds of millions of years, tens of thousands of sites have been studied and documented. Although it is impracticable to conserve every rock exposure and landform feature, it is important that the most important of these sites remain available for study. The most distinctive and most representative sites of importance to scientific research have been identified through site-based evaluation programmes with a view to their long-term conservation and statutory protection.

2.5.2 For Earth sciences in *Britain*, the statutorily conserved sites are those localities that were identified by the Geological Conservation Review (1977 to the present), according to the criteria summarised in Ellis *et al.*, 1996. In Northern Ireland, the broadly similar Earth Science Conservation Review (ESCR) provides the rationale and methods for Earth science ASSI selection.

3 DEFINING EARTH SCIENCE INTEREST FEATURES

3.1. The definition of Earth science interest features for monitoring must relate to the reasons for the selection of geological and geomorphological SSSIs and ASSIs, and therefore relate to GCR and ESCR site selection categories. The GCR sites were selected according to around 100 geological categories, called 'GCR Blocks'. Suites of sites were selected for these categories, but only the *minimum number* of sites were chosen in order to represent the scientific highlights of the geology and geomorphology, so there is minimal duplication of features of special interest between sites. The detailed reasons for why a particular site qualified for selection for a GCR/ESCR 'Block' are documented in SSSI/ASSI citations, the GCR Series of publications and in country conservation agency site archives.

3.2 In the Earth sciences, it is the combination of ESCR and GCR 'Blocks' that is used as the interest feature list (Appendix 1). It should be noted that this list is not the exactly the same as the list of GCR Blocks, because JNCC needs to report at a UK level and therefore has produced an aggregated ('common denominator') interest feature categorisation that embraces both ESCR and GCR Blocks. However, it is a simple matter for JNCC to aggregate data if supplied by GCR or ESCR Block for the relevant interest feature, since each interest feature relates to one or more GCR and ESCR Blocks (i.e. Blocks are not divided across interest features).

3.3 The interest features can be grouped into seven broad themes:

- Stratigraphy
- Palaeontology
- Quaternary geology and geomorphology
- Geomorphology
- Igneous petrology
- Structural and metamorphic geology
- Mineralisation

The differences between the broad categories of interest features are outlined below. A full list of the 78 Earth science interest features is given in Appendix 1.

3.4 *Stratigraphy*

3.4.1 For the most part, stratigraphical interest features relate to stratigraphical age (principally, geological *stages*) or to a range of stratigraphical ages (e.g. Caradoc–Ashgill). Some stratigraphical interest features, however, were defined not purely by age, but also by environmental setting, where there are significant variations in rocks across the UK formed at the same time. This is why there are two for the Devonian Period, one for marine rocks and one for non-marine rocks. Sites that are of particular interest for their sedimentology (e.g. lithology or sedimentary structures) are included within the stratigraphy interest features.

3.4.2 Most sites that are important to geological research because of their invertebrate fossils (e.g. trilobites, corals, echinoderms, shellfish, ammonites and other molluscs) are also addressed within the stratigraphical interest features, because these fossils are widely used in correlating rock strata and are relatively common. Therefore, some 'stratigraphy' sites will have been selected specifically for their fossil invertebrate content, because they are of crucial importance palaeontologically and palaeobiologically, or because they yield significant assemblages of invertebrates that provide evidence for past ecosystems and the evolution of life. Moreover, some sites have international significance because they have yielded fossils that are the 'type' material for a taxonomic group.

3.4.3 However, because of the relative rarity of vertebrate and terrestrial plant fossils, these are covered by separate palaeontological interest features.

3.5 *Palaeontology*

In contrast to the manner in which most invertebrate fossils are represented, fossils of vertebrates (reptiles, fish, mammals, birds), arthropods (insects, arachnids, terrestrial and aquatic crustaceans *excluding trilobites* [which are relatively common]), and terrestrial plants do have their own dedicated interest features. These address the evolution and diversity of significant animal and plant groups that are not included in the stratigraphy blocks (see above). Geological time is used as the basis to define some interest features, for example, Jurassic-Cretaceous *Reptilia*.

3.6 *Quaternary geology and geomorphology*

During the Quaternary Period (the Pleistocene Epoch and 'Recent' (Holocene) times, together representing the time period from about 2 million years ago to the present day) northern UK was covered by a succession of ice sheets, whereas southernmost Britain was not glaciated, a history that has resulted in a variety of Quaternary stratigraphical units and range of geomorphological features of this age in different parts of the UK. The relative recency of Quaternary landforms and sediments means that there are potentially a large number of surviving sites available for study, with a more 'complete' record of geological events than older sediments. In consequence of the regional 'distinctiveness' and numbers of sites available, the Quaternary interest features are classified on a *regional* basis. Sites included in the Quaternary interest features are those that represent the stratigraphy and fauna and flora of Quaternary successions, and the development of landforms.

3.7 *Geomorphology*

Geomorphology interest features cover the history and development of landforms and geomorphological processes that are actively evolving today, for example, in rivers, coasts, caves and landslides. Unlike geological sites where processes can only be inferred, active geomorphological sites provide field sites where active processes can be studied directly. Some of these sites also include important static, relict (no longer active) geomorphological features in the assemblage of landforms (e.g. emerged beaches, stabilised/vegetated dunes and relict spits) that contribute to the historical and scientific interest of the site.

3.8 *Igneous Petrology*

3.8.1 The igneous petrology interest features relate to major episodes of intrusive and extrusive igneous activity in the UK. These major episodes of igneous activity form the basis of six igneous interest features, and these are associated with the effects of mountain building activity, such as the Caledonian Igneous rocks associated with the Caledonian 'Orogeny', and the 'opening' of oceans (e.g. Tertiary Igneous events, responsible for the British Tertiary Volcanic Province and the Antrim basalts). .

3.8.2 Sites that are important for unravelling the geological history of these major igneous events will also be important for demonstrating general processes of igneous rock petrology, magma evolution and emplacement, and vulcanology (e.g. Cauldron Subsidence theory at Glencoe) irrespective of their role in building up a picture of the sequence of events of geological history of the UK.

3.9 *Structural and Metamorphic Geology*

3.9.1 Structural interest features relate to the rock deformation and metamorphic processes during three major mountain building orogenies (e.g. Caledonian, Variscan and Alpine) and their variation across the UK. These interest features include geological structures such as folds and faults and other phenomena resulting from compressional and tensional forces acting within the crust of the Earth, as well as petrological change resulting from (thermal and/or compressional) metamorphism.

3.9.2 Four interest features relate to Precambrian rocks in Scotland and Ireland: Torridonian, Moine, Lewisian and Dalradian. Three of these, Moine, Lewisian and Dalradian have been deformed and metamorphosed during mountain building.

3.10 *Mineralisation*

These interest features relate to minerals produced as the result of igneous, metamorphic or sedimentary processes according to major regions that have a linked geological setting, or 'ore province'.

4 THREATS

4.1 The need to take active measures to conserve geological sites is, perhaps, less obvious than for biological sites, which ensure the survival of important or rare animals, plants and habitats. Rocks are, after all, commonly hard and durable, and some have existed for many millions of years. Similarly, some mature landscapes have remained almost unchanged for centuries. However, resources such as crushed rock, sand and gravel are required to meet the demands of modern society. There is also an increasing need for waste disposal sites, and

quarries, gravel pits, old mines and caves have all been used for this purpose. Some historically important sites have been lost to science as a result.

4.2 Some engineering practices can also pose problems for Earth heritage sites. In protecting coastal cliffs from further erosion, rock exposures of value to science may be covered. Such practice not only conceals the geology and geomorphology, but may exacerbate erosion elsewhere by altering the geomorphological process regime, for example, cutting off the sediment supply that feeds and maintains coastal shingle bars, beaches, saltmarshes and mud flats, causing them to become eroded by the action of the sea. Similarly, river engineering works have altered natural fluvial geomorphological features, and commercial and industrial developments have destroyed or covered sites. Even the shape of the land has been changed as features are levelled or exploited to extract materials for the construction industry, and the planting of coniferous trees in upland areas has obscured landforms and geological exposures. Development and the effective conservation of the Earth heritage are not mutually exclusive if properly co-ordinated.

4.3 *Quarrying*

Rock exposures created by quarrying and related activities have played a key role in the interpretation of Britain's geology and have proved vital to the development of the Earth sciences over the last 200 years. Although active quarrying and conservation of the Earth heritage may not appear to be compatible, since quarrying is essentially a destructive process, it has also *revealed* exposures of rock formations, mineral veins and fossils than would otherwise have been known from natural exposures alone. Therefore, quarrying can be both a threat and a potential benefit. This situation also applies to road construction, which can both destroy exposures and create new ones.

4.4 *Fossil/mineral collecting/ research excavation*

4.4.1 Specimen collecting is a problem on a small number of sites, depending on the scale of collecting and the extent of the fossil/mineral bearing resource. Responsible collecting is generally not a problem on sites where the resource is extensive (for a definition of ‘responsible collecting’ see http://www.jncc.gov.uk/earthheritage/module/jnccfoss.htm). If collecting of rock, fossil or mineral specimens is considered to be damaging – i.e. unsustainable at present removal rates (whether the collecting has been consented to or not) – then the conservation objectives should state what level/method of collecting can be tolerated, and what the threshold to ‘unfavourable status’ on the site would be; active management of collecting should be initiated if necessary.

4.4.2 If the resource is of limited extent, collecting may represent a serious threat to the interest and the site will be generally vulnerable to damage by collecting, and therefore a greater frequency of monitoring, and active management of collecting are required (see the section entitled ‘Rare Mineral Or Fossil Deposit Or Unusual Body Of Rock Of Limited Extent’ below for further discussion). Consented removal of vulnerable material will not be reported as ‘destruction’ if it is placed in a suitable repository, e.g. to a museum where the material will be preserved for research *ex situ*.

4.4.3 Where soft sediments are excavated or ‘trenched’ for stratigraphical study, thresholds and guidelines for the scale and frequency of such disruptive activity should be set, taking into account the extent of the resource and the perceived gain in scientific knowledge likely to be achieved by the excavation, since repeated trenching and infilling could ultimately destroy the stratigraphy if the sedimentary deposit is of limited extent.

5 THE EARTH SCIENCE CONSERVATION CLASSIFICATION (ESCC)

5.1 In the Earth sciences, it is not helpful to give general guidance on conservation objectives *directly* for Earth science interest features. This is because sites of different physical type (that have very different threats and management needs) can be selected for the same interest feature. For example, it is not possible to give guidance on conservation objectives for the conservation of the 'Marine Permian Stratigraphy JNCC Interest Feature' in itself that has real practical use. Any attempt to draw up general guidance on setting conservation objectives for this interest feature directly would be littered with exceptions to the general rules, to cope with the different conservation strategies associated with disused quarries, coastal cliffs, foreshore exposure etc..

5.2 Nevertheless, it is possible to develop a framework for setting conservation objectives by classifying *sites of a similar physical type*. For example, it is possible to produce general guidance (without immediate reference to the interest feature) for conservation objectives of an important body of rock in a *disused quarry* (e.g. concerning extent of rock exposure and degree of concealment by vegetation), and different guidance for exposures of rock on a *foreshore*. A useful classification of site by physical types was devised by NCC (NCC, 1990), called the 'Earth Science Conservation Classification' (ESCC – see 5.7 below for a list of ESCC categories) It is recognised that this classification will need to be amended in the future, so that each category better fits its association with monitoring work.

5.3 Sites may fall into more than one ESCC category. For example, an active quarry site containing an extensive stratigraphical interest would lie in the 'Active Quarries and Pits' ESCC category, but localized mineral veins within the same site would be classified as 'rare mineral or fossil deposit or unusual body of rock of limited extent'. Conservation objectives for the stratigraphical and mineralogical interests would be different: whereas removal of rock would be unlikely to damage the stratigraphical interest (as more equivalent rock material should be uncovered), removal of mineral vein material could result in partial or complete loss of mineralogical features of interest.

5.4 In the ESCC, categories can be placed into two main groups – 'Integrity Sites' and 'Exposure Sites', described below, although as indicated above (5.3) it is recognized that in a single 'exposure site' there may be localised areas that are of an 'integrity site' nature, for which the ESCC category 'rare mineral/ fossil deposit or unusual rock body of limited extent' will apply.

5.4.1 ***Integrity sites*** contain *finite* deposits or landforms that are *irreplaceable if destroyed*. A typical situation is a mineral or fossil sites where the mineral or fossil bearing body of rock is of very limited extent. Other examples include glacial landform of limited lateral extent, such as a kame terrace or esker, or presently active, and previously active, geomorphological sites, caves and karst, and some stratotypes.

5.4.2 ***Exposure sites*** provide exposures of a rock that are extensive so that removal of rock should uncover more material of the same type. Exposure sites are numerically the more common type and may include exposures in disused and active quarries, cuttings and pits; exposures in coastal and river cliffs; foreshore exposures; mines and tunnels; inland outcrops and stream sections.

5.5 The broad conservation principle for these groups of site is different. 'Integrity sites' are, by definition, finite and irreplaceable. To conserve them a 'protectionism' approach must be adopted, seeking to maintain the physical integrity of the deposits or landforms, with restrictions against detrimental anthropogenic changes. This does not mean, for example, that no specimens can be collected from an 'integrity site', but there may be a need to monitor and control such usage of the site, depending on the vulnerability of the resource.

5.6 In contrast, the principle for 'exposure' sites depends on the maintenance of an exposure, the precise location of which is not always critical. Thus, for example, it may be stated that it is acceptable for an outcrop to be lost provided that the amount/quality of exposure is retained or increased. Quarrying may be welcomed under some circumstances because it creates a fresh exposure and progressively reveals new rock surfaces enabling a rock body to be analysed in three dimensions. Similarly, marine erosion is often vital in creating fresh exposure, particularly in softer rock formations. Conversely, maintaining a high quality exposure of soft sediments by regular manual cutting of 'faces' may lead to unnecessary erosion or removal of the important material.

5.7 The consideration of the nature of the locality as an 'integrity site' or 'exposure site' helps define the fundamental conservation objective: to protect the resource or maintain the exposure.

Integrity Sites – *Minimise detrimental changes and preserve physical integrity of sites*

- Active process geomorphological site
- Cave/Karst site
- Static ('relict') geomorphological site
- Rare mineral/ fossil deposit or unusual rock body of limited extent*
- Mine dump

Exposure Sites - *Maintain exposure, judging changes on their merits in terms of degree and quality of exposure, and where required, enhance sites*

- Mine/tunnel site
- Inland outcrop or stream section †
- Foreshore exposure
- Coastal and river cliffs
- Exposure in active quarry/pit
- Exposure in disused quarry, pits and cuttings

5.8 ***Buried sites***

5.8.1 If a site has important geological characteristics of limited extent ('integrity site') and they are considered to be vulnerable, a conservation strategy of *deliberate burial* or allowing talus to build up to protect the features, may be applied. The sites will usually be those that were once in the ESCC category 'rare mineral or fossil deposit or unusual body of rock of limited extent', but where the extent of the resource has reached critically low levels and needs stronger protection measures. In this situation the conservation objective will be that *the features remain concealed by the protective cover but are accessible through excavation* and that the cover is not removed or disturbed without consent. Retaining the potential of the site is the key requirement for favourable status – the burial must not be irreversible. 'Unfavourable' conditions might include irresponsible excavation of the material, failure to re-bury the site after excavation, excess accumulation of natural cover to the point where re-excavation is virtually impossible (e.g. covered by a slump or rockfall); permanent developments above the buried material.

* Such 'integrity sites' *may* occur in what otherwise might appear at first inspection to be an 'exposure site' – e.g. a localised area of rare mineralization in an active quarry, but site documentation and maps will indicate and pinpoint where the important geological entities are located at the site, and their extent, thereby enabling the distinction to be made.

† Stream sections are generally those rock exposures in a stream bed or those adjacent areas that are periodically 'cleaned' by erosion by the stream/immature river, such that the river cliff, if one is present, is generally less than 2 metres high; thereby 'river cliffs' (exposure sites) are of greater vertical extent and are more likely to be cut by larger, more mature, rivers. The key difference is that the rate of erosion of the exposure by the river is different, so that the conservation strategy will also be different.

5.8.2 General guidance on setting conservation objectives for buried sites can be accounted for elsewhere – particularly under the 'rare mineral or fossil deposit or unusual body of rock of limited extent' ESCC category.

5.8.3 If the scientifically important parts of an '*exposure* site' become buried, then by definition the site will generally not be in favourable condition, but a defined degree of cover can usually be tolerated, particularly if in non-critical parts of the site, and if cover is relatively easily excavatable and/or ephemeral, for example, if the cover can be removed using hand tools in less than one man-day.

5.9 The ordering of categories in the list in 5.7 above indicates broadly the continuum from Integrity to Exposure sites. Evidence available so far confirms the supposition that 'integrity sites' are more sensitive to change/vulnerable in comparison with 'exposure sites', and generally are likely to constitute higher monitoring priority.

5.10 By combining the two systems of categorising Earth science sites – interest feature and ESCC site type, patterns of conservation rationales become apparent (e.g. all stratigraphy interest features in disused quarry sites, all palaeontology interest features on foreshore exposure sites etc.). It is this combination of the two systems that is fundamental to deriving a uniform approach in monitoring sites for different interest features, since knowledge of the 'integrity' or 'exposure' nature of the site, coupled with its ESCC type and the interest feature, directs the monitor to the relevant attributes, factors and conservation objectives for a site.

5.11 The ESCC is used as the basis of the common standards for setting conservation objectives, and monitoring guidance for each category is discussed below.

6 MANIFESTATION OF INTEREST FEATURES AT A SITE

6.1 In considering an Earth science site, the ESCC type may be relatively easily identified‡, but it will not usually be immediately clear what the interest feature is. The geological importance of a 'Marine Permian Stratigraphy' site, which will seldom be confined to one geological entity, will be manifested by a collection of factors such as the rock type (chemical and physical composition), the *range of* (succession of) rock types, the fossils, the relationship of the Permian rocks to older and younger ones, the sediment structures (preserved ripples, etc), the orientation of the rocks and so forth. For monitoring of the interest feature at a site to be meaningful, we need to identify the whereabouts of the actual entities that made the site qualify for selection – the primary, or critically important, geological features that will be the main focus of monitoring work, rather than 'hosted' or 'incidental' ones. So the *manifestations* of the interest feature – usually identifiable from site descriptions – could be, for example, a specified sequence of rock strata; a Precambrian-Cambrian unconformity with sufficient exposure of the strata astride it to provide context, a pegmatitic dyke and contacts with country rock, a drumlin field, a kidney ore body, a fossiliferous rock body, shingle spit, meander cut-off, etc.. If necessary, technical names of entities can be avoided to assist monitors who may lack detailed geological knowledge. For example, it may not be helpful to discuss the pulchra-similis biozone; instead we might discuss the maintenance of 'exposure of a particular horizon of rock' in a rock succession. Of course, in setting conservation objectives, it will be important to consider not only the

‡ 'rare or atypical mineral, fossil or other geological site' may be considered to be a special ESCC site type, essentially one that identifies specific areas of a site that might otherwise be represented as a ESCC 'exposure site', e.g. a localised rare mineral deposit in an extensive coastal cliff. One site may be categorised into more than one ESCC.

critically important entities, but also how much important contextual exposure or landform is required to support the scientific value of the key entities, e.g. the sediment layers between true 'igneous' deposits and intrusions in large Igneous Petrology sites.

6.2 Therefore, the entities to be monitored within a site will be one or more from the indicative list given in Appendix 2. This list is not intended to be exhaustive but merely to indicate the kinds of entities that led to a site qualifying for an interest feature and therefore as an SSSI or ASSI. For example, the site Compton Bay on the Isle of Wight qualifies for the Cenomanian–Maastrichtian Interest Feature because it displays a continuous succession through the different rock horizons ('members') of the Grey Chalk subgroup; someone monitoring the site need not necessarily know what this means, because they will be concerned with the continuity, quality of and amount of exposure of the rock 'face' between two grid reference points.

7 ATTRIBUTES

7.1 In general terms in JNCC's scheme of Common Standards for Monitoring, 'attributes' should be quantitatively measurable. But in geological monitoring, attributes may also include subjectively assessable *quality* of geological features, rather than presence or absence of indicative species in a chalk grassland sward. Therefore, the 'visibility' or 'intactness of exposure' of geological features or 'naturalness of geomorphological processes' are important attributes. This is to be expected in situations particularly where the geological features are static – i.e. their presence is not dependent on a currently active/changing natural system, such as in a disused quarry.

7.2 Access (by third parties) and safety are not used as criteria for determining the condition of the interest features, because they do not affect the appearance or ongoing physical presence of the key geological entities themselves. However, because the primary purpose of geological sites is to conserve them for scientific study, it is invariably desirable to secure or maintain site access, therefore safe access to feature should be a fundamental **management** target.

7.3 Given that the list (Appendix 2) indicates the entities we are assessing, then the attributes of these entities to monitored will include:

- 'visibility' – factors to be monitored will be lack of concealment from vegetation/soil/talus build ups/ engineering constructions;
- quality of appearance or lack of disturbance to the internal structure of entities – the physical condition of rock/sediment/landform/spoil heap/etc e.g. lack of disruption of sediments in a landform (that are not yet visible); lack of fragmentation of exposure, no physical damage to important parts of rock 'faces'/sediment stacks/landforms etc.; quality and visibility are intimately linked attributes;
- extent of features (e.g. quantity of important geological material such as volume of important spoil material in a mine dump, or area of rock face in an exposure site where it is advantageous to have a greater amount of rock exposure to study)
- Process dynamics: freedom of geomorphological processes to evolve naturally and unimpeded.

8 TARGETS

8.1 Because of the special nature of Earth science sites compared to biological sites that are subject to a greater degree of natural variability, many geological sites are subject to natural deterioration, with features becoming progressively concealed over time, through build up of talus, soil and vegetation, for example. Although the 'ideal targets' for an Earth science site would be as in the list below, in practice, *some deterioration in condition will be tolerated away from this hypothetical ideal situation* within the 'favourable' conservation condition status (the point at which a site reaches 'unfavourable' condition is discussed in the section below). Therefore, so long as quality and quantity of the features on critically important parts of the site *remain at acceptable levels* (see 8.3 and 9) that do not unduly inhibit study of the site, a degree of concealment through soil build-up or vegetation cover will be tolerated. In this way the 'targets' for a particular Earth science site will need to consider impact of engineering works, tree planting, tipping etc. with levels specified for the degree to which temporary or partial loss of exposure at critical and non-critically important parts of the site is tolerated within the 'favourable maintained' conservation status.

8.2 Ideal targets (targets for hypothetical optimal condition as described in 8.1 above) can be summarised as follows:

- Landform elements remain unconcealed
- Physical composition, morphology and internal structure of the key landforms and sediments remain intact and undisturbed by anthropogenic interventions
- Extent of key geomorphological features are not diminished through physical damage or fragmentation
- Natural geomorphological processes are unimpeded : the levels of activity of the geomorphological processes and their spatial domain retain the capacity to operate across their full range of natural variability
- Geological exposure remains unconcealed, intact and unmodified by anthropogenic intervention
- Extent of key geological features has not diminished: both vertical and lateral extent of features constant or increasing:

8.3 For exposure sites in general, the main conservation objective is to achieve or maintain an acceptable level of reasonable quality exposure of the interest features. Although maintaining 100% of high quality exposure (compared to its projected optimum exposure) is frequently impractical any overall loss of exposure must be temporary and reversible if the site is to maintain 'favourable' condition status. In general, *permanent* overall loss of exposure on any geological ASSI/SSSI is not acceptable (except where it has been consented, and if critically important parts of the site are not lost). There is no universal rule defining an '*acceptable level* of *reasonable quality exposure*' that can be applied to every exposure site, as these factors will depend on how the features of interest are distributed on the site and their resistance to weathering and natural (not anthropogenic) change. 'Acceptable levels' will have to be established for each site. For example, on a stratigraphical site where the beds are horizontal, there may be little variation along a face and it may be sufficient to maintain exposure on a small section of the face. On the other hand, if the beds are dipping along a face, it may be necessary to maintain several small sections along the face at ground level so that each part of the stratigraphy has a representative exposure. Such areas represent the approximate minimum needed to achieve favourable condition, with the potential to expose more of the site if necessary to provide a fuller scientific context. The danger in defining relatively small areas for permanent exposure is that it may give the impression that the remainder of the site could perhaps be permanently lost and the site would still be in favourable condition.

8.4 The reason for not setting *generic* guidance for targets such as 'minimum level of exposure', for example 'maintaining 90% of the level of exposure compared to the time of site notification [if it was in favourable condition at the time of notification]' may imply that 10% loss of exposure is acceptable. Also, because the quality of the interest feature as manifested at the site may vary from place to place within the exposure, if such an arbitrary lower limit were breached, a site might be recorded as 'unfavourable', but the main geological features may still be unconcealed or the remaining 80% of exposure is still sufficient to expose the interest features.

8.5 In certain circumstances – especially in soft sediments where trying to preserve an exposure continuously is undesirable – conservation objectives and the definition of 'favourable condition' might stated in terms of whether the site retains the *potential for being re-exposed*; for the site to continue to be in favourable condition, the re-exposure work would need to be a small-scale operation that can be performed by an individual or small group of people in less than a day. If heavy machinery (e.g. a bulldozer or JCB) were necessary, then the site should be considered to be in unfavourable condition.

9 'FAVOURABLE CONDITION' STATUS

9.1 A key attribute for assessing 'favourable condition' status is the ongoing *visibility/quality* of the critically important features of interest in the site. As stated above, the amount of tolerance permitted of partial concealment while still retaining 'favourable status' will depend upon the ease of reversing undesirable changes and any variability of the quality of the interest feature in space. The limit of acceptable level of temporary loss of exposure (e.g. by talus build up or vegetation growth) could be determined as the point at which it is considered necessary that management intervention take place because the resource has become too small/the periodicity of exposure unsuitable for the site to be of use as a potential research site.

9.2 *Active geomorphological process sites*

Conservation of dynamic environments, however, is more complex, and requires an understanding of geomorphological sensitivity and the capacity of the system to absorb externally imposed stresses. Sometimes it is the *process itself* we are trying to conserve e.g. an unimpeded fluvial system – not the manifestations of it (bars, banks etc.), but the condition of these manifestations will usually be used as a surrogate for monitoring the condition of the real 'interest feature' (fluvial processes). So if there are ephemeral manifestations and they are 'lost' (e.g. shingle bar is eroded in a storm surge) there needs to be some assessment of whether the system will recreate the lost features before an assessment of 'unfavourable condition' is made. This will require specialist advice. Note that the system may not necessarily recreate exactly the same landforms or in exactly the same place and that there may be a delay before/if they are recreated. Active process sites may also be damaged by activities outwith the confines of the sites e.g. through upstream changes that affect water discharges or sediment inputs, leading the site to be recorded as being in unfavourable condition although corrective management activity within the site itself is unnecessary.

9.3 *Partial destruction*

A site would be recorded as 'partially destroyed' if it had undergone *irreversible detrimental change* to *critically important parts of the site*, for example if important parts of the original exposure/landform had become permanently damaged, removed or buried such that the research value of the site had significantly diminished (e.g. deep burial under landfill, concealment under 'hard', coast-protection structures, aggregate extraction from an esker,

encroachment of scrub that damages the integrity of soft sediment structures, the 'working out' of rare fossil/mineral material (i.e. material removed in significant quantities compared to the original quantity of resource)).

9.4 ***Unfavourable – recovering***

If a site that is in 'unfavourable' condition shows potential for return to favourable status through natural change, or if site management action has begun to improve the site, then the site would be recorded as 'unfavourable – recovering' Examples include removal of 'hard' coast-protection structures allowing geomorphological systems to become re-naturalised, grazing regime changes resulting in landforms being less susceptible to concealment and damage by scrub invasion.

10 SKILLS REQUIRED FOR GEOLOGICAL MONITORING

10.1 The process of monitoring and conservation objective setting for many geological sites is generally straightforward and should often be achievable by non-geologists. For example it is possible to assess the condition of 'an important rock body', regardless of the geological age or scientific definition of that rock body, since it is probably an assessment of visibility or degree of rock exposure (lateral, and perhaps vertical, extent, degree of concealment and overall physical condition) that is required. Of course, it will be necessary to demonstrate to the monitor which 'important rock body' is to be monitored at a site, perhaps photographically. Once this is established, then the assessments of site condition can be made year-on-year without experts being called in when no obvious threats have arisen. At this lowest level, monitors will require simple question and answer sheets to assess site condition by assessing the changes in degree and quality of exposure of the interest features.

10.2 **However, there are exceptions where either specialised scientific expertise may be required and/or where health and safety considerations preclude staff from performing site visits.** Examples of the former include large, fragmented (i.e. where the important features are dispersed over the site area) sites, many mine dumps, the condition of which often requires assessment by an expert mineralogist, and complex or vulnerable active geomorphological process sites. In terms of health and safety restrictions, most underground sites, both caves and disused mines, cannot be assessed by staff.

10.3 ***Photomonitoring***

Further assistance to the non-geologist is by fixed-point photography, particularly where the geological exposures or landforms are not widely dispersed within a site. Firstly, the process is easily repeatable if the points at which the photographs are taken are properly recorded, and such photographs can be helpful if the person carrying out the monitoring needs to seek expert advice. For example, at a simple site, a small number of digital images could simply be emailed to a remote 'expert' for comparison with earlier photos in order to assess site condition. A photographic history in an archive would be the best way of demonstrating change within sites over time and would allow new monitors to develop quickly an understanding of how sites have changed in the past.

11 MULTIPLE INTEREST FEATURE SITES AND MULTIPLE ESCC SITES

11.1 As indicated above, most Earth science sites will have a complex mix of geological and geomorphological features that led to a site being selected for an interest feature. For example, a site might have eskers, kames, drumlins and moraine, and a Quaternary stratigraphy that together led to the site being selected for the Quaternary of Scotland interest

feature. Moreover, some sites attain SSSI/ASSI status independently for several interest features, e.g. where a locality is selected for the GCR for more than one GCR Block. The SSSI/ASSI may also have especially important biological 'interest features'. For example, a single site might be important for Coastal Geomorphology on account of its beach/dunes *and* soft cliffs, it might also be selected for the Aptian-Albian Stratigraphy [Cretaceous] rocks and have an important colony of birds nesting in burrows in the soft sediments.

11.2 For this 'multiple' site to be entirely in favourable condition, it must be in favourable condition with respect to each interest feature. It is possible for such a 'multiple' site to be in favourable condition with respect to one interest feature, but not another. It is recognised that there may be conflicting conservation objectives for the various interest features which will need to be carefully considered for site management activities.

11.3 In the example given above for the Coastal Geomorphology interest feature the site would need to have *both* its beach/dunes *and* its soft cliffs in favourable condition, because these are both elements of <u>one</u> interest feature.

11.4 Many sites have more than one Earth science interest feature and may fall into more than one ESCC category (e.g. *foreshore* and *coastal cliff*, or a *disused quarry* containing an extensive stratigraphical interest also containing localised mineral veins within the same site (*rare mineral site of limited extent*). The different interests on the site would have fundamentally different, but easily integrated, conservation objectives. While removal of rock material would be unlikely to result in any damage to the stratigraphical interest (as more equivalent material should be uncovered) removal of mineral vein material could result in partial or complete loss of the mineralogical interest.

12 REPORTING

At a UK level, JNCC will be reporting site condition statistics according the themes (groups of interest features') given in section 3.3.

STATIC / RELICT GEOMORPHOLOGY § ESCC CODE: IS

This category encompasses a large range of sites that contain evidence of no-longer active landscape-forming processes or 'palaeo-' or 'fossil' (typically Pleistocene or 'historical') landforms, e.g. eskers, drumlins, river terraces, emerged ('raised') beaches. The **conservation objectives** of these sites focus on maintaining the visibility, integrity and extent of the geomorphological features, which, by definition, cannot re-form if destroyed. The **principal target** will be that there are no artificial developments of any kind. Very small superficial or temporary changes, such as fence laying, may be permitted, however. The key consideration with small developments is the cumulative effect over time.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Key landform elements/entities remain unconcealed	In general, very low levels of disruption that are reversible or temporary can be accepted. Changes that may be acceptable are: • small superficial modifications such as fencing or tree planting in non-critically important parts of the site • small alterations if they are reversible and short term and do not contaminate the site and do not affect critically important parts of the site. In order to study relict geomorphological sites, it is sometimes necessary to dig small trenches and pits, or take boreholes to study internal structures; how much of this potentially disruptive research is permitted will depend upon frequency of disruption, quantity of disruption, and likely gain in scientific knowledge. Expert advice may be needed before permission is given. If the geomorphological features are considered to be vulnerable and have been *deliberately buried* for protection, then the target will be *that the features are not visible but remain accessible through excavation.* Inland, keeping a site completely uncovered by talus, soil and vegetation might not be practical or desirable for the long-term conservation of the site (e.g. if a site is not being grazed and rapid recolonisation of vegetation conceals parts of the site, but causes no long-term damage). Therefore, a certain degree of natural scrub/other vegetation invasion can be tolerated, if it does not completely obscure (or cause damage by root disruption to) key
Quality/Physical integrity	Physical composition, morphology and internal structure of the key landforms and sediments remain intact and undisturbed by anthropogenic interventions	
	Factors that will need to be assessed: • tipping, dumping, infilling of depressions/hollows • tree planting, deep ploughing • 'landscaping' (e.g. sediment redistribution/levelling) • development and engineering works (buildings/artificial structures) • track/road building • coastal reclamation/sea defence developments • significant vegetative disruption, e.g. scrub/woodland invasion/development • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • deterioration caused by agricultural use change; (if ongoing agricultural use is not harmful to the site in the long term. • damaging recreational pursuits (e.g. mountain biking/ scrambling) causing accelerated erosion • irresponsible research excavation. • significant build up of soil/mud /talus [where not part of the special interest]	

§ This category **includes** 'integrity sites' that have relict geomorphology in inland outcrops/stream sections; river and coastal cliffs (although these types of site have their own ESCC for 'Exposure' sites) but **excludes relict** (inactive/'dry') Caves and Karst, (and relict tufa), which have their own ESCC. Bogs important for glacial/ interglacial sediments and peat (sampled by coring) are dealt with under the 'Active Geomorphology' ESCC rather than here. Cross reference to the other relevant ESCC guidelines is recommended when devising conservation objectives for a particular site.

		parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. Conversely, vegetation may actually help stabilise sites undergoing rapid erosion.
Extent	Extent of key geomorphological features has not diminished through physical damage or fragmentation. **Factors** that will need to be assessed: • removal of material, (e.g. sand/gravel extraction/ quarrying); • addition of rock/sediment/soil • vertical and lateral extent of features constant (e.g., if the relict features are exposed in a section like a cliff)	Where the important relict geomorphology lies exposed in a cliff (e.g. a Quaternary sediment sequence, or a cross-section through a landform like a kettle hole), unimpeded coastal or fluvial erosion may be important to remove eroded material, and maintain a good, clean 'face'. However, if cliff-line retreat is very rapid, the important material may be completely eroded away. Sympathetic protection may be considered in this case, such as allowing a certain degree of cover by talus, soil or vegetation or 'soft engineering' solutions.

ACTIVE PROCESS GEOMORPHOLOGY** ESCC CODE: IA

This category encompasses mass movement, coastal and fluvial geomorphological sites in which landscape-forming processes are active. **Conservation objectives** focus on allowing the processes and features that they create to evolve naturally, unimpeded by human intervention, although almost every site will be affected by some degree of land management. The **principal target** will be that there are no artificial developments or modifications of any kind that affect the evolution of the natural geomorphological systems. Small-scale superficial or temporary changes, such as fence laying, may be permitted, however, so long as the predicted impact of the change is negligible. The key consideration with small developments is the cumulative effect over time.

The variability of geomorphological processes within one site over time makes it difficult to define 'acceptable natural variation', and to determine whether some gradual changes to landforms have been the result of human intervention or are in the natural range. Incremental changes may be detectable only over long periods of time, and their causes are hard to deduce. Conversely, a site might be affected by dramatic and sudden change, yet still be 'evolving naturally', e.g. if there is a storm surge that breaches a shingle spit or erodes a section of saltmarsh.

We cannot always easily asses the 'naturalness' of the active geomorphological processes directly, but we can note if the processes have been affected by anthropogenic influences such as bank protection, flow deflectors, etc.. Furthermore, although we might not be able to measure the processes directly, we can consider the condition of their manifestations – the sand dunes, shingle spits, waterfalls and so on. In most cases it will be the manifestations of the processes that will be the cited reasons for a site's conservation rather than the geomorphological process itself. It will not be easy to set absolute limits for acceptable variation of the extent and integrity of these features, considering the natural variability of the systems. However, we will need to consider the likely variability and the capacity for the system to recreate components damaged or destroyed by any means (natural or artificial). Expert advice will probably be necessary.

Processes acting outside of the site may affect the integrity of the component features, e.g. land adjacent to the site may be linked hydrologically or the sediment 'store' for a coastal 'cell' may lie outside the site. Changes outside of the site therefore may lead to damage or 'unfavourable' conservation status, even though there has been no intervention within the site boundary area. The key point here is that if a particular landform is the cited reason for a site's conservation, and if it is irrevocably damaged by anthropogenic changes inside *or* outside of the site, *or even* by a 'natural event' (such as catastrophic erosion resulting from storm surge) then the site will still have become 'unfavourable' in condition, conversely, if a site undergoes episodic high-magnitude processes that completely remodel it, it will be favourable if it is the process system itself that is the reason for site selection**.**

Attribute	Targets and Factors	Practical considerations
Visibility	Key landform entities not unnaturally concealed or obscured	In general, very low levels of disruption that are reversible or temporary may be acceptable and permitted with consent. Changes that may be acceptable are: • small superficial modifications such as fencing or tree planting in non-critically important parts of the site; or
Quality/Physical integrity	Physical composition, morphology and internal structure of the landforms and sediments remain undisturbed by anthropogenic interventions	
	Factors that will need to be assessed:	

** Sites in which landforms are being actively formed by rivers [erosion/deposition], coastal processes [erosion/deposition and saltmarsh] or mass movements [landslides or gravity-driven processes]. This category excludes actively forming Caves, and Karst, and relict geomorphology landforms, which have their own ESCCs to which readers should cross-refer. Quaternary bog sites – although technically a 'relict geomorphology site' or 'buried exposure' – are included in this category because they are best conserved in the long term through ensuring hydrological integrity of the system.

	• natural woodland development and scrub invasion • concealment through the erection of artificial structures • significant build up of soil/mud /talus [where not part of the special interest] • tipping, dumping, infilling, • tree planting, introduction of vegetation or deep ploughing • 'landscaping' (e.g. sediment redistribution/levelling) • development or engineering works (buildings/ artificial structures/recreational and amenity developments) • track/road building • coastal reclamation/sea defence developments • river management works (bank protection/channel straightening) • slope/dune stabilisation • dredging in active coastal 'cell' • damaging recreational pursuits (e.g. mountain biking/ scrambling/ water sports) causing accelerated erosion • artificially induced changes to water levels (flooding or draining) • contamination/ pollution detected • deterioration caused by agricultural use change; (if ongoing agricultural use is not harmful to the site in the long term • irresponsible research excavation.	which do not significantly affect the functionality of the active process system • small alterations if they are reversible and short term and do not contaminate the site and do not affect critically important parts of the site. if the system overall will not be damaged in the long term and can recover. • small excavations to study internal structures or removal of samples for research that does not disrupt the site significantly; (i.e. acceptable if the system can re-create disrupted sampled components); how much of this potentially disruptive research is permitted will depend upon frequency of disruption, quantity of disruption, and likely gain in scientific knowledge. Expert advice may be needed before permission is given. Inland, keeping a site completely uncovered by talus, soil and vegetation might not be practical or desirable for the long-term conservation of the site (e.g. if a site is not being grazed and rapid recolonisation of vegetation conceals parts of the site, but causes no long-term damage). Therefore, a certain degree of natural scrub/other vegetation invasion can be tolerated, if it does not completely obscure (or cause damage by root disruption to) key parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. Continuing agricultural use in its present form may be an important factor to maintain the site in favourable condition – e.g. grazing, which improves the visibility of the elements within the site by removing invasive vegetation and might otherwise stabilise (or conceal) features such as active dunes. Conversely, vegetative development may be judged acceptable - part of the natural stabilisation of parts of a river or coastal site, or perhaps because it protects parts of the site undergoing rapid erosion by pedestrian trampling.
Freedom of geomorphological processes to evolve naturally	Natural geomorphological processes are unimpeded : the levels of activity of the geomorphological processes and their spatial domain retain the capacity to operate across their full range of natural	Small-scale changes may be tolerated, for example, 'soft engineering' solutions to coastal erosion which has been accelerated by activities outside of the site.

	variability, the site maintains the capacity to recreate the geomorphological features where these have been lost or damaged or altered through natural processes. **Factors** to be assessed: • water flow changes induced by developments within the site • artificially induced stabilisation of processes.	However, if interventions have begun to cause significant changes to the site's process regime and its landforms, or the geomorphological processes have been permanently altered and the system is no longer evolving in a natural way, the site will be in unfavourable condition.
Extent of the geomorphological features	Extent of key geomorphological features has not diminished: the volume, vertical and lateral extent of the features must be within their normal natural range. **Factors** to be assessed: • sand/gravel extraction • beach 'feeding' or unnatural addition of rock/sediment/soil to the geomorphological system. • unnatural redistribution of sediment/gravel within the site.	Limited extraction and addition and movement of sediment may be tolerated if the system is not likely to be irrevocably affected. However, if interventions have caused geomorphological processes to be permanently altered and the system is no longer evolving in a natural way, the site will be in unfavourable condition.

CAVES AND KARST†† ESCC CODE: IC

Although caves and karst are grouped together, the approaches to monitoring and setting conservation objectives are quite different. Karst sites can generally be monitored by agency conservation officers, as karst sites are above ground and often have a closely interlinked biological/geological features of interest; the main threats are removal of rock material (e.g. for rockery stone) and dumping of effluent or rubbish. The **conservation objectives** should focus on maintaining the integrity of the entire site – no artificial developments – and should attempt to integrate the geological and biological objectives or at least clarify how any conflicts (if there are any) have been resolved. The **principal target** will be that there are no artificial developments or modifications of any kind.

Caves, as with disused underground mines, cannot be monitored by agency staff for health and safety reasons but, unlike mines, caves can sometimes be monitored by cavers that are not necessarily geologically trained, if the interest lies in the cave morphology (e.g. speleothem – photographic surveys may be important here) rather than in the integrity of the hydrological regime.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Key geological and geomorphological features of karst and cave are unconcealed	In general, very low levels of disruption that are reversible or temporary may be acceptable and permitted with consent. Changes that may be acceptable are: • small superficial modifications such as fencing or tree planting in non-critically important parts of a karst site; or which do not significantly affect the functionality of the active process system in a cave. • small alterations if they are reversible and short term and do not contaminate the site and do not affect critically important parts of the site, if the system overall will not be damaged in the long term and can recover. • minor 'show cave' developments that do not affect the integrity of the cave system; entrance 'control', handrail or similar safety constructions. Inland, keeping a karst site completely uncovered by talus, soil and vegetation might not be practical or desirable for the long-term conservation of the site (e.g. if a site is not being grazed and rapid recolonisation of vegetation conceals parts of the site, but causes no long-term damage). Vegetation in a karst site might be an 'interest feature' in its own right to be reported on independently. Therefore, a certain degree of natural scrub/other vegetation invasion can be
Quality/Physical integrity	Karst landforms and cave sediments remain intact and unmodified/undisturbed by anthropogenic interventions; caves are evolving naturally with natural processes cave sediments remain undisturbed	
	Factors that will need to be assessed: • natural woodland development and scrub invasion of karst • concealment through the erection of artificial structures • significant build up of soil/mud /talus • tipping, dumping, infilling, • deliberate introduction of vegetation to karst • development or engineering works (buildings/ artificial structures/recreational and amenity developments) • track/road building • river management works affecting water flow to the cave system • *damaging* recreational pursuits (e.g. scrambling on karst or, wastes (fixings or other wastes) left by cavers) causing accelerated erosion or litter • artificially induced changes to water levels (flooding or draining) • contamination/ pollution	

†† Sites at which limestone scenery/landforms are being actively formed, or where have been formed previously ('relict' caves/karst). Note that this is a separate category to 'Relict' and 'Active' geomorphology sites, which have dedicated ESCCs to which readers should cross-refer. Bone cave deposits or mineral veins may be classed as 'rare mineral or fossil deposits of limited extent' to which category readers should refer.

	• deterioration caused by agricultural use change to karst; (if ongoing agricultural use is not harmful to the site in the long term • entrance closure • irresponsible research excavation	tolerated, if it does not completely obscure (or cause damage by root disruption to) key parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. Continuing agricultural use in its present form may be an important factor to maintain the site in favourable condition – e.g. grazing on karst areas, which improves the visibility of the elements within the site by removing invasive scrub; or maintaining unchanged agricultural use on ground overlying cave sites. Cave collapse and flooding will only be unfavourable if the collapse or flood has been induced by anthropogenic activities *or* if the reasons for site selection were features that have been rendered inaccessible (even by natural processes). Deliberate concealment / passage blocking may be a useful conservation mechanism where features (e.g. a cave bone-bed deposit) are vulnerable or limited in extent and may be subject to irresponsible collecting or damage from recreational caving.
Freedom of hydrological processes to evolve naturally	The levels of activity of the hydrological processes and their spatial domain retain the capacity to operate across their full range of natural variability; the capacity to recreate the cave features, where these have been lost or damaged or altered through natural processes is maintained. **Factors** to be assessed: • water flow changes created by developments within the site • artificially induced stabilisation of water processes. • water abstraction from boreholes	Small-scale changes may be tolerated, however, but if interventions have begun to cause geomorphological processes to be permanently altered and the system is no longer evolving in a natural way, the site will be in unfavourable condition.
Extent of the cave/karst features	Extent of key features has not diminished: the volume, vertical and lateral extent of the features must be within their normal natural range. **Factors** to be assessed: • rock removal from karst areas, rock/sediment removal from caves • unnatural addition of rock/sediment/soil/talus to the cave system. • unnatural redistribution of sediments within the cave site. • fossil/mineral collecting/ research excavation	Small excavations to study cave sediments for research that do not disrupt the site significantly may be permitted; how much of this potentially disruptive research is permitted will depend upon frequency of disruption, quantity of disruption, and likely gain in scientific knowledge. Expert advice may be needed before permission is given. Movement of vulnerable material to suitable repository (e.g. bone cave excavation and recording) may in fact be preferable if likely to deteriorate rapidly *in situ*).

RARE MINERAL OR FOSSIL DEPOSIT OR UNUSUAL BODY OF ROCK OF LIMITED EXTENT‡‡ ESCC CODE: IM

This category includes all rock bodies and fossil and in-situ mineral sites that have a finite amount of geologically important material. The strategy for conserving sites with a finite resource obviously needs to be different from that for a site where removal of geological material simply reveals more equivalent material. The sites are generally vulnerable. Irresponsible specimen collecting (see http://www.jncc.gov.uk/earthheritage/module/jnccfoss.htm and section 4.4) can be a significant threat to many of these sites, but other threats such as landfill, coastal defences and developments can also be important.

The important material may be present in a localised part of a larger site area, or be intermittently available throughout the site, so that it is vital to pinpoint the key areas and their extents within the conserved site when monitoring the site (e.g. fossil-rich fissure-fill deposits of the Brassington Formation will occur sporadically within a site).

The **conservation objectives** will focus on ensuring that there is no reduction in the quality or quantity of the resource, e.g. by irresponsible collecting. Activity that results in removal of small amounts of material of interest will not *necessarily* cause damage to the site, but assessment of the type and amount of removal needs to be carefully considered, often in consultation with a geological expert, by assessing the extent of the resource. The conservation objectives for a site should define acceptable thresholds for specimen collecting or other activities that may deplete the finite resource to critically low levels.
Removal of vulnerable material will not be reported as 'destruction' if it is placed in a suitable repository.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	The key Earth science elements/entities are unconcealed (or if deliberately buried to protect them, that the key elements remain concealed)	Inland, keeping a site completely uncovered by talus, soil and vegetation might not be practical or desirable for the long-term conservation of the site (e.g. if rapid recolonisation of vegetation conceals parts of the site, but causes no long-term damage). Therefore, a certain degree of natural scrub/other vegetation invasion can be tolerated, if it does not completely obscure (or cause damage by root disruption to) key parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. If soil/ talus vegetative cover had reached an unacceptably high level that was going to make any use of the site very difficult the site would be in 'unfavourable' condition. The point at which management intervention becomes necessary may be a good indicator of when this unacceptable point is reached. Conversely, vegetation may actually help stabilise sites undergoing rapid erosion and
Quality/Physical integrity	The geological resource remains intact – undisturbed and unmodified by anthropogenic intervention	
	Factors that will need to be assessed: • tipping, dumping, infilling • tree planting, deep ploughing • 'landscaping' (e.g. sediment redistribution/levelling) • development or engineering works (buildings/artificial structures) that would damage the resource of conceal it • track/road building • coastal reclamation/sea defence developments • addition of rock/sediment/soil (unless the feature is deliberately buried, in which case the target is irresponsible removal of cover) • significant scrub/woodland	

‡‡ Sites at which there are finite and irreplaceable geological resources. Originally called 'Unique mineral/fossil or geological site', but the definition of this category concerns the general scarcity and/or limited extent of the geological features of interest at a site. The resource may occur in a quarry/foreshore/cliff/mine/cave - the reader should cross refer to the appropriate ESCC for further guidance.

	invasion/development • significant build up of soil/mud /talus • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • damaging recreational pursuits (e.g. mountain biking/ scrambling) causing accelerated erosion.	erosion may completely remove the feature of interest. Construction of fencing to protect highly vulnerable materials may be desirable without damaging the interest. If the geological features are considered to be so vulnerable that they have been *deliberately buried* for protection, or natural concealment has occurred, then the site will not be in unfavourable condition and the target then will be *that the features remain concealed but accessible through excavation.* Where the important finite resource lies exposed in a cliff (e.g. a gold lode), unimpeded coastal or fluvial erosion may be important to remove eroded material, and maintain a good, clean 'face'. However, if cliff-line retreat is very rapid, the important material may be completely eroded away. Sympathetic protection may be considered in this case, such as allowing a certain degree of cover by talus, soil or vegetation or 'soft engineering' solutions. (i.e. acceptable if regulated or if movement of vulnerable material (e.g. rare fossils) to suitable repository may in fact be preferable);
Extent of the features	Extent of key features has not diminished. **Factors** to be assessed: • rate and type of removal of material, (e.g. sand/gravel extraction/ quarrying); • vertical and lateral extent of features. • research excavation/sampling or collecting.	Responsible collecting may be permissible [monitors should refer to the JNCC position statement on fossil collecting, as well as guidelines produced by the Geologists' Association], i.e. removal of small amounts of material if collecting seems to be sustainable at present levels without entirely removing it in the foreseeable future. The site would be in unfavourable condition if collecting had led to removal of a significant amount of the important material

MINE DUMP ESCC CODE: ID

Mine dumps represent finite resources, since the mines from which they have been produced have invariably ceased operating. **Conservation objectives** will take into account the main threats – over-collecting and large-scale removal of material. As the latter is covered either by the planning or consent process, over-collecting is generally the more serious problem on many dump sites.

Two factors are important in mine dump assessment. Firstly, the overall volume of the dump material. Some dumps are very large – and the impact of collecting therefore less – whereas others have a very limited resource of material of interest and are highly vulnerable. Secondly, and often more importantly, the quality of the resource within a particular dump can be very variable, i.e. richer in minerals/fossils in discrete areas within the site. Therefore, for mine dump sites, it is necessary to know if the material of interest is uniformly or locally distributed within the dump.

The **principal target** is to ensure that there is no reduction in the quality or quantity of the resource, e.g. by irresponsible collecting, by ensuring that there are no new artificial developments of any kind, especially 'landscaping', and that there is no irreversible burial of material. Activity that results in removal of small amounts of material of interest will not *necessarily* cause damage to the site, but assessment of the amount of removal needs to be carefully considered, often in consultation with a geological expert, by assessing the extent of the resource. The conservation objectives should define acceptable thresholds for specimen collecting or other activities that may deplete the finite resource to critically low levels.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Critically important parts of the dump are unconcealed	Keeping a site completely uncovered by talus, soil and vegetation might not be practical for the long-term conservation of the site (e.g. if recolonisation by vegetation conceals non-critical parts of the site, but causes no long-term damage). Therefore, a certain degree of natural scrub/other vegetation invasion can be tolerated, if it does not completely obscure (or cause damage by root disruption to) key parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. If the dump is being replenished with fresh spoil, it will be important that the spoil is of the same type as that already in the existing dump (i.e. not foreign material). In order to collect material for research or education, it may be important to 'rotate' the dump to reveal fresh specimens. This is acceptable where secondary mineralisation or metallophyte plant growth are not part of the geological or biological interest features (i.e. where the integral structure/stratification of the dump and exposure to weathering are important). If the dump material is being deliberately rotated by machinery to enable research or collecting, then maintaining the integrity of the structure will not be an attribute to be assessed.
Quality/Physical integrity	Physical composition, morphology and internal structure of the dump remains intact and undisturbed	
	Factors that will need to be assessed: • tipping, dumping with foreign dump material/ landfill/other waste • 'landscaping'/'reclamation' (e.g. rock/sediment or soil redistribution/introduction/ levelling) • development or engineering works (buildings/artificial structures) • track/road building • significant vegetative disruption, e.g. scrub/woodland invasion/development. • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • damaging recreational pursuits (e.g. mountain biking/ scrambling) causing accelerated erosion • significant build up of soil/mud /talus concealing the dump	

Extent of the features	Extent of important dump material has not diminished. **Factors** to be assessed: • major excavations (major removal of spoil) • addition of rock/sediment/soil [excepting addition of more spoil material of the same type] • research excavation and collecting.	It will generally be necessary to consult with an appropriate specialist (often, an external mineralogical or palaeontological expert), to consider not only the quantity of mine dump material in total, but the quantity of dump material *where the special mineralisation/fossil resource is known to be greatest*. If the dump quantity remains at acceptable levels, further consideration will need to be given to whether the site continues to yield the mineral/fossil specimens that make the site important, since selective collecting will reduce overall abundance of rare materials to critically low levels, leaving behind host rock of little scientific interest.

MINE/TUNNEL SITE§§ *** ESCC CODE: EM

Monitoring of underground sites is problematic. Staff cannot monitor mines for health and safety reasons. In any case, *disused* mines are often inherently unstable and safe access usually cannot be maintained in the long term because of the very high costs involved. Also, because, as a rule, a high degree of expertise is required to assess the condition of the geological features of interest present in mines (typically the mineralisation interest feature), input from external experts will be required. There are few individuals prepared to undertake potentially highly dangerous work with sufficient expertise to assess the condition of the features in disused mines.

In *active* mines and 'show mines' (tourist attractions), although staff will still not be permitted access for health and safety reasons, there will at least be access available to those working/using the mine, and the likelihood that experts will be able and willing to provide the assessments required will be greater.

The **conservation objectives** will focus on ensuring that the all the key geological features for which the site was selected continue to be available for study, are unobscured, undamaged and that any developments have been agreed to.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Key Earth science elements/entities are unconcealed	An important consideration will be whether the mine is still being worked, and if so; whether there is any capacity for the important geological material to be found elsewhere in the mine if 'worked out' from one area. In active mines engineering works that secure the ongoing safety or working the mine (e.g. roof supports) or face stabilisation will be necessary and will not be deemed to be damaging the resource so long as reasonable levels of rock exposure remain available. Build up of rock debris, as part of the mining process, will also not be unfavourable if it conceals only parts of the site, is temporary, and causes no long-term damage. In disused mines, a certain degree of natural build up of talus/fallen rock can be tolerated, if it does not completely obscure key parts of the site. The accepted level may be determined by the point at which it becomes necessary for management intervention. Fencing off shafts, open stopes and adits may be necessary in the interest of safety or for protection of vulnerable materials and this should not be regarded as decline in favourable condition. If the geological features are considered to be
Quality/Physical integrity	The geological resource remains intact and unmodified by anthropogenic intervention	
	Factors that will need to be assessed: • dumping, infilling • development or engineering works (buildings/artificial structures) that would damage the resource or conceal it • introduction of underground hazards • effluent/waste disposal, including storage of hazardous waste • significant build up of rock/sediment soil/mud /talus • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • damage by mine users • surface subsidence (implying mine collapse) • shaft/tunnel/ /stope/adit blockage by natural build up or artificial barriers. • collapse blocking access to features	

§§ excluding 'integrity sites' occurring in mines/tunnels - these are covered in the 'rare mineral or fossil deposit of limited extent' ESCC, although readers should consider the guidance given in this section on mines and tunnels and adapt it for use as necessary.

*** Mines and tunnels potentially contain any geological 'interest features' except Caves, Karst and Quaternary, relict or active geomorphology.

		so vulnerable that they have been *deliberately buried* or *access has been restricted by physical barriers* for protection, or natural concealment/tunnel blockage has occurred, then the site will not be in unfavourable condition but the target then will be *that the features remain accessible through authorised excavation.* Therefore adit or shaft closure can be acceptable if desirable/reversible. Sympathetic show mine developments (e.g. lighting, flood-water pumping, strengthening works, handrail construction or fencing off dangerous parts of the site) will be permissible without damaging the site if reasonable levels of availability of the scientifically important geological materials are available, which do not obscure important parts of the site.
Extent of the features	Extent of key features has not diminished. **Factors** to be assessed: • in disused mines, removal of material • vertical and lateral extent of features • research excavation/sampling and collecting.	If the rate of rock removal through mining is rapid, the important material may be completely mined away; in such cases it is important that reference sections are left intact as 'rare mineral deposit' ESCC category. Low levels of rock/mineral/fossil collecting / rock coring of from the rock body of interest - if it seems to be sustainable at present levels without entirely removing the features of interest it in the foreseeable future - may be permissible. [A point may be reached when collecting is no longer sustainable and the remaining resource needs to be physically protected against any collecting]. Some decrease in the level of exposure through collapse may be regarded as acceptable, particularly if the tunnel instability is an ongoing problem or if it helps to protect more vulnerable parts of the site from overcollecting. The site would be in unfavourable condition if irresponsible collecting had led to removal of a significant amount of the important material, or perhaps if fallen rock cover had reached an unacceptably high level that was going to make any research into the site very difficult. The point at which management intervention becomes necessary may be a good indicator of when this unacceptable point is reached.

INLAND OUTCROP OR STREAM SECTION††† ESCC CODE: EO

This category covers a wide range of outcrops not occurring in cliffs or quarries, from large upland sites to small stream sections (the river-cliff in a stream section will be less than 2 metres high at most otherwise the site will be classified as a 'coastal or river cliff' ESCC category, and/or an 'active geomorphology' site). In general, for the large upland exposure sites the only significant threat is major afforestation. Housing or industrial developments may represent threats to smaller inland outcrops, particularly if located near or in urban areas. If the geological features are considered to be vulnerable the site may then need to be reclassified as 'Rare mineral/fossil deposit or unusual rock body of limited extent' ESCC category.

The **conservation objectives** will focus on the maintenance of exposure quantity and quality.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Key Earth science features are unconcealed	Keeping a site completely uncovered by talus, soil and vegetation might not be practical or desirable for the long-term conservation of the site (e.g. if a site is not being grazed and rapid recolonisation of vegetation conceals parts of the site, but causes no long-term damage). Therefore, small build ups of talus/soil and vegetative cover or temporary build-up of channel deposits that entirely or partially cover up an exposed stream section can be tolerated. The accepted level may be determined by the point at which it becomes necessary for management intervention. Scrub invasion will damage integrity of soft sediment deposits through root penetration, however. A certain amount of natural concealment (by soil/talus/vegetation) may be helpful in deterring collectors if overcollecting or site misuse is a problem (e.g. the site becomes littered with collecting debris). Stream sections may occasionally become obscured by natural build up of sediment/talus/rock fall material. If this occurs through natural processes (i.e. not artificially induced through land-use changes), then the site will not necessarily be recorded as unfavourable condition, so long as the stream has the natural capacity to remove the cover and re-expose the important rock. In general, very low levels of disruption that are reversible or temporary may be acceptable and permitted with consent. Changes that may be acceptable are:
Quality/Physical integrity	The geological resource remains intact and unmodified by anthropogenic intervention	
	Factors that will need to be assessed: • natural woodland development and scrub invasion • significant build up of soil/mud /talus [where not part of the special interest] • tipping or dumping or infilling of depressions/hollows • tree planting or deep ploughing • 'landscaping' (e.g. sediment redistribution/levelling) • development or engineering works (buildings/artificial structures) track/road building • significant vegetative disruption, e.g. scrub/woodland invasion/development • river management works • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • deterioration caused by agricultural use change; (if ongoing agricultural use is not harmful to the site in the long term). • damaging recreational pursuits (e.g. mountain biking/ scrambling) causing accelerated erosion	

††† Excluding man-made outcrops such as railway and road cuttings – see under Disused quarries ESCC; also excluding 'integrity sites' occurring as outcrops/stream sections -these are covered by 'relict geomorphology', 'Karst/Caves', 'Rare mineral/fossil deposit or unusual rock body of limited extent' ESCCs as appropriate. Active fluvial landform sites are dealt with under 'active geomorphology'.

		• small, superficial, isolated developments *in non-critically important parts of the site*, such as roads/tracks; fencing, including deer fencing; tree planting. • access restriction, to vulnerable or unsafe parts of the site • modifications such as face stabilisation (such as chicken wire covering, rock bolts etc) on non-critically important parts of a site; • sympathetic drainage works (to prevent face collapse) If the exposure is of soft or unstable material that tends to weather or disintegrate quickly, maintaining large amounts of 'clean' exposure of fresh faces will not be practical or desirable because this will lead to over-rapid erosion. Vegetative cover may protect the exposure, and will only become damaging if root disruption becomes extensive.
Extent	Extent of geological resource has not diminished. **Factors** to be assessed: • removal of material, (e.g. sand/gravel extraction/ quarrying); • addition of rock/sediment/soil • vertical and lateral extent of features (e.g., if the relict features are exposed in a section like a cliff) • research excavation, unsustainable collecting	If erosion caused by the stream is very rapid, the important material may be completely eroded away. Sympathetic protection may be considered in this case, such as allowing a certain degree of cover by talus, soil or vegetation or 'soft engineering' solutions. Acceptable to a degree are: • small scale removal of samples for research (this may in fact be desirable if vulnerable material (e.g. rare minerals) is discovered; it may be preferable to move it to a suitable repository, or reclassify part of the site as 'rare mineral site of limited extent'. • small scale collecting [monitors should refer to the JNCC position statement on fossil collecting, as well as guidelines produced by the Geologists' Association], i.e. removal of small amounts of material if the resource is sufficiently extensive and if collecting seems to be sustainable at present levels and is carried out safely and with owner permission. [A point may be reached when collecting is no longer sustainable and the remaining resource needs to be physically protected].

FOREHORE EXPOSURE‡‡‡ ESCC CODE: EF

Conservation objectives for foreshore sites are similar to those for coastal cliffs, as similar threats apply. Maintenance of natural processes is again the key to successful conservation. Many sites with foreshore exposures also have cliff exposures but the objectives for both site types are easily integrated. The focus of the **conservation objectives** is on maintaining exposure of the interest features and there is usually no need for active management. Any development that directly or indirectly affects the amount or quality of the exposure of the interest features constitutes a threat to the site. As with the other site types described above, if specimen collecting is likely to seriously damage the resource problem, the site should be reclassified as 'Rare mineral/fossil deposit or unusual rock body of limited extent' .

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	Key geological entities are unconcealed	Natural build-up of sediment/rock from rock-falls and seaweed cover that entirely or partially covers up the exposure is acceptable *if it is likely to be temporary* and if *the features remain accessible for research through excavation.* The site will not necessarily be recorded as unfavourable condition so long as sediment build-up has not been artificially induced and if erosion has the natural capacity to remove the cover and re-expose the important rock. The accepted level may be determined by the point at which it becomes necessary for management intervention. Some sediment build up may, in fact, help to protect more vulnerable parts of the site from erosion or .in deterring collectors, if overcollecting or site misuse is a problem. This cover can be tolerated if it causes no long-term damage to the key Earth science elements/entities and if the site can still be excavated prior to consented research. An unacceptably high level of cover from rock slumping that is going to severely restrict access for research or make clearance very difficult would be recorded as unfavourable. In general, very low levels of disruption that are reversible or temporary may be acceptable, such as small, superficial, isolated developments *in non-critically important parts of the site*, such as small jetties, pipelines.
Quality/Physical integrity	Exposure remains intact and unmodified by anthropogenic intervention	
	Factors to be assessed: • concealment through the erection of artificial structures such as pipelines, jetties marinas, barrages • significant build up sand/shingle/mud/seaweed or beach renourishment • long-term concealment through rock cover from slumping • coastal protection works obscuring the features • development or engineering works the foreshore exposure • coastal reclamation/sea defence developments • damaging recreational pursuits causing accelerated erosion • research excavation	
Extent	Extent of key features has not diminished. **Factors** to be assessed: • removal of material, (e.g. quarrying); • addition of rock/sediment	Acceptable to a degree are: • small scale removal of samples for research (this may in fact be desirable if vulnerable material (e.g. rare minerals) is discovered; it may be preferable to move it to a suitable repository, or reclassify

‡‡‡ Excludes 'integrity sites' occurring on foreshores - these are covered by the 'rare mineral or fossil deposits of limited extent' ESCC.

	• vertical and lateral extent of features • collecting	part of the site as 'rare mineral site of limited extent'. • small scale collecting [monitors should refer to the JNCC position statement on fossil collecting, as well as guidelines produced by the Geologists' Association], i.e. removal of small amounts of material if the resource is sufficiently extensive and if collecting seems to be sustainable at present levels and is carried out safely and with owner permission. [A point may be reached when collecting is no longer sustainable and the remaining resource needs to be physically protected].

COASTAL AND RIVER CLIFFS§§§, **** ESCC CODE: EC

Coastal cliffs represent the majority of sites in this category and are a very important part of the total geological resource of the UK, as there are many areas of the country where exposure is absent inland and present only on the coast. The main threat to these sites is from coastal defences and large developments, both of which are covered by the planning process. For cliffs in soft sediments, or where erosion is particularly rapid, maintaining optimum extents of 'clean', fresh exposure all the time will not be practical or desirable; maintaining the ability to clear faces for research will be important however. Specimen collecting may be problem on a small number of sites, depending on the scale of collecting. However, on many coastal sites, particularly those which are undergoing rapid erosion, responsible fossil collecting is a positive activity, as specimens would otherwise be lost.
The **conservation objectives** will ensure maintenance of natural processes that allow erosion to proceed unimpeded and thereby maintain degree and quality of exposure of the geological features.

Similar principles that apply to coastal cliffs apply to the conservation of *river* cliffs, although cross reference to guidance under the 'Active geomorphology' ESCC is recommended.

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	The key Earth science elements/entities are unconcealed	In general, low levels of disruption that are reversible or temporary may be acceptable such as: • small superficial modifications in non-critically important parts of the site such as fence construction, sign erection and paths at the cliff top; sensitively planned beach-hut construction. • face stabilisation to unsafe parts of the site if not in critically important parts of the site; • sympathetic cliff-protection may be acceptable, if cliff-line retreat is very rapid, and if the important material may be completely eroded away. A certain degree of cover by talus, soil or vegetation or 'soft engineering' solutions (e.g. offshore berms) could be allowed. Cliff foot accumulations should be removable. Natural build-up of sediment/rock from rock-falls that entirely or partially covers up the exposure is acceptable *if it is likely to be temporary* and if *the features remain accessible for research through excavation.* The site will not necessarily be recorded as 'unfavourable' so long as sediment build-up has not been artificially induced and if erosion has the natural capacity to remove the cover and re-expose the important rock *in situ*. The accepted level may be
Quality/Physical integrity	Exposure remains intact and unmodified by anthropogenic intervention	
	Factors to be assessed: • erection of artificial structures, including 'hard' coast protection /sea defence developments, e.g. concrete structures • significant build up of soil/mud /talus/ sand/shingle/mud/seaweed [where not part of the special interest] • vegetation/ scrub invasion • developments above cliffs undergoing erosion • tipping or dumping at clifftop or clifffoot • agricultural use change in the vicinity of the clifftop that might destabilise the cliff • significant vegetative disruption, e.g. scrub invasion of a soft cliff • unimpeded coastal or fluvial erosion to remove cliff-foot accumulations, and maintain a good, clean 'face'. • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • damaging recreational pursuits	

§§§ Excludes 'integrity sites' occurring in coastal cliffs and river cliffs – these are classified as 'relict geomorphology', 'Caves/Karst', or 'rare mineral or fossil deposits of limited extent' ESCCs as appropriate.

**** Potentially any except those that may occur in 'Cave/Karst' and 'active geomorphology' ESCCs. Active river and coastal geomorphology sites are accounted for under the 'active geomorphology' ESCC.

	(e.g. rock climbing) causing accelerated erosion	determined by the point at which it becomes necessary for management intervention. Cover from rock slumping that is going to severely restrict access for research or make clearance very difficult would be recorded as unfavourable. [For cliffs above the MHWM, only storms or very high tides may remove talus etc. and the likelihood of this occurring needs to be assessed. If the site is a mass movement site, the site will be considered under the 'active geomorphology' ESCC] Some sediment build up or natural scrub/other vegetation may, in fact, help to protect more vulnerable parts of the site from erosion or in deterring collectors, if overcollecting, site misuse or over-rapid erosion is a problem (e.g. site becomes littered with collecting debris or cliffs are being artificially undermined). This cover can be tolerated if it causes no long-term damage and if the site can still be excavated prior to consented research. Build ups of sediments that allow access to higher parts of the section can sometimes improve research potential - where no key features occur at the cliff-foot.
Extent	Extent of key geological features has not diminished: both vertical and lateral extent of features constant or increasing. **Factors** to be assessed: • quarrying/large scale rock removal • addition of rock/sediment/soil to cliff foot • collecting,research excavation	Acceptable to a degree are: • small scale removal of samples for consented research and education (this may in fact be desirable if vulnerable material (e.g. rare minerals) is discovered; it may be preferable to reclassify part of the site as 'rare mineral site of limited extent'. • responsible specimen collecting, including commercial collecting [monitors should refer to the JNCC position statement on fossil collecting, as well as guidelines produced by the Geologists' Association], i.e. removal of material if the resource is sufficiently extensive and if collecting seems to be sustainable at present levels. [A point may be reached when collecting is no longer sustainable and the remaining resource needs to be physically protected].

ACTIVE QUARRIES AND PITS††††, ‡‡‡‡ ESCC CODE: EA

In general, quarrying is considered to be a positive activity from the perspective of geological conservation. Quarrying has resulted in the creation of a large number of geological exposures in areas such as south-eastern England, where there was little or no pre-existing inland exposure and has, therefore, been responsible for the generation of a vast scientific resource.

Most active quarries are in favourable condition – particularly if the interest features are represented by the rock that is being quarried, except where the key rock body is in danger of being 'worked out'. If the interest features are in the overburden or form the quarry floor, it will be important that they are not permanently buried or removed through quarrying operations. 'Conservation faces' (set-aside rock exposures) will not generally be necessary in the normal operation of the quarry, so long as periodic investigation for research is possible on the faces being actively worked. However, as a quarry comes to the end of its working life and is nearly 'worked out', the main threat to geological conservation is where any conservation faces are covered by back-filling with quarry waste and, in some cases, landfill or developments (these activities are generally covered by the planning process and it is necessary to ensure that planning conditions.)

In general, specimen collecting from active quarries is a positive activity if permitted by the quarry operators, as specimens would otherwise be lost.

The main **conservation objective** is to ensure that the key geological features are not entirely removed or destroyed, and are likely to be exposed during normal quarrying operations if not presently exposed; any conservation 'faces' must not be permanently concealed. An assessment of the extent of the interest features not yet exposed (i.e. the total extent of the rock resource, not just the exposed parts, and the capacity for exposing important new 'finds', or rock faces, by normal quarrying operations if elsewhere it is being removed or covered). It will be important to ensure that geological conservation is included in restoration plans towards the end of the working life of a quarry.

Any 'final' faces left for study must be in good 'clean' physical condition [i.e. safety and solidity of remaining face will be important. Ideally the face should be smooth blasted rather than shattered, or left at 50 degree angle for soft sediments. There should be a reasonable resource of the important material behind the ultimately conserved face]. Such faces will then fall into the category 'disused quarries', and should not be *permanently* obscured or damaged by waste material/ build up/ reclamation schemes/ building or engineering developments.

Attribute	Targets and factors to be assessed	Practical considerations
Extent	Extent of key geological features has not diminished: both vertical and lateral extent of features constant or increasing: **Factors** to be assessed: • quarrying continuing to reveal rock material of the same type; • capacity in the quarrying operations for exposure of the interest features to be created is maintained • vertical and lateral extent of features constant or increasing as quarrying progresses • addition of rock/sediment/soil against conserved faces	The site is likely to change significantly over time. Acceptable changes that will be tolerated within the 'favourable – maintained' condition will be: • removal of material through normal quarrying operations, so long as any 'final' faces are agreed and conservable upon cessation of quarrying; • removal of samples for research and education (this may in fact be desirable if vulnerable material (e.g. rare minerals) is discovered; it may be preferable to reclassify part of the site as 'rare mineral site of limited extent'. • specimen collecting that is sustainable. • temporary build ups of rock debris/sediment that entirely or partially

†††† Excluding 'integrity sites' co-incidentally present in active workings - these are covered in relict geomorphology, Karst/Caves, rare mineral or fossil deposits of limited extent ESCCs as appropriate.

‡‡‡‡ Potentially any geological types except those that may occur in Cave/Karst and active geomorphology ESCCs.

		covers up the exposure, if they are deemed to be part of normal quarrying and likely to be removed through normal operations eventually; if rock cover through slumping/ dumping/ blasting had reached an unacceptably high level that was going to severely restrict access in the long term for research or make clearance very difficult the site could become unfavourable in condition.
Visibility	Key Earth science elements/entities are unconcealed	Modifications such as pipeline laying or engineering works normal to the operation of the quarry which do not permanently damage critically important parts of a site will be acceptable. Quarry floor developments will only be damaging if the interest features lie in the quarry floor material. Natural build-up of sediment/rock at the foot of important quarry faces will only lead to the site being recorded as unfavourable condition if build-up has exceeded specified levels such that it would severely restrict access for research or make clearance exceedingly difficult. For unstable faces, accumulated talus material, soil or vegetation may be helpful to the long-term conservation of the site, so long as the cover can be removed when the site is being studied for research. The accepted level may be determined by the point at which it becomes necessary for management intervention. Talus/vegetation may also help to protect more vulnerable parts of the site from overcollecting (e.g. site becomes littered with collecting debris or cliffs are being artificially undermined) and site misuse if it causes no long-term damage and if the site can still be excavated prior to research. Build ups of sediments that allow access to higher parts of the section can sometimes improve research potential – where no key features occur at the cliff-foot. If stability of quarry/ pit sides is a problem, sympathetic protection in the interests of safety may be considered without reducing the conservation status of the site e.g. accumulated waste material or a slump may stabilise a pit side – important here is whether the cover can be removed when the site is being studied for research.
Quality/Physical integrity	This will be an attribute that applies to any c*onserved exposures* within an active quarry or 'final faces' left at the end of quarrying: for which see guidance under the 'disused quarries' ESCC category.	
	Factors to be assessed: • new physical obstructions; buildings and other structures impairing access • long-term storage of materials against key quarry faces; • engineering works (including inappropriate restoration works) that would permanently obscure or damage the important quarry faces • significant build up of soil/mud /talus • face reprofiling/stabilisation • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • planning conditions and working/restoration agreements/plans are being observed on site; build up of talus, talus and overburden does not unacceptably impair access, flooding does not impair access; • natural woodland development or scrub/vegetative invasion	

DISUSED QUARRY, PITS AND CUTTINGS§§§§ ESCC CODE: ED

The main threats to the conservation of geological features in disused quarry sites are landfill and fly-tipping, and excessive vegetation growth and build-up of talus, which conceal the features of interest. Landfill activities are dealt with through the planning process.

'Restoration' of quarries (e.g. infilling and 'landscaping') may also pose a threat; in which case a negotiated 'conservation face' to be set aside needs to be preserved. In such cases, the **conservation objectives** should clearly define the location and extent of the conservation face and specify the permissible limit of encroachment by e.g. landfill.

Vegetation growth is a major problem for geological conservation in many disused quarries and cuttings, as erosion rates are usually too low to maintain exposure of the geological features. The conservation objectives should define the areas on a site that need to be maintained clear of vegetation or talus through the use of accompanying maps and photographs.

Specimen collecting may be a problem on a small number of sites, depending on the scale of collecting. If the resource is finite, the site should be reclassified all, or in part, as 'Rare mineral/fossil deposit of geological rock body of limited extent' and conservation objectives written accordingly.

The **principal target** will be to maintain the degree and quality of exposure of the key Earth science elements/entities and where necessary enhance their exposure – the degree will depend particularly on upon the rock resistance to erosion (the less stable/softer the sediment the greater degree of vegetative stabilisation and concealment will be permitted) and level of permissible accumulations at the foot of the quarry face .

Attribute	Targets and factors to be assessed	Practical considerations
Visibility	The key Earth science elements/entities are unconcealed	In general, low levels of disruption that are reversible or temporary may be acceptable such as: • small superficial modifications in non-critically important parts of the site such as fence construction, sign erection and path laying. • small alterations if they are reversible and short term and do not contaminate the site and do not affect critically important parts of the site. • face stabilisation (by artificial means such as chicken wire covering, rock bolts etc.) to unsafe parts of the site if not in critically important parts of the site or if erosion is over-rapid, and the important material is likely to be completely eroded away. • minor restoration and landscaping that does not damage or conceal the critically important parts of the site e.g. sympathetic drainage works (to prevent face collapse), afforestation/ landfilling or fencing off dangerous parts of the site. • quarry floor developments that do not conceal key features. • minor rock climbing developments
Quality/Physical integrity	Exposure remains intact and undisturbed by anthropogenic activity.	
	Factors to be assessed: • natural woodland development or scrub/vegetative invasion • concealment through the erection of artificial structures • significant build up of soil/mud /talus [where not part of the special interest] • tipping, dumping, infilling of depressions/hollows • 'landscaping' (e.g. sediment redistribution/levelling/ 'restoration' or 'reclamation' by infilling and tree planting) • face reprofiling/stabilisation • development or engineering works (buildings/artificial structures) track/road building • vegetative disruption, e.g. scrub/woodland	

§§§§ Excluding 'integrity sites' in disused workings - these are covered in the 'rare mineral or fossil deposits of limited extent', 'relict geomorphology' or 'Karst/Caves' ESCCs as appropriate.

	invasion/development • artificially induced changes to water levels (flooding or draining) • contamination/ pollution • deterioration caused by agricultural use change; (if ongoing agricultural use is not harmful to the site in the long term. • damaging recreational pursuits (e.g. scrambling/rock climbing) • accumulation of leachate/landfill gas; where site is partially landfilled.	Natural build-up of sediment/rock at the foot of the quarry face may lead to the site being recorded as unfavourable condition, if sediment build-up has exceeded specified levels such that it would severely restrict access for research or make clearance very difficult. Some talus build up or natural scrub/other vegetation is acceptable if it does not completely obscure (or cause damage by root disruption to) key parts of the site. For unstable faces, accumulated talus material, soil or vegetation may be helpful to the long-term conservation of the site, so long as the cover can be removed when the site is being studied for research. The accepted level may be determined by the point at which it becomes necessary for management intervention. Talus/vegetation may also help to protect more vulnerable parts of the site from overcollecting (e.g. site becomes littered with collecting debris or cliffs are being artificially undermined) and site misuse if it causes no long-term damage and if the site can still be excavated prior to consented research. Build ups of sediments that allow access to higher parts of the section can sometimes improve research potential – where no key features occur at the cliff-foot.
Extent	Extent of key geological features has not diminished. **Factors** to be assessed: • removal of material, (e.g. sand/gravel extraction/ quarrying); • addition of rock/sediment/soil • vertical and lateral extent of features constant • collecting, research excavation.	Acceptable to a degree are: • removal of samples for research and education (this may in fact be desirable if vulnerable material (e.g. rare minerals) is discovered; it may be preferable to reclassify part of the site as 'rare mineral site of limited extent'. Excessive coring will damage the site. • responsible specimen collecting, including commercial collecting [monitors should refer to the JNCC position statement on fossil collecting and code produced by the Geologists' Association], i.e. removal of material if the resource is sufficiently extensive. [A point may be reached when collecting is no longer sustainable and the remaining resource needs to be physically protected] • limited sustainable quarrying may be acceptable, e.g. if local stone is required for building restoration, if the available resource is sufficiently extensive.

REFERENCES

Nature Conservancy Council (1990) *Earth Science Conservation in Great Britain - A strategy* 84pp + 5 Appendices

Ellis, N.V. (ed) (1996) *An Introduction to the Geological Conservation Review*. GCR Series No.1, JNCC, Peterborough.

JNCC (October 1997) *Conserving Our Fossil Heritage - a JNCC Policy Statement* (http://www.jncc.gov.uk/earthheritage/module/jnccfoss.htm)

APPENDIX 1

The interest features, which combines both SSSI and ASSI selection categories for Earth science sites is not the same as the GCR or ESCR 'block' list – but each GCR and ESCR block will fall into one interest feature category.
I.

Table of Earth science interest features

STRATIGRAPHY
Neogene
Palaeogene
Cenomanian-Maastrichtian
Aptian-Albian
Berriasian-Barremian
Portlandian-Berriasian
Wealden
Kimmeridgian
Oxfordian
Callovian
Bathonian
Aalenian-Bajocian
Toarcian
Hettangian-Pliensbachian
Rhaetian
Non-marine Permian and Triassic
Marine Permian
Upper Carboniferous
Lower Carboniferous
Non-Marine Devonian ('Old Red Sandstone')
Marine Devonian
Ludlow
Wenlock
Llandovery
Caradoc-Ashgill
Llandeilo
Tremadoc-Llanvirn
Cambrian
Precambrian of England and Wales
Precambrian Palaeontology of England

MINERALOGY
Mineralogy

STRUCTURAL AND METAMORPHIC GEOLOGY
Moine
Torridonian
Lewisian
Dalradian
Post Variscan Structures
Variscan Structures
Caledonian Structures

IGNEOUS PETROLOGY
Tertiary Igneous rocks
Carboniferous-Permian Igneous rocks
ORS Igneous rocks
South-West England Igneous rocks
Ordovician Igneous rocks
Caledonian Igneous rocks

PALAEONTOLOGY
Tertiary Reptilia
Jurassic-Cretaceous Reptilia
Permian-Triassic Reptilia
Tertiary Mammalia
Mesozoic Mammalia
Pleistocene Vertebrata
Aves
Palaeoentomology
Arthropoda (excluding insects/trilobites)
Silurian-Devonian Chordata
Permian/Carboniferous Fish/Amphibia
Mesozoic-Tertiary Fish/ Amphibia
Tertiary Palaeobotany
Mesozoic Palaeobotany
Palaeozoic Palaeobotany

QUATERNARY GEOLOGY AND GEOMORPHOLOGY
Quaternary of Northern Ireland
Quaternary of East Anglia
Quaternary of the Midlands and Avon
Quaternary of eastern. England
Quaternary of north-east England
Quaternary of Cumbria
Quaternary of the Pennines
Quaternary of south-east England
Quaternary of south central England
Quaternary of South-West England
Quaternary of Somerset
Quaternary of the Thames
Quaternary of Scotland
Quaternary of Wales
Peat and related stratigraphy

GEOMORPHOLOGY
Karst and Caves
Coastal geomorphology
Fluvial Geomorphology
Mass Movement

APPENDIX 2

Manifestations of interest features at Earth science sites

This list is not intended to serve a formal purpose but merely demonstrates that it is the presence of geological and geomorphological entities like these that will be the focus of site specific conservation objectives – i.e. we are not setting conservation objectives for interest features directly.

- exposure of a sequence of rock/sediment units (i.e. several lithological units in continuity)
- exposure of rock body (e.g. -igneous sill, igneous dyke, volcanic neck)
- exposure of specific 'horizon' in a rock/sediment succession (e.g. lithological unit, change in rock type or fossiliferous layer)
- exposure of a junction or boundary between rock/sediment bodies (unconformity; igneous contact; contact metamorphism
- exposure of rock body/layer/ veins potentially bearing fossils or minerals
- exposure of rock body/layer/ veins actually containing minerals/fossils (excluding 'cave mineral deposits' below)
- buried rock body containing rare or unusual mineral/fossil material (*where burial is part of the conservation management of the site)*
- presence of specific mineral or fossil not *in situ* (loose/within boulders, slag heap etc)
- exposure of sedimentary structures (sole marks, cross bedding; ripples etc.)
- exposure of deformation structures (folding; faulting; cleavage)
- exposure of visible/large/visually spectacular fossils (e.g. tree stumps; footprints)
- active landslip landform
- relict landslip landform
- glacial (including glacio-fluvial) interglacial and/or periglacial landforms/morphological features (deposits or erosional features e.g. moraine, drumlins, isostatic/eustatic features - raised beaches, striations, róche moutonnée, crag and tail, patterned ground)
- soft sediment containing buried, but excavable, important 'fossil' material/information' (e.g. bog sites)
- cave chamber or passage
- cave choking/collapse feature;
- cave mineral deposits [speleothem; tufa]
- cave sediments, fossiliferous cave deposit Is it important to distinguish 'cave' deposits from other deposits? (Carboniferous 'lagoonal ' and river' deposits are not, for example differentiated. Could 'cave sediment' not come under 'exposure of a sequence of rock/sediment units (i.e. several lithological units in continuity)' or 'soft sediment containing buried, but excavable, important 'fossil' material/information' (see 'Quaternary bog') as appropriate to whether cave sediments buried or exposed. Similarly fossiliferous cave deposits could be included in other categories.
- chalk/limestone drainage feature; active solutional processes, relict solutional processes]
- karst landform [doline, karst valley, dry valley; gorge; limestone pavement; scar]
- active coastal erosion/deposition landform assemblage: shingle structures; beach complexes; spits, dunes, soft cliffs; hard-rock cliffs; beach complexes, machair
- relict coastal erosion/deposition landforms (including 'fossil' shingle structures, spits; beaches; machair; raised wave-cut notches or wave cut platforms)
- saltmarsh
- active fluvial landforms [erosion/deposition characteristics] (e.g. active bars, meanders, gorges, waterfalls, levees) and/or fluvial process characteristics (e.g. river bed form (potholes; rocky, gravely or muddy character), river 'load' type and quantity) and/ or river channel and floodplain change characteristics (e.g. rejuvenation evidence, storm surge deposition, ox-bow lakes)
- relict fluvial landforms [not part of a currently active fluvial system: relict erosion/deposition characteristics e.g. terraces, relict river channels, river capture evidence]