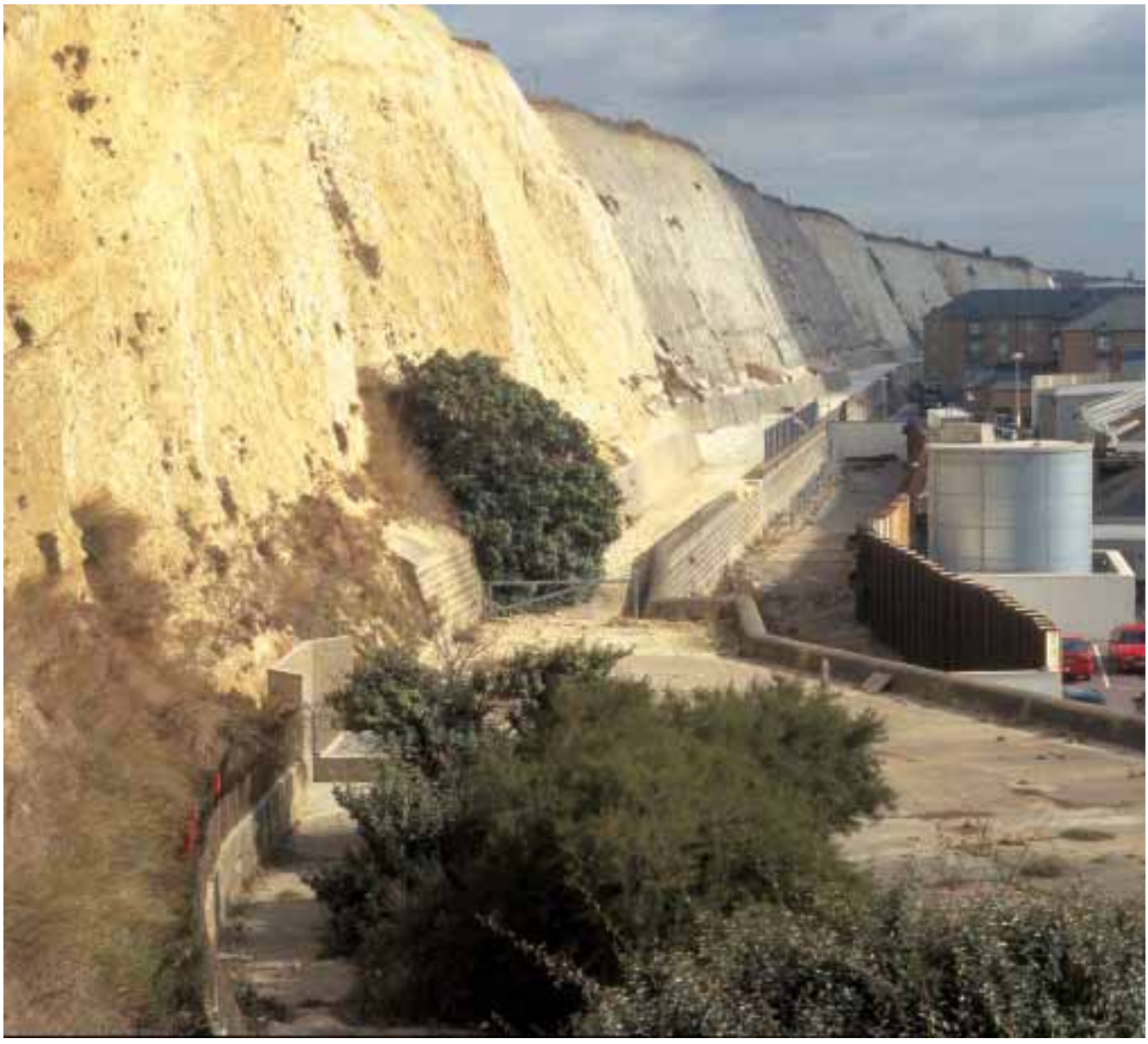
4 Case studies

This chapter presents a series of case studies based on actual experience in conserving geological sites. At least one case study is presented for each of the Earth Science Conservation Classification (ESCC) site types. The case studies were chosen to provide practical illustrations of the range of issues associated with geological site conservation in general, rather than to highlight specific sites.

Most or all of the sites here are in private ownership and their use as case studies does not imply that they are open to public access. In all cases, permission for access should be sought from the owner, occupier or appropriate authority.

Former sea-cliffs and adjacent development at Black Rock, Brighton, East Sussex. Colin Prosser/English Nature



4.1 Barrington Chalk Pit and Broadway Quarry

Active quarries (EA) in Cambridgeshire and Worcestershire

Conservation issues discussed here

- The importance of early discussions with local planning authorities and quarry operators to ensure that geological conservation is considered with respect to regular quarry operations and quarry restoration schemes.
- The use of planning conditions for the protection of geological sites.

Site descriptions

Barrington Chalk Pit SSSI is designated for Cretaceous stratigraphy, exposing the uppermost part of the Gault Clay, the Cambridge Greensand, the West Melbury Chalk Formation, the Totternhoe Stone and part of the Zig Zag Chalk Formation. The site is particularly important as the only remaining exposure of the Cambridge Greensand, renowned for its large and diverse vertebrate and invertebrate fossil faunas.

Broadway Quarry, Worcestershire, exposes a series of limestones, sandstones and mudstones of Lower Jurassic age. The site is not an SSSI but is locally important as the type section of the Harford Member, a sequence of mudstones and sandstones, overlying the Scottsquar Member of the Birdlip Limestone Formation, which is not as well-exposed elsewhere in the Cotswolds. The quarry operator brought the site to the attention of the local RIGS group and part of the site is to be designated as a RIGS.

Management issues and solutions

At both quarries, the primary objective is to ensure that the features of interest remain exposed and accessible throughout the working lives of the quarries and when extraction ceases.

At Barrington Chalk Pit, principles for conserving the interest at the site during continued quarrying operations and restoration have been agreed between English Nature, Cambridgeshire County Council and the quarry operators. As part of a phased restoration, a benched conservation face, with routes allowing access to the full succession, will be left at restoration. However, the floor of the pit, where the Cambridge Greensand is exposed, is subject to flooding. While extraction continues, this is managed by pumping. Flooding will become a problem once extraction ceases. This means that the retention and maintenance of exposures of the Cambridge Greensand will become problematic at that time.

Broadway Quarry has planning permission for an extension that will lead to the loss of the existing exposure of the Harford Member, for which the site is geologically important. However, the quarry extension will provide further exposures of the Harford Member and will also provide the opportunity to design and retain a conservation section within the restored site. Liaison between the quarry operators and the local RIGS group has resulted in the inclusion of a planning condition requiring the creation of a conservation section about 200 m in length to be retained at restoration. The section will be designed so that it will be accessible for study and is proposed for a RIGS designation. The conservation section is to be created after completion of extraction. There are plans to involve the local RIGS group in managing the exposures and authorising future access for interested parties.

Important fossil finds at Barrington Chalk Pit SSSI, where the quarry operators have a keen awareness of the scientific significance of the geology. CEMEX

Conservation outcome

Liaison between conservation organisations, local planning authorities and quarry operators have played a vital role in securing the future of the geological interests on these sites. This has been achieved through including conservation faces within the restoration plans, supported through conditions set out in the mineral permissions.

4.2 Clee Hill Quarries

Active and disused quarries (EA and ED) in Shropshire

Conservation issues discussed here

- Use of a grant to conserve, enhance and promote important geological features.
- Using site interpretation to assist site management.

Site description

Clee Hill Quarries, Shropshire, are operated by Hanson Aggregates. The quarries expose the doleritic Clee Hill Sill, intruded during the late Carboniferous. Clee Hill Quarries include the currently dormant Incline Quarry and the active Dhustone Quarry. Both quarries provide outstanding exposures of the Clee Hill Sill.

Management issues and solutions

The Aggregates Levy Sustainability Fund (ALSF) was introduced in April 2002 as a means of distributing some of the revenue raised through the Aggregates Levy, a tax on primary aggregate extraction applicable across Great Britain. Ten per cent of the money raised through the Aggregates Levy is used to finance the Sustainability Fund, which is distributed through grants by a number of organisations, including English Nature.

Grants have been awarded to support local projects in England that increase or promote biodiversity and/or geodiversity. Grant provision for geological projects aims to support the management, conservation and interpretation of geological features associated with aggregate quarrying, as well as increasing access for the purposes of scientific research, education, recreation and tourism.

In 2003, Hanson Aggregates submitted an ALSF grant application aimed at providing the general public, schools and geological interest groups with an opportunity to learn about the geology of Clee Hill Quarries. This was to be achieved through the construction of safe footpaths and viewing platforms, with interpretation panels providing information about the geology and history of mineral extraction at the site. The aim of the project was to promote a better understanding of the links between geology, quarrying, restoration and geological conservation. This was to appeal to both local and national interest groups.

The opening of the viewing platform with interpretation panel in 2004. Hanson Aggregates

The grant application was successful. Design work was undertaken by Hanson's in-house geologists, landscape architects and estates management team.

The viewing platforms, with interpretation boards, were opened in July 2004. The platforms provide good views of the geological exposures, but fences have been installed to restrict access to unsafe areas. The interpretation boards provide information about the geology and history of mineral extraction at Clee Hill and were developed by Hanson, with several partners, including the Shropshire Geological Society, Shropshire RIGS Group, Shropshire Wildlife Trust and South Shropshire District Council.

The viewing platforms are used regularly by schools and various groups, including the local RIGS group, amateur geological societies, academic institutions and local residents.

Conservation outcome

The viewing platforms at Clee Hill Quarries are a good example of how a mineral operator, with local partnership, can secure a grant to help provide the local community and specialist groups with an educational facility that promotes geology and helps people to understand mineral extraction processes.

4.3 Asham Quarry

A disused quarry (ED) in East Sussex

Conservation issues discussed here

- The creation of an alternative geological conservation section adjacent to a quarry which is being landfilled.
- Improved safety and access to a geological interest.

Site description

Asham Quarry SSSI is designated for its late-glacial and post-glacial deposits which are important in understanding late Quaternary environmental changes in south-eastern England. The post-glacial deposits are unusually thick and are believed to provide a near continuous record of environmental and landscape changes. Molluscan faunas contained within them have allowed a particularly full reconstruction of Holocene palaeo-environmental conditions. The deposits are also important for carbon dating. The Quaternary deposits overlie the Cretaceous Chalk for which the site was worked. Chalk extraction left a deep quarry and permission to landfill the site was given when works ceased.

Management issues and solutions

Landfilling from the base of the former quarry up to the level of the Quaternary deposits would have conserved the special interest of the site and made access to the deposits easier. There were, however, concerns regarding the loss of the extra void space at the top of the quarry for landfill and over the safety of the site, particularly where landfilling operations are ongoing. There were also concerns over the visual impact of leaving a void space in open countryside within the South Downs Area of Outstanding Natural Beauty (AONB).

The developer, the local planning authority and English Nature agreed an alternative solution which involved complete infilling of the existing void and creation of a new exposure adjacent to the landfill, as mitigation for infilling the original quarry. The creation of the new exposure was funded by the developer and was sited adjacent to the original sections, but in an area of relief which renders the excavation less visually intrusive.

The section took two days to construct and consists of an amphitheatre-shaped void, which is around 3 m deep at its maximum depth. Fencing surrounds the exposed section, with a gate and steps for entry. Access is obtained by permission from the site office. The new section also provides a safe environment for studying the deposits.

Maintenance of the site requires vegetation management and occasional re-exposure of the soft sediment, but deterioration of the site has been slow and management works have consequently been minimal to date.

Conservation outcome

Negotiations between the mineral operator, local planning authority and English Nature ensured the creation of an alternative exposure, securing the geological interest at the site, and leaving the quarry void available for landfill.

The alternative section at Asham Quarry SSSI, constructed by Haul Waste. Natalie Bennett/English Nature

4.4 Eartham Pit, Boxgrove

A disused quarry (ED) in West Sussex

Conservation issues discussed here

- Integrating conflicting statutory conservation interests.
- A partnership approach to secure the conservation of geological and archaeological interests.
- Creation of a conservation face as part of quarry restoration.

Site description

Eartham Pit, Boxgrove SSSI, is a recently disused sand and gravel pit in West Sussex. It is designated as an SSSI for a complex sequence of Quaternary sediments, containing evidence of a number of different climatic intervals, which occur beside a fossil chalk cliff. The site is also important for Quaternary faunal remains associated with the cliff and beach sequence. Certain horizons within the sequence contain an extensive interglacial small mammal fauna, while large mammals, other vertebrates, molluscs and pollen also occur. In addition, the site is archaeologically important as a rare Palaeolithic human occupation site and has yielded numerous artefacts and early human remains. The site is considered to be of major importance in piecing together the Quaternary record of Britain and Northern Europe.

Management issues and solutions

While Eartham Pit was still operational, it became subject to the ROMP (Review of Old Mineral Permissions) process under the Environment Act (1995), which identified the need for ongoing scientific recording as extraction progressed. Consequently, geological and archaeological recording have taken place throughout extraction and, more recently, restoration of the site. This ongoing research is vital in order to gain maximum scientific benefit because material would otherwise be lost through the quarrying and restoration processes.

Since the quarry ceased to operate, the main management issue is related to the different approaches to conserving geological and archaeological interests on the site, which in this case are conflicting. In general, it is necessary to maintain permanent exposures of geological features for ongoing study, particularly on a site like Eartham, where the environmental context of the sedimentological and palaeontological interests is important. In contrast, the normal approach to archaeological conservation on an artefact site like Eartham is to bury the interest features to prevent unauthorised removal of specimens and degradation.

There is recognition by English Nature and English Heritage, which are responsible for the archaeological interest, that the most vulnerable interests at the site dictate its future management. It is difficult to avoid disturbing or damaging the archaeological interest with a geological conservation section, as the archaeological artefacts are widespread across the site.

However, a revised minerals planning permission includes a condition requiring provision of a geological conservation section as part of the restoration. A location for this, in an archaeologically less sensitive part of the site, has now been identified.

Eartham Pit, Boxgrove SSSI. Natalie Bennett/English Nature

Conservation outcome

Recording of the geological interest has taken place as quarrying has progressed. The need for both recording and a final geological conservation section is recognised as part of the minerals planning permission. Having agreed an approach with the local planning authority and English Heritage, English Nature and the operator are currently working in partnership to identify an area in which to place a geological conservation section as part of the final restoration of the site.

Further information

BENNETT, N. 2000. Best of both worlds. *Earth Heritage*, 14, 8–9.

ROBERTS, M. 1998. Middle Pleistocene sediments and archaeology at Eartham Quarry, Boxgrove, West Sussex. *In: The Quaternary of Kent and Sussex, A Field Guide*, 187–213. Quaternary Research Association.

4.5 Lime Craig and Teindland Quarries

Disused quarries (ED) in Stirling and Moray, Scotland

Conservation issues discussed here

- The use of partnerships and management plans in securing positive conservation outcomes.

Site descriptions

Both sites discussed here are disused quarries and geological SSSIs. The quarries lie within forestry plantations and are owned and managed by Forest Enterprise.

Lime Craig Quarry, Stirling, exposes the Dounans Limestone and other elements of the tectonically disrupted Highland Border Complex. The evidence provided by fossils from the Dounans Limestone, as well as other units belonging to the Highland Border Complex, is of great importance for the dating of these rocks and for understanding the relationships of the Highland Border Complex to adjacent terranes.

Teindland Quarry, Moray, is a key site for interpreting and dating late Quaternary events and environmental change in Scotland. It is one of a few sites in Scotland with deposits dating from the last interglacial, and provides crucial evidence for environmental conditions at this time.

Clearance works in progress at Teindland Quarry. John Gordon/Scottish Natural Heritage

Management issues and solutions

At Lime Craig quarry, encroachment of trees up to and onto the quarry faces is the main management issue. The seeding and growth of saplings on the quarry faces results in the interest features becoming obscured, limiting both visibility and physical access to the exposures.

At Teindland Quarry, the growth of gorse and the accumulation of spoil has obscured the exposures. The penetration of roots from trees growing above the faces also disrupts the geological features and there is a potential risk of further damage from trees being blown over in strong winds. Occasional fly-tipping also occurs.

In order to positively conserve the geological features at the quarries, management plans were agreed between Scottish Natural Heritage (SNH) and Forest Enterprise. At Lime Craig Quarry, the management plan addresses the removal of young trees from both on and around the exposures. At Teindland Quarry, the management plan includes removal of scrub by hand, felling of trees close to the quarry faces, limited removal of spoil, access improvements to the site and erection of fencing to prevent fly-tipping. Funding for the work is provided jointly by Forest Enterprise and SNH.

Conservation outcome

Both sites demonstrate working in partnership with landowners. The development of management plans for both sites has ensured that Forest Enterprise is now more aware of the importance of the geological interests at the sites and is actively involved in carrying out long-term management.

4.6 Robin's Wood Hill Quarry and Weybourne Town Pit

Disused quarries (ED) in Gloucestershire and Norfolk

Conservation issues discussed here

- The need for vegetation clearance and re-excavation to maintain soft sediment exposures in disused quarries.
- Partnership approaches to site management.

Site description

Robin's Wood Hill Quarry SSSI is a disused quarry in the Robin's Wood Country Park, Gloucestershire. The site is designated for Jurassic stratigraphy and palaeontology. It is considered to contain the best inland section through the Middle Lias in Great Britain and has yielded a diverse range of fossils.

Weybourne Town Pit SSSI is a disused lime pit in Norfolk. It is the type locality for the Quaternary Marly Drift, a distinctive chalk-rich till found in Norfolk.

Both sites are visited by universities and geology groups from around the country and it is important to maintain the exposures in good condition for further study.

Management issues and solutions

Both sites have been disused for about 50 years and the exposures had become seriously degraded through vegetation growth and slumping of the relatively soft faces. In addition, preferential slumping of soft clay-rich units at Robin's Wood Hill has left unstable, overhanging ledges, that represent a potential hazard for visitors.

Robin's Wood Hill Quarry SSSI after clearance works. Mark Campbell/Gloucestershire Geoconservation Trust

At Weybourne Town Pit, English Nature and the local parish council are involved in management of the site. Vegetation thinning and clearance is carried out on the face to maintain an exposure of the Marly Drift. Most of the pit is covered by relatively mature trees but, because the face is only a few metres high and does not need to be viewed from a distance, taller trees are allowed to remain, in order to provide shade and inhibit scrub growth on the face itself. It is necessary to maintain an access path to the face through the wooded area.

At Robin's Wood Hill, Gloucestershire Wildlife Trust and Gloucestershire RIGS Group carried out regular vegetation clearance in the past but re-colonisation is rapid and the clays are prone to slumping. Major works involving the excavation and re-profiling of faces, as well as the clearance of vegetation, were carried out in 2000. This was partly funded by English Nature's Face Lift Programme and supervised by the Gloucestershire RIGS Group. Access for machinery was created to the upper levels of the former pit through the construction of ramps. The ramps were left in place in order to provide permanent access to the upper levels of the quarry. As well as clearing previously existing exposures, additional exposures were excavated, improving the value of the site as a whole.

Conservation outcome

Vegetation clearance, re-excavation and re-profiling of unstable exposures is vital if disused quarries like Robin's Wood Hill and Weybourne Town Pit are to be maintained in a condition suitable for research and educational use. Partnerships between statutory nature conservation bodies and local organisations and groups can be very effective in managing such sites.

4.7 Webster's Claypit

A landfilled disused quarry (ED), West Midlands

Conservation issues discussed here

- The impact of landfill on a geological exposure in a disused quarry.
- The failure of the planning system to protect an SSSI in a situation where a planning permission predates the notification of the SSSI.

Site description

Webster's Claypit SSSI lies within the city of Coventry. The site was notified as an SSSI for Carboniferous sandstones and mudstones of the Enville Formation. The exposures at Webster's Claypit represented the only available exposure of alluvial plain deposits within the Enville Formation. The site has also yielded a distinctive fossil flora, reflecting more humid conditions than other sites of the same age and was considered the best British site for studying Upper Palaeozoic conifers.

Webster's Claypit showing good exposure. Colin Prosser/English Nature

Conservation issues

Webster's Claypit was notified as an SSSI a short while after planning permission to landfill the site had been granted. Therefore, under planning law, the planning permission for landfilling the site took precedence over the statutory nature conservation designation and the associated legislation aimed at conserving the SSSI.

Although legally powerless in this situation, English Nature made representations to the local planning authority to try and persuade them to retain a conservation section within the site alongside partial landfill. The local planning authority, however, wished to see the quarry infilled in order to provide a much-needed greenspace area with football pitches within this urban setting.

Arguing a case for the accommodation of the geological interest within the site was made difficult by both the local importance attached to the proposed end-use of the site and by health and safety concerns arising from having a rock face included within an inner-city recreational area.

Conservation outcome

Although the site was designated as an SSSI, the pre-existence of a planning permission for landfill meant that the local planning authority was in full control of the conservation outcome. Despite English Nature and other parties, such as the Warwickshire Wildlife Trust, making strong pleas for the site to be conserved, no variance from the planned total landfill was forthcoming.

It is unlikely that the geological importance of Webster's Claypit was fully appreciated by the local planning authority. This illustrates the need for geologists to undertake activities that raise the awareness of decision-makers of the importance of designated geological sites.

This site has now been fully landfilled and the geological exposures lost. This case provides a very rare example of a geological SSSI that has been completely destroyed.

Further information

PROSSER, C. 2003. Webster's Clay Pit SSSI – going, going gone…but not forgotten. *Earth Heritage*, 19, 12.

Webster's Claypit, now infilled to a point where the geological interest is permanently buried. Colin Prosser/English Nature

4.8 Wren's Nest and Dryhill

Restored disused quarries (ED) in the West Midlands and Kent

Conservation issues discussed here

- Geological conservation in an urban environment.
- The importance of community partnerships and involvement in managing and promoting disused quarry sites for geological conservation and education.

The conservation of unstable, steeply dipping beds, which expose spectacular ripple marks on the bedding planes, provides a particularly difficult challenge at the Wren's Nest. Mick Murphy/English Nature

Site descriptions

The Wren's Nest SSSI includes a number of disused limestone quarries, located in a heavily urbanised area of Dudley, West Midlands, in the heart of the Black Country. The Wren's Nest is internationally renowned for the wide range of fossils of Silurian age which have been discovered there, especially during the period it was worked between the 18th century and about 1920. The site has yielded a fauna of well-preserved corals, crinoids, brachiopods and trilobites. To date, over 600 different fossil species have been formally described from the Wren's Nest. There are significant rock exposures on the site, including reefs and several spectacular ripple-marked bedding surfaces. The limestone pillars and caverns of the Seven Sisters Mine (see separate case study) are also located within the Wren's Nest.

The Wren's Nest is an internationally famous geological SSSI, and was declared a National Nature Reserve (NNR) in 1956, one of the first NNRs in Great Britain declared solely on the basis of its geology. The Wren's Nest NNR is managed by Dudley Metropolitan Borough Council by agreement with English Nature.

Dryhill SSSI, Kent, is a disused quarry which exposes sandstones and sandy limestones of Cretaceous age. The sandy limestone, known locally as 'rag', was quarried for building stone and roadstone until the early 1900s, since when the quarry has remained disused. Kent County Council, with the support of English Nature, has declared the site a Local Nature Reserve (LNR).

Management issues and solutions

The Wren's Nest NNR is located in the heart of an urban housing estate and is subject to the usual pressures that impact on areas of open space located in urban environments. A management team, based on the reserve, perform a range of duties, including management of vegetation, maintenance of fences and footpaths, leading tours of the reserve and maintaining relationships with the local community.

A geological trail and some very robust interpretation boards have been put in place on the reserve. Problems such as vandalism and fly-tipping result in ongoing maintenance work for the reserve staff. All on-site interpretation and safety fences have been designed to be robust and

vandal-proof, and considerable improvement has been achieved through community involvement. This is aimed at encouraging those who live locally to develop a sense of ownership and pride in the site, and in doing so, to help maintain and enhance, rather than abuse what is an internationally important geological reserve.

In order to manage fossil collecting, a Fossil Collecting Code has been established. Collecting fossils from the rock faces and the use of tools is not permitted and only a few representative specimens may be collected from the loose scree. This allows visitors to enjoy the experience of collecting fossils without unduly depleting the resource.

Safety is a major issue on the Wren's Nest. Unstable rock faces and mine entrances are securely fenced off and viewing in these areas is only permitted from safe viewing platforms. The former mines here are also prone to collapse and areas above known mine tunnels are also securely fenced off.

Funding for the management of Dryhill LNR comes from the local planning authority and potentially from other sources willing to support the management and development of LNRs. In advance of the official opening of the site as an LNR, some rock exposures were cleared of vegetation and scree by Kent County Council, the local RIGS group and other local volunteers. Kent County Council continues to monitor the site to ensure the rock exposures remain well-exposed and safe for visitors to use.

An integrated approach to nature conservation usually works very well in urban environments. Both the Wren's Nest and Dryhill promote wildlife alongside geology and aim to provide the public with access and recreation as well as with an experience of nature. Both sites also show the close links between the geology and wildlife, demonstrating how bare geological faces and disused quarries can become wildlife habitats as well as geological resources. On both sites, some faces have been cleared of vegetation to allow access to the geology, whilst others have been left for wildlife.

At the Wren's Nest, the geological trail, accompanying handbook and a hands-on experience of geology provides the basis of interpretation. Ancient reefs, well-preserved fossils, a rippled sea-bed and spectacular caverns all help to inspire visitors, especially school children, for whom a teaching pack for the site has been produced. A visitor centre has also been established which includes a geological mural, fossil displays and space for the school children to carry out educational activities.

At Dryhill, interpretation panels provide on-site explanations of the geology for visitors.

Conservation outcome

The Wren's Nest NNR and Dryhill LNR demonstrate how disused quarries can be managed and interpreted for public as well as for scientific and educational use. In both cases, enthusiastic local planning authorities, committed to managing the sites, have been critical to the success of the sites, as has been the involvement of local geological groups and the local community. Both sites have been very successfully developed as educational resources.

Further information

CUTLER, A., OLIVER, P. G., & REID, C. G. R. 1990. *Wren's Nest National Nature Reserve geological handbook and field guide*. Dudley: Dudley Leisure Services Department and Peterborough: Nature Conservancy Council.

PROSSER, C. 2002. Geological first for Kent. *Earth Heritage*, 17, 24.

Dryhill Quarry, designated both as an SSSI and LNR, provides an excellent scientific educational and recreational resource. Interpretation panels help visitors to understand the geology exposed in the quarry faces. Colin Prosser/English Nature

4.9 Chewton Bunny

A coastal cliff and foreshore site (EC) in Hampshire

The cliffs west of Chewton Bunny have been protected and re-graded to a point where no geological exposures are available for study. Colin Prosser/English Nature

Conservation issues discussed here

- The conflicts between geological conservation and coastal protection on an actively eroding coastline.
- The importance of taking a strategic rather than piecemeal approach to coastal management.

Site description

Chewton Bunny is a small valley that cuts the coastline at the boundary between Dorset and Hampshire on the south coast of England. The valley has been landfilled in the past and the stream that originally ran down the valley has been culverted.

Chewton Bunny lies within the Highcliffe to Milford Cliff SSSI, which consists of a long stretch of relatively soft cliffs, composed of Palaeogene sediments that are rapidly eroding. The sediments around Chewton Bunny are of international geological importance, forming the international stratotype for the Bartonian Stage of the Eocene Epoch. The sediments are very fossiliferous, yielding some of the best preserved and most varied fossil fauna of the British Eocene. The fossil fauna includes molluscs, fish, reptiles, mammals, and birds as well as a range of fossil plants.

Management issues and solutions

This stretch of coastline is subject to high erosion rates and illustrates many of the difficulties which arise from taking a piecemeal approach to coastal management. Coastal protection works along the coast to the west of Chewton Bunny, at nearby Hengistbury Head, have disrupted natural coastal processes, resulting in a reduced supply of beach-forming material and accelerated rates of erosion. As a response to this, the area of cliff immediately to the west of Chewton Bunny was subjected to several phases of coastal protection and cliff stabilisation. This resulted in loss of geologically important cliff exposure, although the continuity of the Bartonian Stage stratotype still remained. These works in turn resulted in increased erosion rates on the unprotected and naturally eroding cliffs immediately to the east of Chewton Bunny, with the threat of erosion into the landfilled area at Chewton Bunny and potentially serious environmental consequences.

To counter this erosion, a further coastal protection scheme immediately to the east of Chewton Bunny was proposed. This scheme involved digging three drains into the cliff face and placing rock armour at the base of the cliff. If implemented, this scheme would have resulted in the stratigraphic continuity of the internationally important Bartonian Stage stratotype being broken.

After negotiation between English Nature and the local planning authority, it was agreed that the proposed rock armour directly against the cliff would be replaced by a less damaging offshore bastion, which would not obscure the cliff and which would slow erosion rather than halt it completely. No agreement could be reached, however, with regard to the proposals to dig three large drains into the cliff face. Alternative drainage proposals were put forward by English Nature which would not directly impact upon the cliffs, but these were not accepted and the issue of the drains was subsequently considered at a public inquiry. At the inquiry, English Nature, backed by the geological community, presented the case for conserving the cliff line without inserting drains into it. The local planning authority argued that protecting the coastline from erosion was the highest priority. After a three day inquiry, the planning inspector concluded that one drain should be permitted. This compromise was not ideal for either side, resulting in further damage to, but not complete destruction of, the stratigraphic continuity within the site.

Conservation outcome

The original proposed coastal protection scheme was modified after discussions with English Nature. The use of an offshore bastion has slowed erosion at the site while retaining access to the geological exposure. The insertion of one drain has partly interfered with the continuity of the stratigraphical succession at the site but this has caused less damage than would have been caused by the three drains originally proposed. The case highlights the importance of taking a strategic view of coastal management, rather than implementing individual coastal protection schemes, without consideration of their knock-on effects.

Further information

PROSSER, C. 1992. Key sites go to inquiry. *Earth Science Conservation* 30, 15–16.

The unprotected cliffs immediately east of Chewton Bunny show good exposure of the Bartonian Stage stratotype. Proposals to protect and drain this part of the cliffs were the subject of a public inquiry held in 1991. Colin Prosser/English Nature

4.10 Dimlington Cliff

A coastal cliff and foreshore site (EC) in Humberside

Conservation issues discussed here

- Managing the conflict between the demand for coastal protection and the need to allow coastal erosion to continue to maintain a geological exposure.
- The development of site management plans with ongoing monitoring.

Cliff erosion at Dimlington. Peter Wakely/English Nature

Site description

Dimlington Cliff SSSI is located on the north-east coast of Humberside. The cliff is about 15 m high and is eroding at an average rate of about 1.8 m per year.

The site is designated as an SSSI for Quaternary sediments which provide an important constraint on the timing of ice advance and on environmental conditions during the late Devensian, between about 26,000 and 13,000 years ago. The site is also known for the presence of glacial erratics derived from Scotland and Scandinavia.

Management issues and solutions

Coastal protection is the main threat to conserving the geological interest at Dimlington Cliff. Local landowners, residents and other interested parties have long wished to see the area protected from erosion by some form of coastal protection. Any process, however, which inhibits or prevents erosion would be detrimental to the geological interest and, in the case of hard engineering works against the cliff, could effectively destroy the interest by permanently concealing it.

The threat of coastal protection is exacerbated by the presence of the Easington natural gas terminal immediately south of the site. The need to protect the terminal led to the construction of a rock revetment in 2000. Although this does not extend to the actual site, it remains to be seen if it may cause a reduction in sand transport along the shore, leading to accretion of sand on the shore to the north and reduction in wave attack at the cliff foot. This could allow a debris fan to form at the foot of the cliff, which could become vegetated, obscuring the exposures for which the site is designated.

Other issues on the site have included the unconsented dumping of household waste, the laying of cables from wind farms and the construction of pipelines from North Sea oil rigs.

The coastal protection scheme for Easington was designed to minimise the impact on Dimlington Cliff SSSI. A Beach Management Plan has also been prepared to help co-ordinate and focus the management and monitoring work of the Humber Estuary Coastal Authority Group since the construction of the coastal protection scheme.

The Beach Management Plan includes a detailed monitoring programme (Easington Coast Protection Scheme Monitoring Plan) of the Dimlington Cliff SSSI and the beach. The aim of the monitoring scheme is to assess whether the beach levels are increasing as a result of coastal protection construction to the south, thus reducing erosion rates. A number of threshold conditions are defined which, if exceeded, trigger a mitigation programme. The threshold condition is determined by a build-up of sand on the beach face to the north of the revetment fronting the SSSI that would, if it persisted, reduce the erosion rate and obscure the exposure at the site. The mitigation programme would involve moving sand to compensate for any slowing of natural sand movement caused by the coastal protection scheme.

Conservation outcome

The development and implementation of the Beach Management Plan and the Easington Coast Protection Scheme Monitoring Plan ensure that continued monitoring of the site will take place. This will help to assess the impacts from the coastal protection scheme and includes detailed mitigation measures.

4.11 Hengistbury Head

A coastal cliff and foreshore site (EC) in Dorset

Conservation issues discussed here

- The effects of coastal protection schemes in reducing coastal erosion and thereby causing degradation of a geological interest.
- The potential for coastal protection works in one area to have knock-on effects on an adjacent stretch of coastline.

Site description

Hengistbury Head forms a headland between Bournemouth and Christchurch Bay on the south coast of England. The headland is part of the Christchurch Harbour SSSI, which has both geological and biological interests. The soft eroding cliffs at Hengistbury Head expose Palaeogene sediments, which are important for stratigraphy, palaeoenvironmental studies and palaeontology. There are also archaeological interests on the cliff top.

Management issues and solutions

Hengistbury Head has been subject to engineering works over many years to slow cliff erosion in order to help protect the public amenity, habitat and archaeological interests which are present on the headland.

A long groyne, constructed to retain a beach in front of Hengistbury Head, and thus slow erosion, has been effective in reducing erosion, but has contributed to the disruption of longshore drift, reducing the supply of beach material to parts of Christchurch Bay to the east. The consequent diminution of beaches on Christchurch Bay has resulted in an increase in the rate of cliff recession, resulting in the construction of a number of coastal protection schemes. Many of these structures have directly or indirectly obscured some of the geological interest features on Highcliffe to Milford Cliffs SSSI, to the east of Hengistbury Head.

Further coastal protection schemes at Hengistbury Head have been proposed which may result in further reduction of cliff erosion rates. This would bring about the degradation of the geological interest, as slumped material builds up in front of the cliff faces.

A management agreement has been negotiated for part of the coastline at Hengistbury Head. This involves the use of machinery to remove material from the foot of the cliff in areas where wave erosion is no longer effective in maintaining a clean exposure.

Erosion of the cliffs at Hengistbury Head has led to a number of proposals aimed at protecting this piece of coastline. However, increased protection is likely to isolate the cliffs from marine erosion and lead to the exposures becoming degraded and vegetated. Colin Prosser/English Nature

Conservation outcome

Negotiations between English Nature and the local planning authority have ensured that fresh cliff exposures are maintained. However, mechanical removal of degraded material from the foot of some areas of the cliffs is required to ensure that the geological interest is not obscured.

Further information

BRAY, M. AND HOOKE, J. 1998. Geomorphology and Management of Sites in Poole and Christchurch Bays. *Coastal Defence and Earth Science Conservation*, 233–266. Bath: Geological Society.

4.12 Lee-on-the-Solent

A coastal foreshore site (EC) in Hampshire

Replenished shingle material and rock groynes at Lee-on-the-Solent. Fine sediments imported with the shingle were selectively transported offshore and deposited as a thick drape over the interest features.
Dave Evans/English Nature

Conservation issues discussed here

- Managing the conflict between the demand for coastal protection and the need to conserve important coastal foreshore exposures.
- Early consultation in the planning process to agree acceptable compromises.
- The importance of monitoring the impacts of developments.

Site description

The Lee-on-the-Solent to Itchen Estuary SSSI, Hampshire, is a large coastal site with mixed biological and geological interests. The site is biologically important for a number of coastal habitats which support several bird species as well as an outstanding assemblage of nationally scarce coastal plants. The site is designated for Quaternary gravel deposits and Palaeogene vertebrate fossils.

The vertebrate fossils occur in Eocene sediments on the foreshore at Lee-on-the-Solent. The site is particularly important for the diversity and abundance of its fossil fish assemblages, including a large number of shark species. It is also one of very few locations to yield fossil birds of mid-Eocene age in the UK and constitutes the type site for five different bird species. The interest is generally concealed beneath shingle and sand but is intermittently exposed on the foreshore at extreme low tides and following storm shift of shingle.

Management issues and solutions

With the close proximity of the town of Lee-on-the-Solent, coastal protection is the main issue for geological conservation. Coastal protection structures had existed prior to notification of the site as an SSSI in 1992 but did not significantly impact on the interest at the site. These structures comprise a concrete promenade along the sea front and wooden groynes retaining shingle on the foreshore.

The local planning authority, however, subsequently proposed the replacement of the wooden groynes with a series of larger and more extensive rock groynes, while also undertaking beach nourishment by importing additional material onto the beach. This posed a threat to the geological interest features in four ways:

- Direct damage to the sediments from heavy machinery during groyne construction.
- Permanent concealment of parts of the interest by the footings of the rock groynes.
- Concealment of the interest features by the beach-feed.
- Interference with natural coastal processes, with possible long-term impacts upon the geological interest and to biological interests in adjacent areas.

Consultation between English Nature and the local planning authority took place at an early stage in the planning process. As a result of the consultation, it was agreed that the length of selected rock groynes would be reduced and appropriate beach levels were agreed. Vehicular access routes were also agreed to reduce potential damage from heavy machinery during the works. Consequently, only minor damage was caused to the sediments during construction and the impact of the new groynes on the geological interest was minimised.

Although appropriate beach levels were agreed, too much beach material was imported to the site, and this included a large volume of fine silt and clay. The latter spread out to form a thick drape over the outer part of the foreshore, significantly concealing the interest features. It was initially hoped that the excess material would be removed naturally by storm activity. After allowing time for the sediment to settle, however, it became clear that sediment levels were unlikely to be reduced naturally. Following further discussions with English Nature, the local planning authority agreed to remove some of the excess beach material. Although some of this excess material has now been removed, this has yet to fully ameliorate the effects of over-feeding.

Conservation outcome

Early consultation led to an acceptable solution that permitted coastal protection to be constructed while effectively conserving the geological features. Over-feeding of the beach during the works led to negative impacts on the geological interest features. Further consultation was required to reach a new agreement to remove some of the excess material that had been imported on to the site.

4.13 Browgill and Stockdale Becks, Skelghyll Beck, Doe Lea and Betton Dingle

River and stream sections (EW) in Cumbria, Derbyshire and Shropshire

Conservation issues discussed here

- How inappropriate management can adversely impact on a geological interest.
- Using a management agreement and access control to conserve a geological interest.

Skelghyll Beck SSSI, Cumbria, showing the vegetated banks of the stream. Colin Prosser/English Nature

Site descriptions

The four sites covered here are all geological SSSIs. Betton Dingle is part of a larger SSSI which also has a biological interest. Doe Lea Stream Section is also a Local Nature Reserve (LNR).

The section at Skelghyll Beck, Cumbria, is designated for a succession of Silurian (Llandovery Series) Shales and mudstones. The rocks are very fossiliferous, containing a rich and diverse graptolite assemblage. The site is of great importance for local lithostratigraphy, as well as national and international biostratigraphy.

The sections at Browgill and Stockdale Becks are important for similar reasons, and complement Skelghyll Beck in providing additional exposures of younger Llandovery Series rocks.

Betton Dingle provides a series of exposures of Middle Ordovician age in the Shelve area of Shropshire. The graptolite and trilobite assemblages that occur here enable correlation of the Shelve successions with other areas, as well as the interpretation of the changing environments in which these rocks were formed.

Doe Lea Stream Section, Derbyshire, is the British stratotype for the base of the Bolsovian Stage of the Upper Carboniferous (Westphalian C). The *Aegiranum* Marine Band, which is exposed at Doe Lea, marks the base of the Bolsovian Stage and is a critical marker horizon traceable across much of Europe.

Skelghyll Beck, Browgill and Stockdale Becks and Betton Dingle are all deeply incised upland stream sections. Exposure typically occurs in the stream beds, on the banks and in crags and cliffs above the stream. Betton Dingle lies within woodland. Doe Lea may be regarded as an example of a lowland stream where exposure is limited to the bed and the banks.

Management issues and solutions

Management issues on these sites include:

- vegetation encroachment
- inappropriate tree planting
- dumping of material in the channel
- engineering structures obscuring exposures.

Vegetation is a major issue on some stream sections. When stream power is sufficient, vegetation is unlikely to take hold, at least on the stream banks. Vegetation may, however, be a problem on cliffs and crags above the stream. Where natural processes are not sufficient to maintain clear sections, grazing may provide an effective solution.

At both Skelghyll and Browgill Becks, much of the exposure takes the form of cliffs and crags above the streams. At both sites, changes

in management regimes have led to vegetation growth which has obscured exposures. Skelghyll Beck was fenced off as a means of controlling erosion, which was perceived to have been caused by over-grazing, walkers, and the activities of geologists. As a consequence of fencing the site and prevention of grazing, vegetation has now become a serious problem, concealing much of the geological interest.

Similarly, the lower reaches of Stockdale Beck were fenced off and trees planted, inhibiting access to the exposures, because of a perceived problem with fossil collecting. In both cases, these actions have resulted in the geological exposures becoming degraded by vegetation growth. The underlying cause of this change in management regime appears to have much to do with some geologists accessing these sites without the permission of the landowners.

Betton Dingle is situated in mature woodland and some exposures are difficult to access because of vegetation cover. The presence of a mature canopy, however, has the overall positive effect of inhibiting the growth of scrub, which would otherwise obscure the geological features. The trees do not generally conceal the geological exposures, which are mostly on the stream bed.

At Betton Dingle, past attempts to control bank erosion have involved the dumping of soil and building waste against the banks. This has not caused any serious problems on the site, as the material does not cover any critical exposure and tends to be washed away. This is not, however, a recommended approach in general, as it could lead to negative impacts on geological exposures downstream.

At Doe Lea, the original stratotype exposure was inadvertently lost through the building of a concrete weir that covered a critical part of the exposure. Subsequently, a new section was identified and excavated in the stream bank away from the weir. A formal management agreement ensures that Doe Lea is positively managed for its geological interest. Vegetation cover is also an issue at Doe Lea and scrub clearance was undertaken in 2002 under English Nature's Face Lift Programme. Access is controlled by a permit system to help protect the site from vandalism.

Conservation outcome

Vegetation management is often necessary on stream sections. Grazing and scrub clearance can help maintain clear exposures and a mature woodland canopy can sometimes help restrict scrub growth on stream banks. On two of these sites, differing perceptions of site users and landowners with regard to the use of the site are among the root causes for the current conditions of these sites. This highlights the importance of maintaining a good understanding of the issues involved in the management of access to the interest features. Good liaison between landowners, the geological community and conservationists may be the key to the successful management of these sites.

4.14 Onny River

A river cliff site (EW) in Shropshire

Conservation issues discussed here

- Illustrating how natural river processes maintain fresh river cliff exposures.
- Linking sites as part of a geology trail.

Site description

The Onny River Section SSSI lies north-west of Craven Arms in Shropshire. Rocks of Upper Ordovician age are exposed in low river cliffs. The unconformity between the Ordovician Caradoc Series and the overlying Silurian Llandovery Series is also exposed.

The importance of the site was recognised in the 19th century. Many of the sections exposed in the Onny Valley and in nearby quarries remain of importance to geologists.

A teaching trail exploring the Ordovician rocks of the Onny Valley sites has been developed. Creation of this trail involved the cooperation of landowners, local councils, statutory bodies and local and national geological societies. The trail is way-marked and is accompanied by a trail booklet.

The Onny River cliff section showing the unconformity between the Caradoc Series of the Ordovician and Llandovery Series of the Silurian. Colin Prosser/English Nature

Management issues and solutions

The Onny River cliff exposures are located in a relatively remote area and have not been subject to development or river management pressure. As such, there are no threats to this site at present. Management of river cliff sites, such as the Onny River Section, generally involves as little interference with the natural river processes as possible. Natural erosion at the site keeps the sections fresh and clear of vegetation.

Potential threats that could arise include engineering schemes that would reduce the amount of bank-side or riverbed exposure, or any works that could lead to a change in the overall flow regime of the river, reducing erosion rates, for example. It is also possible that irresponsible fossil collecting from the river cliff could undermine the river bank, leading to pressure to have the banks protected against such activities.

Conservation outcome

Providing that the natural river processes are allowed to continue, the integrity of the river cliff sections will be maintained. Thus, a regime of non-interference is the appropriate management requirement for this site. This site forms an integral part of the scientifically and educationally important Onny Valley river trail. The 1.75 km long trail illustrates very well the benefits of linking a number of sites together and of promoting sites like this to a wider audience, thereby encouraging their conservation for the future.

Further information

TOGHILL, P. 1992. *Onny Valley, Shropshire: Geology Teaching Trail*. Geologists' Association Guide No. 45. London: Geologists' Association.

4.15 Mam Tor, Burrington Combe and Raw Head

Inland outcrop sites (EO) in Derbyshire, Somerset and Cheshire

Conservation issues discussed here

- Conservation of inland outcrop sites.

Site description

The steep hillside of Mam Tor is part of the Castleton SSSI, Derbyshire, and is designated for its thick sequence of Carboniferous clastic sediments. It is renowned for active landslides, for which it is also designated.

Burrington Combe SSSI, Somerset, is a steep-sided gorge, similar to Cheddar Gorge (see separate case study). Unlike Cheddar Gorge, Burrington Combe is designated for its stratigraphy – a thick section of Dinantian limestones and associated marine rocks. It is a classic site for studying the Lower Carboniferous succession in southern England. It is also notified for its karst geomorphology and for a range of associated biological interests.

Raw Head SSSI is a partly wooded escarpment in Cheshire. The site is designated for a sequence of Lower Triassic sandstones. Raw Head is part of the Cheshire Sandstone Trail, a series of walks on the sandstone ridges of Cheshire, which are promoted by the local planning authority for recreation and education.

Mam Tor, Derbyshire. Richard Cottle

Management issues and solutions

Vegetation control is the main management issue on natural inland outcrops in lowland areas. In contrast, in upland areas, natural processes are often sufficient to maintain geological features free of vegetation, particularly because vegetation growth rates tend to be lower. Other issues include tree planting and recreational damage.

Mam Tor is a good example of a site which needs no management to maintain excellent geological exposures. The active landslips produce a steep scarp slope so that vegetation cannot take hold.

Vegetation control is an important management issue at Burrington Combe. The site had become very overgrown with invasive scrub over a number of years, partly obscuring the geological exposures and affecting the quality of the karst and the biological features. A major vegetation control initiative, over the last few years, has now reversed the geological and biological decline, greatly enhancing the geological exposures.

Mature forestry plantation at Raw Head had resulted in the sandstone exposures becoming obscured by trees and scrub. Although the rocks could still be studied close-up on the steep slopes, there was very little exposure visible from the public paths through the site, which is being promoted for its geology by the local planning authority. A recent initiative has cleared selected areas of trees and restored some important exposures, enhancing the site aesthetically and educationally.

Conservation outcome

Some inland outcrop sites need no active management, as natural processes are sufficient to maintain exposures. On the other hand, many sites, particularly those in lowland areas, require active vegetation management to maintain exposures.

Burrington Combe SSSI after scrub clearance. Simon Lee/English Nature

4.16 Florence Mine

An underground mine exposure site (EU) in Cumbria

Conservation issues discussed here

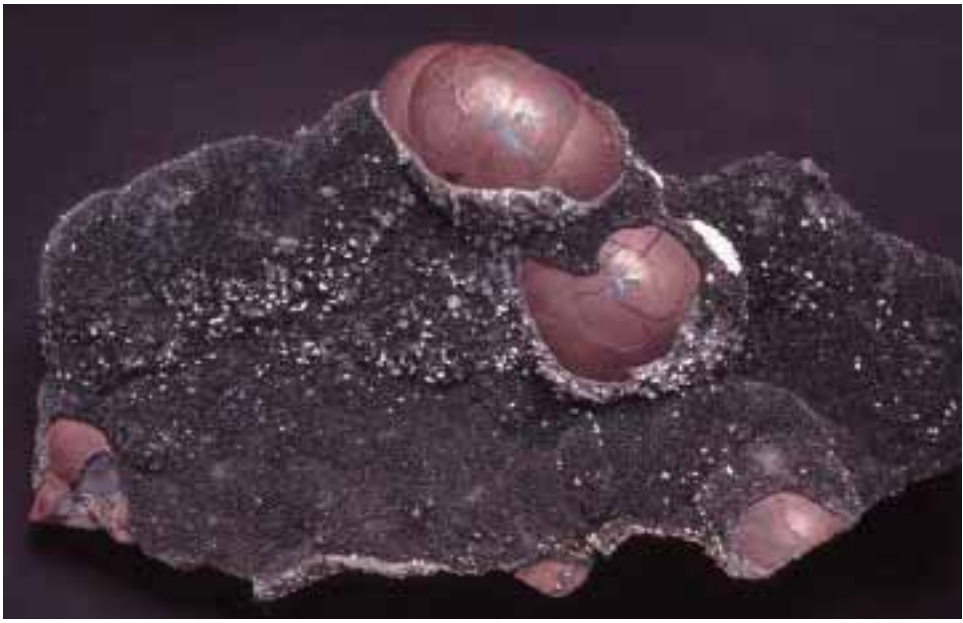
- Conservation management of the only working underground metalliferrous mine in Britain.

Site description

Florence Mine SSSI, near Egremont, Cumbria, is the only working underground metalliferrous mine in Britain. Because it is still being worked, it is one of the few underground mines in Britain which can be regarded as an exposure rather than finite site.

The underground exposures of iron ore represent the only remaining three-dimensional exposures of the globally renowned West Cumbrian haematite deposits. The origin of these deposits remains controversial and, consequently, the exposures in Florence Mine are of major scientific importance for future studies of their genesis.

Access is available to the public in the form of an underground tour, run in conjunction with the Mine Heritage Centre.



Botryoidal haematite (kidney ore) from Florence Mine SSSI. David Green/Manchester University Museum

Management issues and solutions

As a working mine, the material of interest at Florence Mine is constantly being removed and fresh exposures created. Removal of material in this way is not a problem from a conservation perspective as long as the mine continues to be worked, and providing the ore body is not completely worked out.

The main conservation management issue is ensuring that the underground mine remains accessible and free from flooding. Currently, the mine is pumped as part of the mining operation, the cost having been borne by British Nuclear Fuels Limited (BNFL), who took water from the mine to use in the cooling systems of the nearby nuclear power station at Sellafield.

However, the production of power at Sellafield ceased in 2003. This removed the demand for water and so the pumping by Sellafield will eventually stop. As a result, Florence Mine could become uneconomical because of the high cost of pumping that it would then have to bear. If the mine closes and pumping ceases, it would flood and become inaccessible, effectively destroying the scientific value of the site.

The Nuclear Decommissioning Agency has agreed to fund pumping for another three years, allowing time for an alternative source of energy funding to be sought. A sustainable energy solution for pumping water from the mine using hydroelectric or wind power is presently being explored by the Florence Mine Partnership. It is hoped that a practical and economically viable solution can be achieved to safeguard the long-term future of this unique geological site.

Conservation outcome

Although the future of Florence Mine is uncertain, a solution to the longer term threats is being actively sought.

4.17 Little Oakley Channel Deposit

An extensive buried interest site (EB) in Essex

Conservation issues discussed here

- Management of surface land use to protect buried geological deposits.
- Impacts of development adjacent to the site.

Site description

Little Oakley Channel Deposit SSSI, Essex, is designated for a series of Quaternary sediments deposited in a river channel, which was cut into an older river terrace gravel sequence. An abundance of animal and plant remains, critical to the interpretation of the environment at the time of deposition and channel formation, has been recorded from the site. The deposits at Little Oakley are especially significant as they represent a warmer period of the Quaternary (the Cromerian) and because they clearly demonstrate a link between river terrace deposits in East Anglia and those in the Thames Valley.

The deposits at Little Oakley are buried beneath land currently in agricultural use. The land is laid to arable use and the surface is, therefore, relatively featureless with no visible geological interest. Access to the deposits at Little Oakley is currently through the use of boreholes, small recorded trial pits and temporary exposures.

Agricultural land overlying the buried interest at Little Oakley. Dave Evans/English Nature

Management issues

It is generally accepted that it is often impractical and unnecessary to provide and maintain a permanent exposure at extensive buried interest sites, which are by definition in situ reserves of material available for future study. The conservation priority for extensive buried interest sites, such as Little Oakley, is to ensure that the deposits are neither disturbed, other than for scientific study, nor permanently concealed.

Whilst neither situation has arisen at Little Oakley itself, there have been cases in the past where changes in land use have compromised the scientific interest at extensive buried interest sites. It is, therefore, necessary to be aware of the impacts on geological sequences of any proposals that involve changing land use on or adjacent to buried interest sites. Being undeveloped, typically flat areas of land, these sites are often selected for new development, involving the construction of solid impermeable structures that restrict or prevent access to the deposits beneath.

In addition, disturbance can occur from development adjacent to a site. Although the development may not impact directly on the site, new service routes and infrastructure may be required to pass through the site. Transport routes, pipelines, drainage works, storage of materials and general increased usage of the area may all disrupt the scientific integrity of the site. The effects of adjacent developments are not always fully appreciated until after planning permission or other licences have been granted.

The management in place at Little Oakley is relatively straightforward. Current agricultural practice is to plough and cultivate the area. The ploughing disturbs the surface but has been ongoing for many years and works to a set depth, therefore having little impact upon the underlying geological interest. Should agricultural practices change, however, monitoring will need to be undertaken in order to gauge any change in the condition of the site.

Conservation outcome

Agricultural land management practices above the Little Oakley Channel Deposit currently have no impact on the buried interest features. Future changes in land use, however, could have serious impacts on the site and would need to be considered on a case by case basis.

4.18 Brewin's Canal

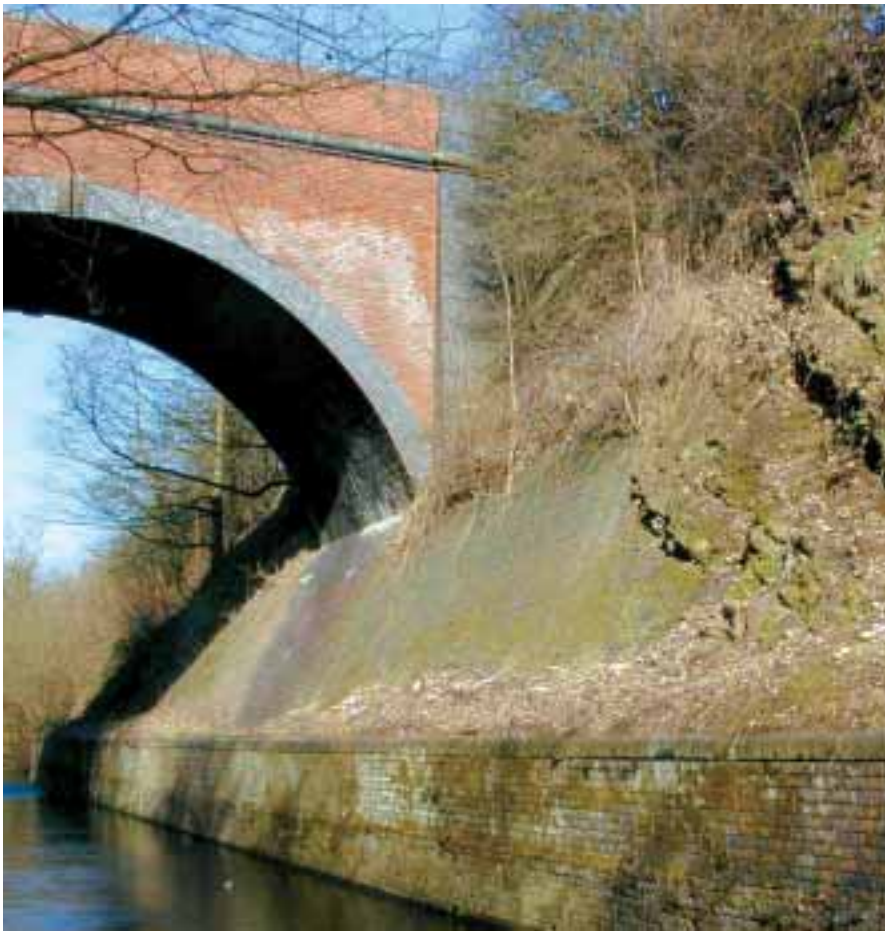
A canal cutting (ER) in Dudley, West Midlands

Conservation issues discussed here

- Vegetation management and cleaning of an exposure to maintain favourable condition of a canal cutting site.
- The role of local voluntary geological groups in managing geological sites.

Site description

Brewin's Canal Section SSSI is located in an urban area of Dudley, West Midlands. The canal cutting exposes sandstones of Silurian age, unconformably overlain by a Coal Measures conglomerate. A vertical dolerite intrusion cutting through the Silurian and Carboniferous strata is also exposed here. This is a historically important section, used and illustrated by Sir Roderick Murchison in his classic, pioneering research into the Silurian rocks of Great Britain.



The north-east canal bank after the clean-up exercise in March 2001, showing the unconformity between the Silurian and Carboniferous rocks. Graham Worton/Dudley Museum and Art Gallery

Brushing moss from the rock faces to produce a fresh exposure. Graham Worton/Dudley Museum and Art Gallery

Management issues and solutions

This section is subject to progressive loss of exposure as vegetation becomes established. A build-up of talus also obscures the lower parts of the section. Physical access to the north-east side of the cutting is restricted by the canal. Occasional fly-tipping from the bridge above the section also has an impact on the exposure.

In order to retain good exposure at this site, the periodic clearance of vegetation from the rock face is necessary. This requires the use of mechanical and hand tools. The cleaning of the exposures with brushes is also of value in improving the state of the faces.

Over the past 10 years, the Black Country Geological Society, based in Dudley, have organised clearance of vegetation, talus and fly-tipped rubbish. Narrow boats were used to remove spoil and rubbish to appropriate disposal points.

The canal cutting is adjacent to Saltwells Local Nature Reserve (LNR), which includes Doulton's Claypit, another geological SSSI. The local authority warden service, which manages Saltwells LNR, includes Brewin's Canal in their patrol of the area. This helps to reduce vandalism and fly-tipping on the site.

The south-west canal bank, showing the dolerite intrusion before vegetation clearance.
Graham Worton/Dudley Museum and Art Gallery

The dolerite intrusion after vegetation clearance. Graham Worton/Dudley Museum and Art Gallery

Brewin's Canal is regularly used for educational purposes and there is great potential for promoting it to a wider audience, linking to the geological exposures at the Saltwells LNR. Intrepretation boards, aimed at the general public, have been installed on both sites.

Conservation outcome

Regular management of the canal cutting is required. Voluntary groups have carried out vegetation clearance, cleaning of the rock exposures and removal of fly-tipped rubbish. As a consequence of these activities, the site is being maintained in good condition for scientific and educational usage.

Canal narrow boat loaded with debris after clearing vegetation on the south-west canal bank.
Graham Worton/Dudley Museum and Art Gallery

4.19 Farley Dingle

A road cutting (ER) in Shropshire

Conservation issues discussed here

- Degradation of exposures as a result of vegetation encroachment and scree build-up.
- Early consultation in the planning process to convert a potential threat to a site into a site enhancement opportunity.

Site description

Farley Dingle SSSI is a road cutting located on the A4169 near Wenlock, Shropshire. The site is designated as an SSSI for exposures of the Silurian (Wenlock Series) Farley Member of the Coalbrookdale Formation in the type Wenlock area.

Management issues and solutions

The site was originally a disused railway cutting. As is typical for many disused railway cuttings, the exposures of this classic section were largely concealed by vegetation and fallen rock debris.

In 1992, a proposed re-routing of the A4169 through Farley Dingle threatened to destroy the section. Following consultation with English Nature at an early stage in the planning process, Shropshire County Council agreed to take advantage of the new route and to leave a permanent exposure in the new road cutting.

A new steep section was subsequently created, greatly improving the exposure and enhancing the SSSI. The steepness of the section inhibits growth of new scrub and helps to maintain the exposure. The soft and friable nature of the shales means that the face is prone to weathering, with rock fragments spalling off, creating a build-up of scree at its base. This presented a significant hazard because of the proximity of the road. In order to counteract this problem, the face was obliquely benched during the creation of the new section. This provided scientific benefits by allowing easier access to higher levels of the face.

A crash barrier has been erected to further reduce the safety risk. This serves the dual purpose of helping to prevent rock debris from falling onto the road and also protects visitors to the site from traffic.

Conservation outcome

Through negotiation with the local planning authority, the new roadside section has significantly enhanced the Farley Dingle SSSI. It cannot be overstated that the opportunity to discuss the retention of a geological section at an early stage within the planning process was crucial to the success of the project. This allowed time to agree on a design for the steep section with platform access, which could be accommodated within the new road design.

General view of Farley Dingle road cutting during construction. Jonathan Larwood/English Nature

Further information

LARWOOD, J. G. AND MARKHAM, D. 1995. *Roads and geological conservation: a discussion document*. Peterborough: English Nature.

4.20 Ainsdale Sand Dunes

An active (IA) and static geomorphological (IS) site in Merseyside

Conservation issues discussed here

- Improving the natural mobility of an active process geomorphological site to maintain the integrity of both the site geomorphology and the biodiversity that it supports.

Site description

Ainsdale Sand Dunes, Merseyside, is part of the Sefton Coast SSSI, which is designated for both geomorphological and biological interests. It is a National Nature Reserve (NNR) and forms part of a larger internationally important wildlife site. The geological interest includes most of the NNR, managed by English Nature, and part of the adjacent Formby Dunes, managed by the National Trust.

The main geomorphological interests are mobile sand dunes and intertidal bars on the foreshore that are renowned for their variety of bedforms. There are multiple biological interests in a range of habitats, some of which depend directly on the active geomorphological processes. The static dunes are also of geomorphological interest.

Management issues and solutions

A large proportion of the site was planted with pines in the early 1900s to stabilise the dunes. This had a significant impact on the habitats and the natural functioning of the mobile edge of the dunes. Over time, however, natural processes have re-asserted themselves and efforts are being made to restore the habitats and processes on the seaward side of the site. Although the site is primarily managed for its biological interest, the effect on the geomorphological interest is positive. The main management activities include:

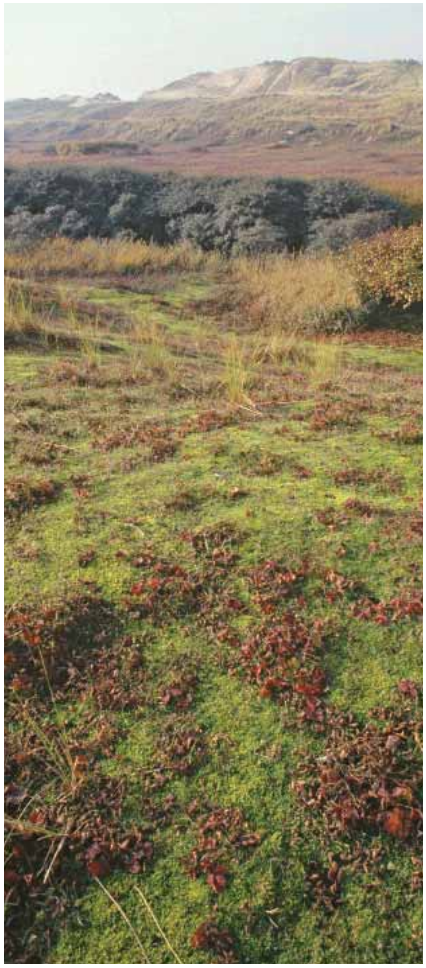
- Extending the area of open dune habitat through the removal of pine plantation from the seaward edge of the NNR.
- Maintaining and extending the area of fixed open dune by grazing with Herdwick sheep.
- Progressively creating a more diverse structure within the remaining 115 ha pine plantation with associated benefits for wildlife.

The removal of part of the plantation has caused concerns among some local people. The main issue is differing opinions on the value of the trees versus the dune habitat. A lot of work has been done on liaison and increasing communication to explain why the site is being managed in this way.

To help inform the management of the site and to provide a research database, English Nature and Sefton Borough Council currently undertake an extensive monitoring programme.

The site monitoring includes:

- Commissioning aerial photographs every five years, to assess the changes in the morphology of the sand dune system.
- Collecting, listing and compiling of maps and GIS data.



Stable dune slack near Fisherman's Path, Ainsdale.
Peter Wakely/English Nature

- Collection of daily climate data.
- Monthly water level readings.
- Collection of geomorphological data, relating to coastal erosion and accretion.

Conservation outcome

Although the site is mainly managed for its biological interest, the importance of the active geomorphology is recognised and the system is allowed to function naturally. The management techniques used to enhance the biology of the site have a positive impact on the geomorphology.

4.21 Birling Gap

A static (IS) and active geomorphological site (IA) in East Sussex

Conservation issues discussed here

- Conservation of active and static geomorphological sites threatened by a coastal protection scheme.

Site description

Birling Gap forms an important part of the Seaford to Beachy Head SSSI in East Sussex on the south coast of England. There are two designated geomorphological interests at Birling Gap, one active and one static. The active geomorphological interest consists of a cliff-beach-shore-platform system developed on chalk, stretching between Seaford and Beachy Head. The static geomorphological interest consists of cliff exposures at Birling Gap which demonstrate one of the best examples of a complete cross-section through a dry valley, with associated valley fill, in Great Britain. The chalk in the area of the dry valley has experienced intense periglacial weathering which has had an impact on the strength and stability of the cliff sections. With coastal chalk habitats in Great Britain making up about 57% of European coastal chalk habitats, the biological importance of the chalk foreshore is also significant.

View along the beach at Birling Gap in 1999, showing the dry valley cross-section in the foreground and the whiter more resistant cliffs in the distance. Mick Murphy/English Nature

Potential threats and solutions

The cliffs at Birling Gap are eroding rapidly, posing a risk to a group of cottages on the cliff top. Because the dry valley feature and the underlying chalk are very strongly weathered, they are even more susceptible to erosion than the surrounding cliffs. Consequently, erosion rates in the area of the dry valley are high. In an attempt to protect the cottages at Birling Gap, local residents put forward proposals to build a rock revetment at the foot of the dry valley cliff section to reduce coastal erosion.

The proposed coastal protection scheme would, however, have impacted upon the SSSI in a number of ways. Firstly, it would have obscured the dry valley and prevented the ongoing erosion required to maintain the exposure of the feature. In addition, the revetment would be potentially damaging to the active process interest by disrupting the natural coastal processes operating within the wider area, which is largely free from coastal protection. Furthermore, the rock revetment would reduce the aesthetic quality of the site and its construction could result in damage to the wave-cut platform and its associated wildlife. In addition, the longer term impact upon the natural evolution of the coastal sections was unclear.

English Nature, the National Trust and the Sussex Downs Conservation Board opposed the planning application and the case was heard at a public inquiry in 2000. As a result of the public inquiry, the application for a coastal protection scheme was refused by the Secretary of State for the Environment.

English Nature, backed by many letters of support from the geological community and local schools, argued that the proposed scheme would have an adverse effect on the geomorphological interest of the site and its educational use. The National Trust and the Sussex Downs

Weathered chalk cliffs at Birling Gap in 1999.
Mick Murphy/English Nature

Conservation Board also opposed the scheme, expressing concern about the visual impacts on this spectacular and naturally evolving stretch of coastline.

The planning inspector made the following points:

- Development proposals affecting SSSIs must be subject to special scrutiny.
- The importance of a scientific feature stems from its intrinsic merit and is not reduced if it has not been fully investigated.
- It is society, through legislation, rather than scientists alone, that places a value on protected sites such as SSSIs.

The applicants argued that a refusal of planning permission would be contrary to certain articles of the Human Rights Act, stating that it was their right to protect their property. The Secretary of State concluded that failure of the State to exercise its powers to protect a person's home from environmental blight may constitute an interference under the European Convention on Human Rights. However, he went on to say that these are qualified rights which require a balance to be struck between the individual's rights and the interests of the wider community.

A further issue relating to this case involved redefining the exact location of the SSSI boundary. Since the site was first designated as an SSSI, coastal erosion at Birling Gap had resulted in the cliffs eroding back to a position landward of the original SSSI boundary, as depicted on the notification documents. The site was re-designated with a new boundary, prior to the public inquiry, to ensure that the interest features in the cliffs remained within the SSSI boundary. This is a potential issue on many coastal sites, where erosion may result in the cliff-line migrating inland of the original SSSI boundary.

Conservation outcome

The geomorphological interest at Birling Gap is secured for the foreseeable future. Balancing the need to protect property from eroding cliffs with the need to conserve the coastline and natural processes is always a challenging issue.

Further information

PROSSER, C. 2001. Spectacular coastline saved. *Earth Heritage*, 16, 4–5.

4.22 Blakeney Esker

A static geomorphological site (IS) in Norfolk

Conservation issues discussed here

- The negative and positive effects of quarrying on a landform.
- Management and promotion of an integrity site.

Site description

The Blakeney Esker in North Norfolk, within the Wiveton Downs SSSI, is arguably the best-developed esker in England. It extends over a distance of some 3.5 km from Blakeney to Glandford. The esker is composed of sands and gravels which were deposited in channels, cut through chalk-rich till. The origin of the esker has been the subject of much scientific debate over the years.

Management issues and solutions

Eskers are potentially valuable sources of sand and gravel but, because they are landforms, quarrying can have a significant negative impact upon their integrity. Quarrying can, however, play an important role in creating exposures, aiding understanding of the internal composition, structure and formation of an esker.

Historically, a number of pits were developed along Blakeney Esker for sand and gravel extraction. All of these pits are now disused. A negative effect of this quarrying has been to fragment the classic landform feature. In addition, many of the sand and gravel channel deposits within the landform have been removed by quarrying and are no longer available for study.

However, the quarrying also created temporary exposures through the sand and gravel channels. These were used by researchers to investigate the origin of the esker while quarrying activities were taking place. Without the quarrying, it would not have been possible to access these exposures, which have been vital for the scientific understanding of the esker. Negotiations with the operator led to a small sand and gravel deposit from one of the workings being retained as a conservation section. In addition, worked-out hollows, which represent parts of channels, have been conserved to demonstrate the original morphology of the channels.

Worked-out hollow at Blakeney Esker, representing part of an original channel. Mick Murphy/English Nature

Norfolk County Council has purchased part of the Blakeney Esker at Wiveton Downs, protecting this part of the remaining landform from further quarrying activities and opening it to the general public. Management of the geomorphological interest is being undertaken in conjunction with a heathland restoration project which involves clearance of gorse and other scrub. An interpretation board was installed in 2004 to explain the importance of the geomorphological features to the general public.

Remnant sand and gravel deposit at Blakeney Esker. Most of the sand and gravel deposits have been removed. Mick Murphy/English Nature

Conservation outcome

Negotiations with the mineral operator led to research being undertaken during the working life of a quarry operation and conservation of features which would have otherwise been destroyed. Through the purchase of the site by the Norfolk County Council, the integrity of the remaining landform has been secured.

Further information

GRAY, J. M. 1992. The Blakeney Esker, Norfolk: conservation and restoration. *In*: STEVENS, C., and others, eds. *Conserving our Landscape*, 82–86. Peterborough: English Nature.

Gorse burning at Blakeney Esker as part of a heathland restoration project. Mick Murphy/English Nature

4.23 Rusthall Common

A static geomorphological site (IS) in Tunbridge Wells, Kent

Conservation issues discussed here

- Vegetation management to maintain a static geomorphological site.
- Management of climbing activities which may damage geomorphological features on the rock surfaces.

Site description

Rusthall Common SSSI, Kent, is an important site for geomorphology. During the Quaternary, Kent was not glaciated but had a periglacial climate, with development of permafrost. The sandstone rocks at Rusthall Common, originally formed during the Cretaceous Period, exhibit a range of surface features, which are characteristic of weathering in a periglacial environment. These weathering features occur on a range of scales, from small-scale textures on the rock surfaces, such as honeycomb weathering, to large-scale features, such as the spectacular Toad Rock, which was sculpted by wind erosion. The site is on common land and is managed by Tunbridge Wells Commons Conservators for public access and conservation.

Toad Rock, Rusthall Common SSSI. Mick Murphy/English Nature

Management issues and solutions

During late Victorian times, Rusthall Common was far more open than at present. Since that time, the rocks had become gradually obscured by trees and scrubby vegetation. This vegetation had a negative impact on the scientific value of the site by obscuring the large-scale geomorphological features.

In order to address this problem, English Nature's Face Lift Programme funded a phased vegetation clearance project on the site, aimed at re-exposing important features. Management work involved thinning trees and carefully removing invasive plant species, such as bramble and rhododendron. An interpretation board was also produced to explain the importance of the site to visitors to attempt to limit damage to the sensitive geomorphological features.

Rusthall Common is one of the 'Southern Sandstone' group of sites. These are used by climbers from across the region, because of the scarcity of other natural rock exposures, suitable for climbing, in London and south-east England. Climbing is not generally a damaging activity on geological sites, except where the scientific importance lies in surface features on the rocks, particularly where the rocks are relatively soft. Both of these conditions apply to the rocks at Rusthall Common, where the small-scale surface weathering features form part of the notified interest and the sandstones are soft and friable. Damage can occur by rope abrasion and rock bolting as well as by general wear and tear.

Small-scale sandstone weathering features at Rusthall Common. Mick Murphy/English Nature

In order to limit damage to the geomorphological features at Rusthall Common, one area of face has been set aside for climbers to use, but climbing is discouraged on other parts of the site. In addition, a code of conduct for climbers using the 'Southern Sandstone' sites is promoted by climbing organisations. The code of conduct details specific precautions and methods for climbing on soft sandstones in order to conserve the special surface features.

The rocks are also prone to damage by vandalism. Carved graffiti is unsightly and is potentially damaging to small-scale weathering features. Painted graffiti is also potentially damaging and cannot be easily removed because of the likelihood of causing additional damage. Vandalism is difficult to control and even the presence of a sign explaining the scientific importance of the site may have little impact.

Conservation outcome

An extensive programme of vegetation management has greatly enhanced the scientific value of this site. Liaison with the climbing community and the setting aside of a particular area of the site for climbers has been effective in helping manage the impact of climbing activities.

Carved graffiti on rock surface at Rusthall Common. Mick Murphy/English Nature

4.24 River Feshie

An active geomorphological (IA) site in the Cairngorms, Scotland

Engineered channel at the apex of the River Feshie fan. John Gordon/Scottish Natural Heritage

Conservation issues discussed here

- The use of conservation-sensitive solutions to allow the natural processes in a dynamic river system to continue to operate, whilst mitigating against flood risk.

Site description

The River Feshie alluvial fan is located at the confluence of the River Feshie and the River Spey. The fan forms part of the River Feshie SSSI, designated for the important fluvial processes and landforms associated with a highly active, braided, gravel-bed river within a mountainous catchment area. The river is typically steep and powerful with wide, shallow channels. The current active fan has a complex history of channel changes and is set within a much larger relict fan, formed towards the end of the last glaciation. The area surrounding the Feshie alluvial fan is used for sheep and cattle grazing and for forestry.

Management issues and solutions

Flooding and bank erosion have been an issue for agriculture and forestry for centuries. Major floods during the winters of 1988/9 and 1989/90 directed local concern to the Feshie-Spey confluence where it was considered that persistent channel change of the Feshie was contributing to the flooding problem. It was also thought that there was a possible link between water backing up behind gravel brought into the Spey by the Feshie and high flood levels upstream at Loch Insh.

In response to these concerns, local landowners carried out channel straightening and bulldozed gravel banks to alleviate channel overspill in the apex area of the Feshie Fan. In 1990, the local planning authority proposed a Flood Alleviation Scheme for the Badenoch and Strathspey area, which included the Feshie-Spey confluence. The proposals involved mitigation works (including re-grading the channel and removing gravel bars) designed to increase the flood conveyance of the Spey and constraining the Feshie to a channel on the eastern margins of the historic alluvial channel.

Following objections by Scottish Natural Heritage (SNH) to the original proposals on grounds of potential damage to the geomorphological interest of the Feshie-Spey confluence and the hydrology and physical habitat of the River Spey Insh Marshes SSSI upstream, the report of a public inquiry in 1992 concluded that the original proposed works should not proceed. SNH subsequently consented a modified proposal to cut a flood alleviation channel through the gravel bars below the Feshie-Spey confluence and permitted repairs to damaged floodbanks along the lower Feshie.

A conservation strategy for the site has now been set out by SNH that is based on an assessment of the geomorphological

sensitivity of different zones. Within high and medium sensitivity zones, no new engineering structures should be introduced and maintenance of existing flood banks should cease. Within the low-sensitivity zone, conservation-sensitive flood protection measures (ideally distant flood banks) should be permitted. Within the active channel zone of the Spey, partial dredging may be permitted to alleviate localised flooding in the reach re-sectioned in 1992.

It is recognised that successful management of the confluence is dependent on the landowners and SNH working together to protect the conservation interest of the site. Forest Enterprise have responded to the likelihood of channel switching and flooding of their land by felling unproductive forest and not seeking to control the river.

Conservation outcome

An assessment in 1999 showed that the river engineering carried out in 1990 had been locally damaging. As no significant engineering measures have been implemented since that time, this has allowed the river system to recover and reconstruct a dynamic channel system.

The current conservation strategy guides development to appropriate areas and mitigates the flood risk, whilst allowing the active processes, for which the site is designated, to operate.

Further information

HOEY, T. B., SMART, D.W.J., PENDER, G., & METCALFE, N. 1998. Engineering methods for Scottish gravel bed rivers. *Scottish Natural Heritage Research, Survey and Monitoring Report*, No. 47.

Flooding on the alluvial fan of the River Feshie in October 1990. John Gordon/Scottish Natural Heritage

4.25 Wootton Bassett

An active geomorphological site (IA) in Wiltshire

Conservation issues discussed here

- Non-intervention and controlled access to conserve an active geomorphological site.

Site description

Wootton Bassett Mud Spring SSSI, Wiltshire is an unusual site, designated for the occurrence of a series of active mud springs. The vents emit liquid mud all year round and at accentuated rates after periods of prolonged rainfall. This mud dries and accretes around the vents, forming mounds (mud blisters) up to 10 m long, 5 m wide and 1 m high.

The exact processes involved are not fully understood but are related to the occurrence of the Ampthill Clay Formation, overlying an aquifer in the limestone of the Coral Rag Formation, both of Jurassic age. Geochemical evidence indicates that the water contained in the mud originates from the Coral Rag Formation aquifer and has a sufficient hydrostatic head to drive the spring. The upwelling mud also contains fossils from the Ampthill Clay Formation.

Conservation issues and solutions

The site is owned by Wiltshire County Council but is not open to the public. It is surrounded by agricultural land and has been fenced-off for many years to prevent risk to farm animals. The site was originally planted as woodland to mark it on the ground as a dangerous area. In 1990, prior to its notification as an SSSI, an attempt to render the site safe resulted in over 100 tonnes of quarry stone and rubble being tipped into the mud springs, only to sink out of sight within 30 minutes. Access to the site is controlled by Wiltshire County Council, primarily because of health and safety issues, but this also helps to prevent damage to the site.

The main management principle is non-intervention. As long as the site and its surroundings are left undisturbed, the processes which underlie the active system are likely to continue. The greatest threat to the site is likely to be external and related to direct, or indirect, interference with the hydrological regime which is responsible for the mud springs phenomenon. This could happen through inappropriate development in the surrounding area or large-scale abstraction from the aquifer. However, because the system is very complex and not yet fully understood, the impacts of development or water abstraction would be very difficult to predict.

Conservation outcome

Non-intervention is required to maintain the integrity of the natural processes and features of the mudsprings. Controlled access helps to restrict damage to the site.

Further information

BRISTOW, C.R, and others. 2000. The lithostratigraphy, biostratigraphy and hydrogeological significance of the mud springs at Templars Firs, Wootton Bassett, Wiltshire. *Proceedings of the Geologists' Association*, 111, 231-245.

GOSNELL, R.P. 1996. More on the Wootton Bassett mud springs. *Geology Today*, 12, 61–62.

Fluidised clay flowing from the mud spring at Wootton Bassett. Peter Wakely/English Nature

4.26 Bagshaw Cavern

A cave (IC) in the Peak District of Derbyshire

Conservation issues discussed here

- Management of a cave system by controlled access.

Site description

The Bagshaw Cavern system is part of the Bradwell Dale and Bagshaw Cavern SSSI in the Peak District of Derbyshire. The system has around 3 km of cave passages, formed in thinly-bedded limestones of Lower Carboniferous age. The cave is scientifically important for its passage morphology, speleothems and cave sediments.

Full Moon Chamber in Bagshaw Cavern. John Taylor/Derbyshire Caving Association

Management issues and solutions

One of the main issues associated with the conservation management of caves in general is inappropriate or irresponsible usage by cavers and other visitors. Potential problems include pollution, disturbance of cave sediments and damage to, or removal of, cave decoration.

The most effective ways of minimising problems associated with caving are by communication of good conservation practice through the national and local caving organisations and by encouraging local caving groups to take responsibility for management of caves in their area. Good management of access to caves can have very positive conservation outcomes by restricting access to sensitive areas, controlling visitor numbers and ensuring that all visitors are well-informed about good conservation practice.

In the case of Bagshaw Cavern, there is only one entrance to the system, which makes access control easier. The Derbyshire Caving Association (DCA) has worked closely with the owner of the cave to devise an access system that uses a grading classification based on the sensitivity of different parts of the cave.

Access control is achieved through gating, taping and meeting with the landowner prior to visits. The main entrance is gated and there are additional gates within the cave to prevent unauthorised access to certain parts of the system. Taping is also used to indicate restricted areas. The keys are obtained through the owner, who provides further information on access restrictions and sensitivity.

A number of usage types have been defined which dictate what restrictions are imposed on particular groups of visitors. These restrictions are based on the sensitivity of different areas and the potential impact of the usage type. For example, guided adventure trips involving relatively large groups are restricted to the least sensitive areas of the cave. Leader-controlled trips, involving small groups and led by an experienced caver with expert knowledge of the cave, are permitted to the more sensitive areas. Exploration usage, which may have high potential for damage to scientific features, is only carried out by experienced cavers with consent from English Nature.

Conservation outcome

The access control system at Bagshaw Cavern is an effective means of managing the cave and ensuring the long-term conservation of the fragile and sensitive system.

4.27 Cheddar Gorge

A karst site (IK) in Somerset

Conservation issues discussed here

- Managing a karst landscape for geological and biological interests.

Site description

Cheddar Gorge, located in the Mendip Hills in Somerset, is Britain's largest and best known limestone gorge. It was formed by fluvial erosion and weathering of the Carboniferous Limestone over a period of about 2 million years.

Cheddar Gorge is part of The Cheddar Complex SSSI which is notified for multiple geological and biological interest features. The geological interests include karst, caves, minerals and fossils. The biological interests include a wide range of semi-natural habitats which support several rare plants.

Management issues and solutions

The site has been subject to a gradual change over many years from a dominantly grassland environment, with just a few trees on the steeper cliffs, to a significantly diminished grassland area, with dense scrub and secondary woodland. This has occurred in response to a reduction in grazing in the 1930s and the effects of myxomatosis in the 1950s. From a geomorphological perspective, the gorge was losing its rugged, rocky character as the cliffs, screes and slopes became increasingly covered in scrub and woodland.

In order to reverse the effects of loss of grassland and the spread of scrub, a major programme of tree and scrub clearance was initiated and grazing was reintroduced to the area. The main driver for this work has been conservation of the biological interests but the karst interest has also benefited indirectly from the work. A gradual improvement to the geological and biological interests has been observed, but the management regime needs to be sustained.

General view of the spectacular limestone gorge at Cheddar. Peter Wakely/English Nature

Conservation outcome

The development of a management programme for restoring the grassland habitats has benefited both the biological and geological interest features.

4.28 Hope's Nose and Birk Knowes

Collection problems at finite fossil and mineral sites (FM) in Devon and Lanarkshire

Conservation issues discussed here

- Irresponsible collecting of fossils and minerals at sites with a finite resource.

Site description

Birk Knowes SSSI, Lanarkshire, Scotland, is internationally renowned for Palaeozoic jawless fish and arthropod fossils.

Hope's Nose to Wall's Hill SSSI, Torquay, Devon, is renowned for the occurrence of unique and very finite gold-bearing carbonate veins within Devonian limestones.

Management issues

At both Birk Knowes and Hope's Nose, irresponsible over-collecting of fossils and minerals respectively has significantly damaged the geological resources at the sites.

Birk Knowes is a remote site that has been the target of irresponsible fossil collecting since the 1970s. At Hope's Nose, intensive and unconsented removal of specimens by the use of power saws has effectively destroyed the geological interest at the site.

At Birk Knowes, there have been management agreements since 1984 with the landowners. These allow Scottish Natural Heritage to manage the site on the landowners' behalf. In the early 1980s, a permit system was introduced in an attempt to control collecting and safeguard the resource. Ironically, the most intensive collecting took place while this system was in operation. The system failed, primarily because it was ignored by the very people it was designed to control. The site's remoteness made it difficult to monitor, enabling collectors to work unnoticed.

In 1995, Scottish Natural Heritage stopped issuing collecting permits and, as a last resort to safeguard the remaining resource, the site was closed and fenced. Notice boards have also been erected with collecting advice in four languages. To safeguard the remaining fossiliferous rock, a plan has been drawn up to ensure the maximum amount of scientific information is derived from the remaining fossil resource. There have also been initiatives to retrieve any fossil material that collectors discarded while searching for the rarest and most complete specimens.

In order to try to safeguard the finite mineral resource at Hope's Nose, the site was notified as an SSSI with a special legal condition attached, requiring the written consent of English Nature prior to the collection of specimens. Hope's Nose, however, is an easily accessible site but is concealed from public view. Consequently, as with the permit system at Birk Knowes, the requirement to seek permission before undertaking any collecting was difficult to enforce and was ignored by irresponsible collectors. The landowners were powerless as it would be necessary to constantly police the site to prevent unauthorised collecting.

Fencing erected to deter fossil collectors at Birk Knowes. Colin MacFadyen/Scottish Natural Heritage

Collectors used power saws to remove whole sections of the carbonate veins which hosted the gold, leaving virtually no material of interest exposed. Because the veins die out laterally over a short distance, there is little likelihood of exposing similar material in the future. The damage to the mineral resource at Hope's Nose was extreme, resulting in effective destruction of the interest.

At the time of the damage at both sites, mainly in the late 1980s and early 1990s, English Nature and Scottish Natural Heritage had little power to act against third party damage (in contrast to damage inflicted by site owners). In England, the Countryside and Rights of Way (CRoW) Act of 2000 rectifies this by introducing stiff penalties for those found guilty of damaging SSSIs.

Conservation outcome

The tiny but internationally significant resource at Birk Knowes has been over-collected, with serious loss of fossil material and, consequently, potential scientific knowledge. At Hope's Nose, over-collecting has resulted in almost complete destruction of a unique mineral interest. Both sites demonstrate the problems associated with managing collecting of a highly sought after finite resource in isolated areas. Although specimens from Birk Knowes and Hope's Nose can still be seen in museums, they can no longer be studied in their original context.

Further information

MACFADYEN, C. 2001. Getting to grips with asset strippers, *Earth Heritage*, 15, 10.

MURPHY, M. 2001. Minerals in the hands of the collectors, *Earth Heritage*, 15, 14–15.

Mineral collectors have removed most of the gold bearing carbonate veins at Hope's Nose using power saws. Mick Murphy/English Nature

4.29 Globe and Purfleet Pits

Disused quarries with finite interest features (FM and FB) in Essex

Conservation issues discussed here

- The need for consultation throughout the planning process for proposed developments.
- Conservation of soft sediments of finite extent.
- The inclusion of reserve areas as a resource for the future.

Site description

Purfleet Chalk Pits SSSI and Globe Pit SSSI are disused chalk quarries, situated in Essex on the outskirts of London, close to the M25 Dartford Crossing. The sites are designated as SSSIs for the occurrence of unconsolidated sediments which are important for understanding the Quaternary history of the River Thames. In both cases, the interest features are restricted in extent and, as a consequence, are being managed as finite sites. The sites are also renowned for the occurrence of abundant Palaeolithic human artefacts. Both sites are of high scientific importance.

These sites were originally worked for chalk which was extracted to serve the local cement industry. The overlying Quaternary sands and gravels were also extracted as an aggregate resource. Because of their location in a highly urbanised area close to London, there was strong pressure to develop the sites after quarrying ceased. Subsequent developments have further reduced what was already a restricted resource.

The remaining exposed interests are considered as finite features for conservation purposes. One area of Purfleet Chalk Pits, which has never been quarried, has been recently incorporated into the SSSI as a buried resource for future study.

Newly notified unquarried reserve area at Purfleet Chalk Pits SSSI. Mick Murphy/English Nature

Management issues and solutions

At Globe Pit, there are a number of conservation issues. Firstly, the deposits are finite in extent. Secondly, the deposits are unconsolidated and mechanically weak. Thirdly, there is very little space between a housing development on the floor of the disused pit and the quarry face.

The last situation should not have occurred, as the initial application for a housing development made clear the need for an area of green space to be left between the proposed development and the geological interest in the quarry faces, to allow visual and physical access to the sections of interest. The initial development proposals, however, were modified during the planning process, without further consultation with English Nature. The modified plans were approved by the local planning authority, allowing properties to be built with gardens encroaching within a few metres of the face. This lack of consultation has resulted in severely restricted access to the geological interest for both study and site management.

Consequently, the management of Globe Pit presents significant challenges, in particular the maintenance of a clean, stable face in the soft sediments. The existing face is becoming overgrown and degraded but continued removal of scrub and re-excavation of fresh faces is not a realistic option because the interest is very finite in extent. However, because of the proximity of the buildings and gardens, it will probably become necessary over time to remove collapsed material. This is likely to have a serious impact on the

Students examining the small exposed section at Purfleet Chalk Pits. Natalie Bennett/English Nature

interest because of its limited extent. The proximity to the properties also increases the likelihood of material being tipped on site. Unfortunately, there is no potential for expanding the site outside of its current boundary.

Purfleet Chalk Pits have been subjected to severe development pressure after quarry operations ceased, with major industrial developments and associated infrastructure being constructed. Although geological conservation has been given consideration in granting planning permission for developments, the remaining important geological exposures are very finite and sensitive. As developments have taken place, further pressure has been exerted on the already finite resource. As at Globe Pit, the sediments are unconsolidated and prone to collapse and there is little potential for re-excavation of fresh faces because of the finite nature of the deposits.

Development encroaching on the Quaternary deposits at Globe Pit. Eric Steer/English Nature

In order to ensure that there will be a resource of material available for scientific study in the future at Purfleet Chalk Pits, the site was renotified as an SSSI in 2003 to incorporate an extra area of unquarried land, which is underlain by similar sediments. This area will act as a reserve and can be excavated in the future if the scientific need arises.

Conservation outcome

The exposed geological resources at both sites are strictly finite and the unconsolidated nature of the sediments has resulted in mechanically weak sections with a tendency to collapse. At Purfleet, the incorporation of a buried reserve into the SSSI relieves some of the pressure on the existing finite exposures. There is no such reserve at Globe Pit and it is important to consider the management of the site very carefully, while potential solutions are investigated.

Further information

BENNETT, N. 2000. Best of both worlds. *Earth Heritage*, 14, 8-9.

BRIDGLAND, D.R., and others. 1995. Purfleet interglacial deposits: Bluelands and Greenlands Quarries. *In: The Quaternary of the Lower Reaches of the Thames, a Field Guide*, 167–184. Quaternary Research Association.

4.30 Clock House Brickworks

A mine dump (FD) and active quarry (EA) in Surrey

Conservation issues discussed here

- Using a rock store to conserve a fossil insect interest in an active quarry and landfill site.

Site description

Clock House Brickworks SSSI is located within a quarry and landfill site in Surrey. The site is quarried for clay and the void space is used for phased landfill as discrete areas are worked out.

The site has been designated as an SSSI for Lower Cretaceous (Wealden) stratigraphy, sedimentology and palaeontology. It is particularly important for the occurrence of fossil insects which occur in relative abundance at certain horizons. The insect assemblages are very significant as they are of great value in the interpretation of Wealden environments.

Management issues and solutions

Although it has been possible to study most aspects of the geology of the site as quarry operations have proceeded, studying the fossil insects requires a special approach. The insects are restricted to particular siltstone horizons which are of no economic value and are discarded as waste. The process of searching the siltstone for fossil insects is slow and does not keep pace with the quarrying. Consequently, there was a danger that this important resource could be permanently lost.

In order to conserve the fossil resource, the quarry operators provided an area for an off-site fenced rock store, where a large quantity of insect-bearing siltstone could be kept safe from destruction. The local planning authority provided a vehicle to transport the material to the store. Approximately 100 tonnes of insect-bearing siltstone was transported to the rock store. This has ensured a supply of siltstone that has lasted around 10 years beyond the working life of the area from which the material came and has formed a prolific source of fossil insects and other fossil organisms.

In order to protect the off-site rock store from vandalism, secure fencing and a padlocked gate were erected. The rock has been regularly turned over in order to provide fresh material to work. Once recovered, the bulk of the insect remains go into collections at the Booth Museum, Brighton. Other more common material, such as fish teeth and scales, may be collected by individuals.

Conservation outcome

The fossil insect resource at Clock House Brickworks was secured beyond the working life of the extraction area. This provided both improved accessibility and a means to successfully collect insects and other fossils. Scientifically valuable material, that would otherwise have been lost during quarrying and landfilling operations, has been conserved.

Further information

English Nature, Quarry Products Association and Silica and Moulding Sands Association. 2003. *Geodiversity and the minerals industry – conserving our geological heritage*. Entec UK Ltd.

Typical fossil-bearing block from the rock store. Peter Austen

4.31 Skiddaw

A large upland site in Cumbria with finite mineral (FM), mine dump (FD) and finite underground (FU) interest features

View over Roughton Gill showing large mine dump, Skiddaw Group SSSI. Mick Murphy/English Nature

Conservation issues discussed here

- Conserving important finite mineral and mine dump sites while allowing continued appropriate usage.

Site description

The Skiddaw Group SSSI in Cumbria is a large upland site with multiple geological, archaeological and biological interests. The Skiddaw Group SSSI has been designated for 12 separate geological interests. These include a number of mine dumps and mineral sites in the former mining area of the Caldbeck Fells, which is renowned worldwide for the quality and variety of mineral specimens discovered there. This case study concentrates on issues associated with conservation management of the mineralogical interests within the Skiddaw Group SSSI.

Management issues and solutions

The main threat to the mineral resource within the Skiddaw Group SSSI is over-collecting of specimens. Irresponsible collecting over many years has resulted in significant damage to important parts of the resource. Some important areas have been depleted to the point that little or no material of mineralogical interest now remains.

Additional related damage has been caused to the landscape by collectors digging large trenches. The blocked-off entrances to some disused mines or levels have been forced open, posing a serious hazard. There has also been concern that irresponsible collecting was having a negative impact on the archaeological interest of certain mine dumps.

A large area of the Skiddaw Group SSSI is owned and managed by the Lake District National Park Authority (LDNPA). In January 2000, in order to safeguard the interests at the site, the LDNPA, in consultation with English Nature, the British Geological Survey, the Russell Society and other mineral collecting groups, introduced a policy to control mineral collecting on the Caldbeck Fells.

In order to monitor activities on the site to provide better management of its wide range of interests, anybody wishing to remove mineral or rock specimens had to apply to the LDNPA for a permit. The permits were granted annually to collectors for scientific research purposes, providing they could scientifically justify their collecting activities.

This system was seen as too restrictive and, in 2004, the mineral collecting permit policy was reviewed and revised. As a first step, English Nature and the

LDNPA carried out an assessment of the geological and archaeological value and sensitivity of the mineralogical sites in the Skiddaw Group SSSI.

In March 2005, following extensive consultation with interested parties, the LDNPA introduced a revised permit system. Under the new scheme, the Caldbeck Fells have been divided into colour-coded zones (red, amber and green) which are of varying sensitivity. The idea is to allow some educational and amateur collecting in green zones, while maintaining tight restrictions in more sensitive areas (red zones). All collectors will still require a permit, but the application process has been simplified for green zones, as all collectors are now required to follow a code of conduct which sets out collecting procedure. This system provides a more flexible approach to granting permits, giving greater access to amateur collectors and educational groups, while protecting the key sensitive areas.

LDNPA rangers, voluntary wardens and the police enforce the permit system and a coordinated system of patrols has been set up. It is hoped that the visible presence of wardens at varying times will be effective in deterring unauthorised mineral collecting.

The LDNPA aims to ensure, as far as possible, that the archaeological and geological heritage of the mine workings are conserved and that legitimate research and recreational activities can continue.

Although the site is heavily used for recreational and educational activities, including mineral collecting, scope exists for further promotion of the geological interest. As well as educational days, there are plans to make collections of mineral specimens from the area available for public use. The LDNPA is also working with the Mines of Lakeland Exploration Society (MOLES), and a local history society to set up a mining exhibition.

Conservation outcome

Although the revised permit scheme is in the early stages of implementation, the management techniques employed by the LDNPA at the Skiddaw Group SSSI should better protect the geological and archaeological heritage of the area, safeguarding legitimate interests and improving public safety. So far, the permit system appears to be successful in deterring irresponsible and unauthorised collecting.

4.32 Writhlington

A mine dump (FD) in Somerset

Conservation issues discussed here

- Recovery and collection of important fossils from a mine dump.
- The involvement of geological societies and groups, school parties and the general public in the recovery of scientifically important fossils.

Site description

Writhlington SSSI forms part of a disused colliery tip located in the village of Lower Writhlington, near Radstock, Somerset. During the reprocessing of the tip in 1984, in order to recover unpicked coal, the Coal Measures mudstones were found to contain a significant fossil insect assemblage. Some 3,000 tons of this mudstone were set aside as a reserve (Writhlington Geological Nature Reserve) and resource for the future collection of these insect assemblages. The reserve is fenced, gated and locked. Use of the site is by permission only.

Funding for the creation of the reserve and for interpretation came from a range of sources. In recent years, a regular mechanical turnover of the dump to expose fresh material has been undertaken.

The site is internationally important because of the high diversity and large numbers of Carboniferous fossil insects and other arthropods that have been recovered from the mudstones. The site also yields large numbers of well-preserved fossil plants.

Management issues and solutions

When the reserve was created, the intention was to recover scientifically important fossil material for research purposes. The site is also used for educational purposes by universities, schools, museums, geological societies and schools. These educational visits take place under the supervision of geological specialists.

Conditions for using the site also set out measures to manage the way in which the resource is collected. These include an obligation to record all fossil insects found and to make them available for scientific study. Fossil plants are also recorded, but, unless they are of particular interest, specimens may be retained by the collector.

Extensive collecting from the site over a long period of time has inevitably resulted in a decrease in the quality and quantity of fossil material being retrieved. In order to help address this issue, the rock store is regularly turned over in order to expose fresh material. A state is now being reached, however, where this activity provides a diminishing return. Inevitably, the time will come when the majority of fossils have been recovered and the resource will be exhausted.

This approach to site management has resulted in maximum scientific and educational gain from what is a strictly finite resource. It has enabled this rare Carboniferous fossil resource to be recovered, studied and curated. Most of the insects recovered from Writhlington are now housed in the City of Bristol Museum and Art Gallery. The experience gained at Writhlington has had the effect of renewing interest in these types of fossil assemblages. As a consequence, new insect fossils have been recovered from other disused tips and opencast workings.

Collecting plant and insect fossils at a Rockwatch event for children in 1994. Colin Prosser/English Nature

Conservation outcome

As a result of the initiative at Writhlington, a large amount of highly important fossil material has been collected. Before work began at the site in 1984, there were less than 200 specimens of fossil insect known from the whole of the British Carboniferous. Now, more than 1,300 specimens of fossil insects and other arthropods have been recovered from the site, many of them new to science. The understanding of British Upper Carboniferous fossil insect assemblages has been substantially increased by this initiative and it has encouraged the search for such assemblages on Coal Measures sites elsewhere.

Further information

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4.33 Alderley Edge

A finite underground mine (FU) in Cheshire

Conservation issues discussed here

- Management of finite underground mines by controlled access.

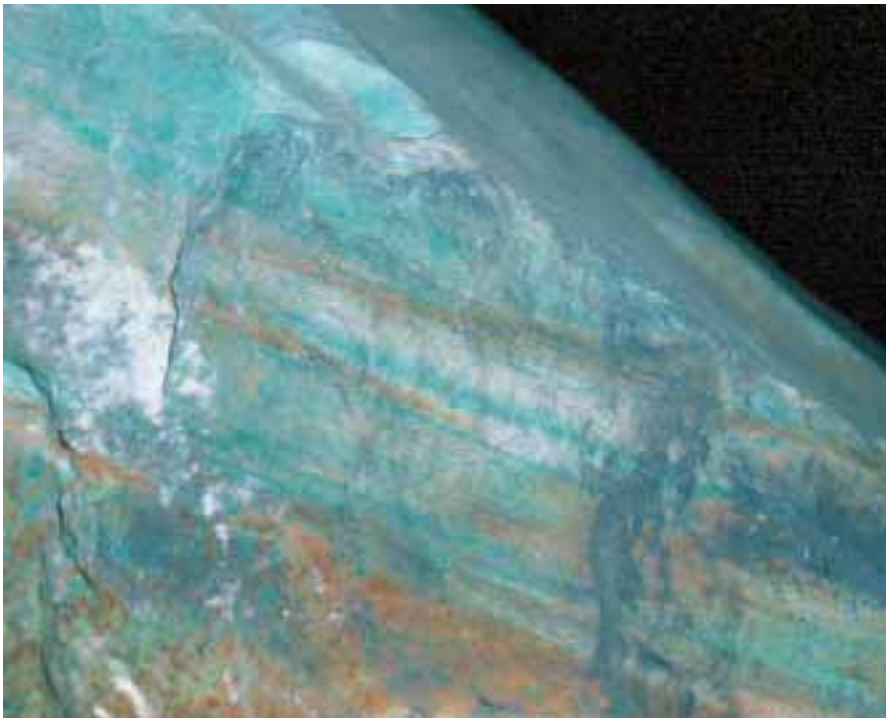
Site description

Alderley Edge SSSI, Cheshire, is designated for its mineralogical interest. The site comprises several mines where ores, chiefly of copper, with minor amounts of lead, cobalt, vanadium and arsenic, occur in sedimentary host rocks of Triassic age. The ore deposits and the sedimentary host rocks remain accessible for study within the disused mine workings. Mined from the Bronze Age until the early 20th century, Alderley Edge mine workings extend over an area of 1.5 km^2 with at least 12 km of tunnels. Important features of the mineralisation and its relationship to the sedimentary host rocks are displayed in unweathered sections in the mines. In addition, parts of the site are designated as a Scheduled Ancient Monument (SAM).

Management issues and solutions

Mineral collecting can be a serious threat to the conservation of disused underground mines because the resource becomes effectively finite once the mine closes. Access control and promotion of good practice are the most effective methods of conserving the finite mineral resource.

The National Trust owns most of the land and leases the mines to Derbyshire Caving Club (DCC).



Copper mineralisation in Alderley Edge mine. English Nature

As part of the conditions of the lease, no minerals may be removed from the mine. The DCC work closely with the National Trust, Manchester Museum and the County Archaeologist to manage and interpret the site.

Work by the National Trust and Cheshire County Council has made the surface features safe. Several mine shafts have been capped and access points to the mine levels have been fitted with locking gates. Members of DCC have worked underground to clear and secure the mine tunnels and the internal access between different mine levels.

Access to the mine is by prior arrangement with DCC and trips are led by an experienced DCC member. Visits to certain areas are limited to small numbers of experienced cavers or mine explorers because of safety considerations. DCC also offers an open weekend every year where members of the general public can visit the more accessible and safest areas of the mine workings.

Conservation outcome

Joint action by the National Trust, Cheshire County Council and Derbyshire Caving Club has secured the site and allowed safe access to the features of interest. The geological and archaeological interests of the site are being conserved while allowing controlled recreational and educational use.

Further information

The DCC website provides further information on the Alderley Edge mines: www.derbyscc.org.uk/alderley

4.34 Seven Sisters Mine

A finite underground mine (FU) in Dudley

Conservation issues discussed here

- A partnership approach to resolving safety issues related to mine instability while retaining access to a mine.

Site description

Seven Sisters Mine is located within the Wren's Nest SSSI and National Nature Reserve (NNR) in Dudley, West Midlands (see separate case study). The site is owned by Dudley Metropolitan Borough Council and managed by them through agreement with English Nature.

Silurian limestone was quarried and mined at the Wren's Nest from the 18th century until about 1920. The Seven Sisters Mine is a spectacular example of pillar and stall mining. As limestone was extracted from the thickly bedded lower part of the Much Wenlock Limestone, large pillars of the limestone were left supporting the mine roof. At the Seven Sisters, so-called because seven pillars were once visible from the surface, the limestone mine opens onto the surface. Until recently, when the cavern entrances were temporarily filled with aggregate for safety reasons, visitors could see down into the steeply inclined mine with its pillars and stalls.

Seven Sisters Mine is of particular importance as the only remaining accessible limestone mine in the Black Country. In 2004, the Wren's Nest received Scheduled Ancient Monument (SAM) status as a recognition of its importance to industrial archaeology. The site is also of importance as a roosting habitat for bats (protected species) with at least five different species of bat having been recorded.

Seven Sisters Mine in the early 1960s. Geoffrey Prosser

Management issues and solutions

The NNR management plan covers routine management of the geological and biological interests of the Wren's Nest and is implemented by Dudley Metropolitan Borough Council. As part of the management plan, significant changes to all features of interest at the Wren's Nest NNR are recorded and reported to English Nature.

In recent years, the main management issues at Seven Sisters Mine have related to the progressive collapse of the mine roof with the associated risk to the public and any ensuing liability matters. Collapse of part of the mine had already resulted in the area around the mine entrance being fenced off with a 2.4 m high, steel palisade fence, and regular mine stability inspections taking place to monitor safety. In order to retain a good view of the cavern entrances and supporting limestone pillars, a viewing platform was constructed.

Further high-profile collapses within the mine in 2003 pushed scrutiny of the various ongoing management issues to the forefront of the local planning authority's considerations. In this situation, some local planning authorities may have prioritised health and safety at the expense of the scientific and heritage importance of the Seven Sisters Mine. In this case, an engineering solution was sought, which took account of both health and safety and conservation needs at the site. In order to achieve this, a working group of interested parties, including the local planning authority, English Nature, mining engineers, geologists and local historians was set up to try to find a solution.

This partnership approach resulted in an engineering solution being developed which retained visibility of the mine entrances and limestone pillars which make up the Seven Sisters, ensured access to some caverns for bats, and enabled the caverns to be stabilised by filling them

with loose dry aggregate. Although the caverns have been largely filled by the aggregate, the mine entrances and supporting pillars are still visible. Furthermore, this approach means that the future option of completely removing the aggregate from the mine entrances and strengthening the roof with rock bolts remains viable, should funding become available.

The partnership approach to this project, involving engineers, conservation professionals, contractors and the local community in the design stage of the work, has been accepted as a national demonstration project under Construction Excellence and achieved a gold star award, the highest honour. The project has also been awarded full marks on the Considerate Constructors Scheme of the Office of the Deputy Prime Minister. This award was based on successful balancing of public safety and environmental issues, together with the adoption of a partnership approach that involved a wide range of interested parties.

Conservation outcome

The involvement of a wide range of interested parties in designing a solution to conserving the key features of the Seven Sisters Mine, while addressing important public safety issues, has resulted in a successful conservation outcome. Safety issues, which could have resulted in complete loss of the features of this mine, have been addressed in a manner which conserves them in the short term and offers an opportunity to enhance them in the longer term.

Further information

CUTLER, A., OLIVER, P. G., & REID, C. G. R. 1990. *Wren's Nest National Nature Reserve geological handbook and field guide*. Dudley: Dudley Leisure Services Department and Peterborough: Nature Conservancy Council.

Fenced entrance to Seven Sisters Mine prior to stabilisation works and infill.
Colin Prosser/English Nature

4.35 Wadsley Fossil Forest

A finite buried interest site (FB) in Sheffield, South Yorkshire

Conservation issues discussed here

- Scientific excavation and recording of a finite and unique fossil resource.
- Deliberate burial of a finite resource for long term conservation.
- Use of a planning condition to conserve a finite resource on a development site.

Site description

A group of in situ fossilised trees of Carboniferous (Westphalian) age, about 310 million years old, lie in the grounds of a new housing development in Wadsley, Sheffield. Although fossil trees and roots are not uncommon in the Upper Carboniferous, the occurrence of numerous fossil tree stumps in one place is rare. Wadsley is one of only two known examples in Great Britain. The other is some 20 million years older and located in Victoria Park, Glasgow.

The Wadsley fossils occur in an inclined bed of sandstone. At least 13 stumps and numerous tree and root remains are preserved together. The site has provided a unique insight into the lower rooting structures and under-surfaces of Westphalian trees, revealing how the rooting systems grew and interacted.

Management issues and solutions

The fossil forest was discovered in 1872 during building work in the grounds of the Middlewood Hospital. Excavations into the underlying sandstone initially exposed the fossilised remains of 10 large tree stumps, the largest around 3 m in diameter. The fossils were described by Professor Henry Clifton Sorby in 1875. Sorby realised the importance of leaving the fossils where they were found and had wooden sheds erected over three of the best fossil stumps to protect them from the elements. The sheds eventually fell into disrepair and the fossils were re-exposed to the elements. Damage by fossil collectors was also a problem. By the mid-20th century, the site had become seriously degraded with little evidence on the surface of its unique geological resource.

In 1987, at a time when the site was changing ownership, it was cleared of vegetation and re-excavated under the guidance of Sheffield City Museum and the Sorby Natural History Society. Four in situ stumps were rediscovered and the site was designated as an SSSI.

Sheffield City Museum, Sheffield City Council and English Nature established a partnership to decide how to manage the site. There was a choice between a major scheme to develop the site as a visitor attraction, or to re-bury the fossils and develop on-site interpretation to mark their presence. The latter was chosen as the most realistic option in the light of available resources.

Subsequently, when planning permission for a housing development was granted, a condition was attached to the planning consent, requiring a full programme of scientific excavation, with recording and conservation of the fossils prior to re-burial, as part of any current or future development. An added proviso was that interpretation could be expanded and the fossils re-exposed if required.

The programme of work took place in 2003. Ground clearance established the level of the tops of 13 fossilised tree stumps. Soil and overburden were removed by hand tools. Rooted vegetation was cut rather than pulled, in order to avoid damage to underlying features, and then treated with weedkiller. Once the stumps were revealed, they were carefully cleaned and were covered at night to protect them from the elements.

Recording during removal of the overburden included a site diary, detailed survey records and both photographic and finds records. A detailed plan, tied into the Ordnance Survey National Grid, was produced to form the basis for future interpretation. In addition, a latex mould was taken to enable a resin cast to be made from the largest and most intact fossilised tree stump. Following this process, the fossils were buried to provide long-term protection against weathering and collecting.

Tree stump exposed prior to cast-making and re-burial. Jonathan Larwood/English Nature

A further phase of activities is planned to promote Wadsley Fossil Forest. This will coincide with transferring the ownership of the SSSI to the local planning authority. The site will then be maintained as a landscaped public open space.

South Yorkshire RIGS Group, English Nature and Sheffield Galleries and Museums Trust are key partners in the project. Two replicas are to be made from the mould that was taken. One cast is to be located on site with accompanying information. The second will form a key exhibit in new displays of local geology at Weston Park Museum. The project archive will be retained by Sheffield Galleries and Museums Trust. With the involvement of a local school, an information leaflet is planned, as well as a series of rock and fossil hands-on activity days both at the museum and on site.

Conservation outcome

As a result of attaching a condition to the planning consent, the fossils at Wadsley were successfully excavated, catalogued and conserved for the long term by re-burial.

Further information

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5 Geological conservation in context

5.1 Introduction

This *Guide to good practice* focuses on the practicalities of site-based geological management and conservation, based mainly on experience of geological SSSI and RIGS management. It is important, however, that site-based conservation is considered in a wider context. Geological sites must be managed alongside a range of environmental interests, including species and habitats, landscapes and archaeological heritage. Not only is it important to consider other designations and the positive role they may play in geological conservation, it is also important to understand the benefits of integrating site management. This chapter, therefore, briefly examines the value of a more integrated approach to environmental management and the context that can be established at a wider scale. It also considers Local Geodiversity Action Planning, which provides a framework for delivering geological conservation.

Sustainable development is at the heart of Government policy and practice and is reflected in the recently published *Planning Policy Statement 9: Biodiversity and Geological Conservation*. This planning policy statement promotes the conservation and enhancement of biological and geological diversity as an integral part of social, environmental and economic development and directly encourages the conservation of biodiversity and geology in the wider landscape as well as on protected sites.

In response to the need for a more integrated and holistic approach to the natural environment, a new government agency, *Natural England*, is being created. This brings together nature conservation and landscape functions in England, with an explicit sustainable development remit, in one government agency. Geodiversity (Gray 2003), a concept which includes geology, geomorphology and soil, will play a central role in adopting this new integrated approach in *Natural England* and in supporting the delivery of sustainable environmental management (Stace & Larwood 2006).

5.2 Integrated environmental management

In simple terms, geology and geomorphology influence habitat, soil, landform, aspect and drainage pattern and are, therefore, fundamental to landscape diversity and to the management and conservation of ecosystems.

Geological sites and their management may provide immediate and direct benefits to biodiversity (English Nature 2004a, 2004b, 2004c). For example, fresh rock faces, scree slopes and eroding and weathering sections may provide nesting sites for birds as well as habitats suitable for a range of invertebrates requiring disturbed ground. Scrub and vegetation management, to maintain geological sections, can increase the diversity of habitat from bare, open ground, through a succession of habitats to mature woodland, and can significantly benefit the wildlife of an area. Equally, management of biological sites is often beneficial to geology. Maintaining natural processes and management activites such as scrub clearance are as important for biodiversity as they are for geology.

Lichen-covered granite, Cornwall. Mick Murphy/English Nature

Wildlife sites, as well as being protected as SSSIs, may also be afforded additional protection, under the European Habitat and Species Directive, as Special Areas of Conservation (SAC) and Special Protection Areas (SPA). Included within these designations are interests such as limestone pavements and salt marshes, which are strongly geological and geomorphological, or, more specifically, habitats such as the 'vegetated sea cliffs of the Atlantic and Baltic Coasts', whose management is largely compatible with the management of their associated geology.

Integrating geological and biological site management is beneficial, therefore, in a number of ways and management prescriptions are often compatible. For example, managing scrub for geology also benefits biodiversity and vice versa. Also, wildlife designations, particularly at a European level, can provide further legislative protection to a geological site. For example, where coastal engineering works affect a geological site on an eroding cliff, an SAC designation for its habitat will provide a powerful additional mechanism for arguing against coastal protection.

5.3 Landscape designation and management

Landscapes are fundamental to the character of any area and are valued for their cultural and historic associations, as well as their natural characteristics. Central to this is the way that landscapes reflect geological diversity, from rolling chalk downs to rugged uplands, and from changing land-use to variation in local building style.

In England, there are a range of landscape designations. National Parks, Areas of Outstanding Natural Beauty (AONBs) and Heritage Coasts are considered to represent England's finest landscapes and are afforded legislative protection to maintain their quality and character. Their management is focused on conserving their natural beauty, wildlife and cultural heritage and promoting sustainable land management, in keeping with their varied character. In England, 159 Joint Character Areas (Countryside Commission & English Nature 1997) provide a landscape framework that is based on physical, historical and cultural influences on landscape. These landscapes are described and assessed using Landscape Character Assessment and it is this that provides a basis for landscape management decisions within and outside of protected landscapes.

The approach to Joint Character Areas and Landscape Character Assessment further reflects the value of adopting a holistic approach to environmental management, particularly as landscape provides a tangible framework for demonstrating how geology, habitat, species and people all fit together. This can directly benefit geological site conservation. For example, a conserved quarry can be used to demonstrate a source of building stone characteristic of local buildings and also provide a rare opportunity to see what underlies the landscape. Equally, understanding how important geology is in our landscape, including villages, towns and cities (Bennett and others 1996), and the way it influences land use, economy and settlement pattern, strengthens the value of geology and, therefore, the justification for its conservation.

The Malvern Hills in the Abberley and Malvern Hills European Geopark. Jonathan Larwood/English Nature

Geological sites within a National Park or an AONB benefit from the additional protection that these designations bring. Consultation with the relevant authority is important and this may also provide opportunities for gaining further resources, particularly where geological sites are considered in the context of landscape and where access to geological sites is encouraged. Wider expertise in site management may be available and geological interpretation could be part of a broader National Park or AONB strategy.

5.4 European Geoparks

The European Geopark Network (EGN) was established in June 2000. A European Geopark is a territory with geological heritage of European significance and a strong management structure, which includes a sustainable development strategy. European Geoparks tend to comprise a network of sites, including geological SSSIs and RIGS, within a wider geological setting. There are currently 25 Geoparks within the EGN, including the North Pennines Area of Outstanding Natural Beauty and the Abberley and Malvern Hills in England. A European Geopark's management and conservation is based upon existing legislation and management plans.

An important aim of the EGN is to promote sustainable development within the Geopark by using geology and this is primarily achieved through geotourism. The emphasis on geotourism reflects a growing realisation of the important role that geology has to play in tourism and its potential economic value (McKeever, Larwood, & McKirdy 2005). Much of the work of European Geoparks is, therefore, aimed at raising the geological awareness of visitors and local communities so that geology is more clearly valued and the need for its conservation is better understood and supported.

This approach can directly benefit site-based geological conservation. The successful conservation of sites is essential to the success of any European Geopark, as these sites are an important part of achieving successful geotourism. European Geoparks add profile and further value to the geology of an area and this in turn can help achieve better support from local planning authorities as well as local communities for the conservation of geological sites. The return can be more resources for geological conservation, interpretation and promotion.

5.5 World Heritage Sites

The Dorset and East Devon Coast was inscribed as a UNESCO World Heritage Site for its outstanding geology in 2001. It is currently the only natural World Heritage Site in mainland Britain and is among a global network of natural and cultural properties that are considered to be of 'outstanding universal value', including the Grand Canyon, the Great Barrier Reef, the Taj Mahal and Stonehenge.

The Dorset and East Devon Coast World Heritage Site includes 13 geological SSSIs, a National Nature Reserve, several European Habitat Directive sites and overlaps with two Areas of Outstanding Natural Beauty.

The coast at Charmouth, Dorset and East Devon Coast World Heritage Site. Jonathan Larwood/English Nature

The management and conservation of the World Heritage Site is complex and, as with European Geoparks, is primarily based upon the established management objectives and plans for the range of designated sites that it includes. The management issues are typical of an eroding coastline which is, in places, highly developed, leading to demands for coastal protection. The Dorset coast, particularly between Charmouth and Lyme Regis, is one of the most famous fossil collecting localities in the world and much time is devoted to the management of collecting and the provision of guidance on good collecting practice.

The successful inscription of the Dorset and East Devon Coast World Heritage Site in part reflected the well-established, site-based management and conservation on this coastline. The World Heritage Site cross-cuts two county boundaries and a large number of site designations and its future management is very much based on integrating the conservation objectives across this range of interests. The World Heritage Site also raises the value of the individual geological sites that it includes as it provides a global context for their importance.

5.6 Local Geodiversity Action Plans

Local Geodiversity Action Plans (LGAPs) are a new and effective mechanism for the delivery of geological conservation. Developed, in part, from the experience of Biodiversity Action Planning, LGAPs provide a context for the broad range of activities associated with geological conservation. LGAPs encompass the tradition of site conservation, not only linking local and national sites in one plan, but also placing sites in a wider context. Importantly, LGAPs involve a wide range of organisations, groups and individuals in their development and delivery. An LGAP establishes a process and provides a shared framework for the delivery of geoconservation that previously has not existed.

Local Geodiversity Action Plans – sharing good practice (English Nature 2004d) sets out core principles for the development and delivery of a successful LGAP. LGAPs vary according to local circumstances but there are fundamental similarities between them. They are typically based on administrative boundaries, are developed through partnership, in wide consultation, and establish a measurable process. An LGAP establishes shared aims and objectives with measurable targets and actions:

- **Geodiversity audit:** an important early objective that can include a standard audit of the geology, geomorphology and geological sites of an area as well as an audit of available information and skills.

- **Communication and education:** promoting an understanding and wider awareness of geodiversity and encouraging participation.

- **Influencing planning:** influencing local plans and planning guidance to support the delivery of the action plan and geological conservation.

- **Conservation and management:** establishing clear goals for the conservation and management of geological sites, natural processes and the geodiversity of our landscape.

- **Resources:** establishing clear objectives for the resourcing (money and people) of the action planning process.

Company GAPs are now also being developed. These take the same LGAP principles but apply them to a company or organisational geological resource. This could include the land holdings of a mineral extraction company or an organisation involved in extensive land management.

LGAPs provide a framework for the integrated delivery of geological conservation, integrating site-based conservation into the wider context of the LGAP area. They are driven locally and, where they are most successful, are established through wide consultation and partnership that engages a range of groups and individuals beyond the traditional geological community. They provide a shared strategic direction which helps justify support for site-based geological conservation, demonstrate the wider relevance of geological sites and allow for the better targeting of resources.

Annex A: Chronology of geological conservation in England

1945: *National Geological Reserves in England and Wales*

This report by the Geological Reserves Sub-Committee of the Nature Reserves Investigation Committee, identified "a list of sites meriting permanent protection as Geological Reserves of national importance", and marked the first steps towards developing a systematic approach to the conservation of our geological heritage on a national scale.

1947: *Command 7122 – Conservation of nature in England and Wales*

This report by the Government-appointed Wild Life Conservation Special Committee recognised geological conservation alongside wildlife conservation and made recommendations as to how the Government could engage in a national nature conservation effort.

1949: *The National Parks and Access to the Countryside Act* and the Nature Conservancy

The Government passed the *National Parks and Access to the Countryside Act* and established, by Royal Charter, the Nature Conservancy. This established a legal framework for nature conservation, including geological conservation, and a government body responsible for delivery. The Act empowered the Nature Conservancy to establish National Nature Reserves (NNRs) for the purposes of nature conservation. It also recognised that it would be a long time, if ever, before all the important wildlife and geological sites could be acquired as nature reserves. It contained a provision, therefore, for the Nature Conservancy to notify local planning authorities of important areas, not yet managed as nature reserves, as areas of Special Scientific Interest, now known as Sites of Special Scientific Interest (SSSIs), by reason of their flora, fauna or geological or physiographical features. Although the Act gave no direct protection to SSSIs, it enabled a local planning authority, once notified of an SSSI, to protect it from adverse development under the controls of the planning system.

1973: The Nature Conservancy Council

The Nature Conservancy Council Act split the Nature Conservancy into two parts. The executive part, including the geological conservation function, was reconstituted as the Nature Conservancy Council (NCC), an independent council with greater autonomy. The research arm of the Nature Conservancy remained within the Natural Environment Research Council as the Institute of Terrestrial Ecology.

1977: The Geological Conservation Review

The Geological Conservation Review (GCR) was initiated to establish a more systematic and scientifically rigorous approach to the identification of nationally important geological sites than had previously been the case. The GCR provided a systematic site assessment and selection exercise

carried out on a Great Britain scale and involved a wide range of geological specialists from academia, museums and industry, assessing sites within discrete subject areas (Ellis and others 1996). All geological sites considered at a national level for conservation as SSSIs have been subject to thorough assessment by specialists in their field through the GCR process. The main phase of the GCR was completed in 1990 and all site descriptions are being published by The Joint Nature Conservation Committee (JNCC). Section 2.2 discusses the GCR process in more detail.

1981: *The Wildlife and Countryside Act*

This Act improved arrangements for the effective conservation of SSSIs. Under the 1949 Act, only local planning authorities had to be informed about the existence of an SSSI. The 1981 Act required the statutory nature conservation bodies to inform all owners and occupiers, as well as planning authorities and the government, about the location of an SSSI. Owners and occupiers also had to be informed about the nature of the features which were identified as being of special scientific interest and about the types of operations or activities that may damage these special features. The 1981 Act also contained a provision enabling a local planning authority to make a Limestone Pavement Order, on either landscape or nature conservation grounds, to prevent the removal of rock from limestone pavement areas.

The provision for notification of geological sites as SSSIs has been widely adopted across Great Britain and is the major tool used to deliver the conservation of nationally important geological sites. In England alone, there are currently around 1,240 SSSIs notified for a geological interest, almost 30 per cent of the total number of English SSSIs.

1990: *Earth science conservation in Great Britain – a strategy*

In 1990, the Nature Conservancy Council (NCC) working with the geological community, published a strategy which, for the first time, set out a framework for geological conservation in Great Britain. The Strategy had six main themes that provided direction for geological conservation in the 1990s. These were:

- maintaining the SSSI series based on the GCR
- expanding the RIGS network
- developing new conservation techniques
- improving site documentation
- increasing public awareness
- developing international links.

1990: Regionally Important Geological and geomorphological Sites (RIGS)

The 1990 strategy document formally introduced the concept of Regionally Important Geological and geomorphological Sites (RIGS). Since 1990, the RIGS movement has expanded rapidly and served to

establish a voluntary geological conservation sector at regional and local level, resulting in conservation activity taking place on hundreds of sites.

RIGS are locally or regionally important sites usually identified within a county or region that are considered worthy of protection for their geological or geomorphological importance. RIGS are selected and managed by RIGS groups, sometimes called trusts, and are typically made up of locally-based geologists, conservationists, teachers, museum workers and planners, usually working at a county level. Although RIGS have no statutory protection, the details of many RIGS have been passed to local planning authorities and these sites receive some protection through planning policies relating to the relevant local plan (see Chapter 2). Although still relatively young, the RIGS movement has resulted in increased conservation activity and involvement in geological conservation at a regional and local level.

1990: *The Environmental Protection Act*

This Act led, in 1991, to the Great Britain-wide conservation agency, the Nature Conservancy Council, being split into three country-based agencies: the Countryside Council for Wales, English Nature and Scottish Natural Heritage. Alongside these three agencies, the overarching Joint Nature Conservation Committee (JNCC) was created, having responsibility for research and advice on nature conservation at both United Kingdom and international levels.

1994: *Planning Policy Guidance 9: Nature Conservation (PPG9)*

In 1994, this planning policy guidance provided the first recognition of RIGS within the planning system.

1999: The Association of UK RIGS Groups (UKRIGS)

Between 1990 and 1999 the number of RIGS groups and their levels of activity continued to grow, leading to RIGS groups or equivalents being established in most areas of England and Wales, and in some areas of Scotland and Northern Ireland. A consequence of this growth was an increased national profile and momentum and a desire for greater national recognition and independence from established conservation bodies. Thus, by 1999, an independent national umbrella body, the Association of UK RIGS Groups (UKRIGS), was established.

1999: *RIGS handbook*

This handbook provided advice and guidance on good geological conservation practice to RIGS groups across the UK.

2000: *The Countryside and Rights of Way (CRoW) Act*

This Act greatly strengthened legislation relating to the conservation of geology and wildlife in England and Wales. It placed emphasis on

management rather than just conservation of SSSIs. It encouraged partnerships to help deliver positive management on SSSIs, but where appropriate management could not be secured through agreement, the CRoW Act made it possible to impose management. This made it possible to tackle sites that were deteriorating through neglect, as well as those suffering from deliberate damage. The Act also required that all public bodies should conserve and enhance SSSIs, meaning that government departments, local planning authorities and privatised utilities had to consider how their functions may affect SSSIs, and plan their work accordingly.

The CRoW Act also made it an offence for anyone to knowingly or recklessly damage an SSSI, providing significantly more power in dealing with damage on SSSIs resulting from third-party activities, such as irresponsible fossil or mineral collecting.

2001: *The UKRIGS Development Strategy*

This document set out, for the first time, an independent vision and series of objectives aimed at supporting the RIGS movement.

2001: The Dorset and East Devon Coast World Heritage Site

In 2001, the first World Heritage Site in England to be inscribed on account of its geology came into being, with the inscription of the Dorset and East Devon Coast. This provided geological conservation in Great Britain with an increased profile and an international stage on which to develop and share good practice. Of particular importance were the opportunities to promote geology, geological conservation and geotourism to a wide audience. For further details see Chapter 5.

2002: Local Geodiversity Action Plans

By 2002, it was increasingly accepted that effective geological conservation required a planned, holistic and participative approach and that a site-based approach alone was not enough. Thus, building on the approach taken to the conservation of biodiversity, the concept of geodiversity action planning was initiated. This included both Local Geodiversity Action Plans (LGAPs), produced for a particular geographical area, and Company Geodiversity Action Plans (CGAPs), produced for the holdings of a business such as a minerals extraction company. These plans integrate objectives for national and local conservation designations with those for other geological features of interest and are developed and delivered in partnership. For further information see Chapter 5.

2002: The Aggregates Levy Sustainability Fund

The Aggregates Levy Sustainability Fund (ALSF) provided, for the first time, a very significant source of funding for geological and geological conservation projects.

The ALSF arose from the Aggregates Levy, a tax on the commercial exploitation of aggregate, introduced in Great Britain in April 2002. The Aggregates Levy was intended to bring about environmental benefits by making the price of aggregates better reflect the cost of the impacts of aggregate extraction on the environment, and by encouraging the use of recycled materials. The importance of the Aggregates Levy for geology and geological conservation is that approximately 10 per cent of the money raised is allocated to the ALSF, part of which is used to fund projects delivering geological conservation or interpretation in any area affected by aggregate extraction. Eligible activities have included site management, interpretation, access provision, promotion and specimen rescue. The ALSF has also been a major funder of the geological audit aspect of LGAPs. The ALSF has made a major contribution to geological conservation, education and awareness raising, through channelling significant sums of money into these areas of activity, and has been of immense importance in supporting the work of the RIGS movement. For further details see the Clee Hill Quarries case study, Chapter 4.

2003: Geology Trusts

The growth and increasing diversity of the RIGS movement led to some RIGS groups forming partnerships to co-ordinate their work. One such group, The Geology Trusts, was launched in 2003 and has been successful in securing resources and delivering projects.

2003: European Geoparks

Throughout the 1990s, levels of geological conservation activity at a European and international scale continued to grow with the European Association for the Conservation of the Geological Heritage (ProGEO) providing a focus for activity. In 2003, one European initiative, European Geoparks, made an impact in England with the declaration of European Geoparks for the Abberley and Malvern Hills and the North Pennines Area of Outstanding Natural Beauty. These European Geoparks introduced a new conservation label and approach to geological conservation in Great Britain and are demonstrating how to deliver geological conservation on a wider scale. For more information see Chapter 5.

2005: *Planning Policy Statement 9: Biodiversity and Geological Conservation (PPS9)*

The publication of this planning policy statement represented a major step forward in terms of achieving greater recognition for geological conservation in the planning system in England. This policy statement, which replaced PPG9 (1994), gave geological conservation a higher profile by including it in its title, and through making more specific reference to it throughout the policies. In particular, it made a number of important statements about the need for the planning system to deliver geological conservation across the whole landscape, not just on protected sites.

2006: The creation of *Natural England*

The creation of *Natural England*, through the merger of English Nature with parts of the Countryside Agency and the Rural Development Service, points the way forward for conservation of the natural environment in England. It reflects a recognition that the natural environment is best managed in an integrated, holistic way. *Natural England* brings together geology, geomorphology, soils, habitats, landscape and public access and recreation, creating an organisation where geological conservation can be delivered as part of the management of the whole natural environment.

Claverley Road Cutting SSSI, Shropshire.
Peter Wakely/English Nature

Annex B: A revised Earth Science Conservation Classification

The Earth Science Conservation Classification (ESCC) was originally devised as a conceptual classification for geological sites by the Nature Conservancy Council (NCC). The ESCC was first published in the NCC Earth science strategy document (Nature Conservancy Council 1990a), which describes the rationale behind the classification in detail. Since then, the ESCC has been used extensively by all of the UK statutory conservation agencies as a primary tool in the conservation and management of geological sites.

The ESCC uses site type as the basic unit of classification (Table B1). The classification allows generic threats and conservation strategies to be defined for the different site types. For example, most disused quarries have similar generic conservation issues associated with them, which are very different from the generic issues on most coastal sites. The ESCC forms the basic classification for monitoring and condition reporting on geological sites, paralleling the BAP Broad Habitat Type for biological conservation.

The ESCC was used in its original form for 14 years from 1990 to 2004 without any formal modification. Although the original classification is fundamentally sound in principle, practical implementation over a number of years has helped identify some areas for improvement. The classification has recently been revised and agreed by all of the UK statutory conservation agencies. Table B1 shows the original and revised classifications.

The revised ESCC has 16 different site types in three main categories: exposure or extensive (E), integrity (I) and finite (F) in contrast to the original classification, which had 11 site types in two main categories.
The distinctions between the three main categories are important, reflecting fundamental differences in conservation strategies.

Table B1: The original and revised ESCC categories shown together for comparison.

Original classification		Revised classification	
Exposure sites		**Exposure or extensive sites**	
Active quarries and pits	EA	Active quarries and pits	EA
Disused quarries, pits and cuttings	ED	Disused quarries and pits	ED
Coastal and river cliffs	EC	Coastal cliffs and foreshore	EC
Foreshore exposures	EF	River and stream sections	EW
Inland outcrops and stream sections	EO	Inland outcrops	EO
Mines and tunnels	EM	Exposure underground mines and tunnels	EU
		Extensive buried interest	EB
		Road, rail and canal cuttings	ER
Integrity sites		**Integrity sites**	
Static (fossil) geomorphological sites	IS	Static (fossil) geomorphological	IS
Active process geomorphological sites	IA	Active process geomorphological	IA
Caves and karst	IC	Caves	IC
		Karst	IK
		Finite sites	
Unique mineral, fossil or other geological site	IM	Finite mineral, fossil or other geological	FM
Mine dumps	ID	Mine dumps	FD
		Finite underground mines and tunnels	FU
		Finite buried interest	FB

Exposure or extensive (E) sites contain geological features which are relatively extensive beneath the surface. The basic principle is that removal of material does not cause depletion or damage to the resource, as new material of the same type is being freshly exposed as material is removed. The main management aim is to achieve and maintain an acceptable level of exposure of the interest features. Site types include active quarries and mines, disused quarries, rail and road cuttings, coastal cliffs and foreshore, inland outcrops and extensive buried interest sites.

Integrity (I) sites are geomorphological and are characterised by the need for holistic management. Damage to one part of a site may adversely affect the site as a whole. In the case of active process sites, the fundamental principle is to maintain the active processes by non-interference as far as possible. Site types include active and static geomorphological sites, caves and karst.

Holme Fen, Cambridgeshire, is an extensive buried interest site, where the underlying sediments contain an important Holocene environmental and climatic record. Mick Murphy/English Nature

Doulting Railway Cutting SSSI, Somerset.
Mick Murphy/English Nature

Finite (F) sites contain geological features that are limited in extent so that removal of material may cause depletion of the resource. The features are often irreplaceable if destroyed. The basic management principle is to permit responsible scientific usage of the resource while conserving it in the long term. Hence, it is often necessary to implement controls over removal of material. Site types include many mineral and some fossil deposits, mine dumps, finite underground mines and finite buried interest sites.

One of the main changes in the classification is the introduction of the finite category. Sites in this category would have been classified as integrity under the original classification. The new main category was introduced to distinguish between geomorphological sites, where holistic management is required, and sites where the resource is limited in extent (finite) and where specimen collecting is often a serious problem. Although there are some overlaps as in caves, for example, where collecting may sometimes be a problem, introducing this distinction facilitates the process of describing generic threats and management strategies for these different site types.

An important change has been the introduction of extensive buried and finite buried categories. The absence of a buried category in the original classification was a serious omission, as there are large numbers of these sites. For example, in England there are more than 100 buried interest geological SSSIs out of a total of about 1,240. The need to define both EB and FB categories caused a minor dilemma in terminology as the concept of a buried exposure site is meaningless by definition. This led to the introduction of the term ‘extensive’ into the general classification.

There have been several changes within the E group of sites. Cuttings have been split from disused quarries (ED) and given a separate new category (ER). Coastal cliffs and foreshore have been merged into a single category. River cliffs have been removed from the original EC category, stream sections have been removed from the EO category and the two merged into a single new category (EW). In addition the EM category has now been relabelled EU to reflect its direct correspondence with the FU category.

One change in the integrity group is the splitting of caves and karst into separate groups. Another change has been the redefinition of the original IM and ID site types as FM and FD.

Another important change is the introduction of the finite underground (FU) category which has a direct counterpart in the exposure underground (EU) category. Most underground mines in Britain are disused and fall into the former rather than the latter category. In general, once a mine ceases to operate, the resource becomes effectively finite as there is usually little likelihood of exposing fresh material underground without blasting.

Limestone pavement in the Burren, County Clare, Ireland. Mick Murphy/English Nature

Annex C: English Nature's approach to monitoring geological sites

Why monitor geological sites?

Site monitoring is a fundamental part of the long-term conservation of geological sites for a number of reasons. Firstly, it is necessary to regularly check on sites to ensure that damaging activities are not occurring and that natural degradation is not preventing the site from being used for the reasons for which it is being conserved. Secondly, monitoring is an essential part of the process of positive management of geological sites, as it helps to identify what management action may be needed. Thirdly, the statutory conservation agencies are required to report to Government on the condition of all SSSIs. A monitoring cycle has been agreed with Government whereby all SSSIs must be monitored at least once every six years, although many sites require more frequent monitoring. The monitoring frequency depends primarily on the sensitivity of the site to damage.

Regular monitoring allows threats to the interest of the site to be detected or foreseen, so that appropriate measures can be taken. Site monitoring in turn informs site management so that appropriate solutions to site-specific problems can be devised when setting objectives for site conservation and drawing up site management plans.

Site condition reporting is performed within the statutory agencies using electronic databases. On a basic level, a condition assessment is entered under one of six fixed categories: favourable, unfavourable recovering, unfavourable no change, unfavourable declining, part destroyed and destroyed. This classification of site condition is used primarily for statistical purposes in reporting on groups of sites under various categories or on the SSSI coverage as a whole. There is also a facility to enter more detailed information on site condition.

Practical site monitoring

The Earth Science Conservation Classification (ESCC), discussed in Chapter 2 and Annex B, is used as the primary classification for monitoring purposes by the statutory agencies in the UK. The varying types of human activity or natural degradation processes, that are likely to damage or inhibit usage of the scientific interest of a site, can be conveniently categorised according to ESCC site type (see Table 2.1, Chapter 2). Generic threats are defined for each site type and these lists are then used to create monitoring forms, termed generic favourable condition tables, for each of the site types. Examples of generic favourable condition tables for ED and FM sites, similar to those used by English Nature, are given in Tables C1 and C2.

The main threats to the conservation of geological exposures in disused quarries and pits (ED), as indicated on the form, are landfill, building developments, rubbish tipping, obscuring of exposure by vegetation or build-up of scree and flooding. In the case of SSSIs, the appropriate agency is required by law to be consulted during the planning stage of a building development or landfill application or if an owner is intending to

undertake an activity for which consent is required, such as dumping of rubbish. It is still, however, important to regularly monitor such sites to ensure that planning conditions are not being contravened, unconsented activities are not taking place and there is no damage by third parties, such as fly-tipping. It is also important to monitor natural degradation processes so that actions, such as scrub management and scree clearance, can be undertaken to positively manage the site for the geological interest.

Table C1: Example of a generic favourable condition table, as used by English Nature, for ED sites.

DISUSED QUARRIES AND PITS (ED)

Attribute	Target	Yes/no	Site visit comments
Exposure of features of interest	The features of interest are exposed or can practically be re-exposed if required		
Vegetation	Vegetation is not obscuring or damaging the features of interest		
Tipping or landfill	There is no unconsented tipping or landfill obscuring or damaging the features of interest		
Tree planting	There is no unconsented tree planting obscuring or damaging the features of interest		
Engineering works	There are no engineering works, including inappropriate restoration works, obscuring or damaging the features of interest		
Planning condition observation	Planning conditions and restoration agreements or plans are being observed on site		
Geological specimen collecting	There is no irresponsible or inappropriate specimen collecting		

Table C2: Example of a generic favourable condition table, as used by English Nature, for FM sites.

FINITE MINERAL, FOSSIL OR OTHER GEOLOGICAL SITE (FM)

Attribute	Target	Yes/no	Site visit comments
Exposure of features of interest	The features of interest are exposed or can practically be re-exposed if required		
Vegetation	Vegetation is not obscuring or damaging the features of interest		
Tipping or landfill	There is no unconsented tipping or landfill obscuring or damaging the features of interest		
Tree planting	There is no unconsented tree planting obscuring or damaging the features of interest		
Engineering works	There are no unconsented engineering works, including inappropriate restoration works, obscuring or damaging the features of interest		
Specimen collecting	There is no irresponsible or inappropriate specimen collecting		

Specimen collecting is generally not considered to be a damaging activity on most types of geological site, if carried out in a responsible manner. Responsible collecting on exposure sites usually does not result in damage to the interest, as removal of rock should reveal more material of the same type. In fact, on sites which are rapidly eroding or where active quarrying is taking place, material will be lost if not recovered. On these sites, responsible collecting is an essential part of site conservation and is often encouraged by the statutory agencies.

It is generally only on finite sites, such as mineral and fossil sites with a strictly finite resource, that over-collecting becomes a serious threat to conservation. In extreme cases, over-collecting can result in complete destruction of the resource. On many SSSIs with a sensitive or finite resource, there is a legal requirement on owner/occupiers and third parties to obtain consent from the appropriate statutory agency before collecting or allowing specimens to be collected. This applies to several FM and FD sites and to all cave sites (IC). In monitoring such sites, any evidence of unconsented specimen collecting may indicate that the site is being damaged, but this needs to be measured against the extent of the remaining resource and usually requires expert judgement.

It is important to note that site access for third parties (ie permission to enter a site for scientific and/or educational purposes) is not used by the statutory agencies as a criterion in determining site condition. While maintaining site access for scientific and, where appropriate, educational purposes is a desirable goal in site conservation, the fact that a landowner may refuse permission to third parties to enter a site does not automatically mean that the site is in unfavourable condition. Under the provisions of the Countryside and Rights of Way Act (2000), English Nature has power of entry to any SSSI in England for monitoring purposes and to enforce positive management of the site, if necessary. There is, however, no requirement by law on any landowner to permit access to third parties for scientific and/or educational purposes. Site access can be an important criterion for determining the condition of certain locally important sites that have been selected primarily for their educational value.

Monitoring procedure

The first step in monitoring a site is to choose the correct generic favourable condition table, according to its ESCC code. As noted above, some sites can have more than one ESCC code. If a site has been previously monitored and site-specific conservation objectives have been produced (see Chapter 2), these should be used in conjunction with the generic favourable condition table to assess site condition.

For statutory sites, the SSSI citation is used to determine what features are designated. More detailed descriptions of the interest features on SSSIs are available to statutory agency staff in site management documents. English Nature produced Site Management Briefs (SMBs) for all geological SSSIs in the early 1990s. Similar documents exist for

Dee Cliffs, Farndon, Cheshire.
Mick Murphy/English Nature

some locally important sites, such as some RIGS. The SMBs, and equivalent documents in the other agencies, are the primary reference source in undertaking site monitoring, providing a baseline against which changes in site condition can be measured.

The SMBs contain general descriptions of the scientific interest features, GCR and SSSI citations and maps, photographs of the site and, in many cases, annotated maps of the sites depicting the location of interest features and photographs. Potential threats to the interest features and other information relevant to site conservation are normally detailed. In addition, a program of production of site-specific conservation objectives has been underway in English Nature since 2002. These provide very specific information on what condition the interest features should be in for the site to be considered as favourable.

The second step in monitoring is to visit the site and to use the site management document to locate the special interest features. The distribution of interest features on geological sites is very variable. Some, such as certain mineral vein interests, may be very localised at one or two places within a site. Others, such as many types of stratigraphic interest, may be distributed across the entire site. Once the interest features have been located, they should be assessed using the appropriate generic favourable condition tables and, if they exist, the site-specific conservation objectives.

In addition to visual assessment, fixed-point photography should be used to record the condition of the interest features. It is generally sufficient to record the positions from which photographs have been taken on a map of the site. In this way, further site monitoring visits can reproduce similar results and a long-term photographic record of the site can eventually be produced.

It is normally necessary only to assess the general condition of the interest features. If a site is notified for a stratigraphic interest in a particular series of beds, for example, and the location of these beds is known from the site management document or conservation objectives, then it is sufficient to check that the beds are well enough exposed to demonstrate the stratigraphic interest. It should not be generally necessary for monitoring purposes to re-investigate the geology of the beds to check that they do actually demonstrate the features for which the site was selected. This should have been done as part of the site selection process.

In general, therefore, monitoring does not have to be performed by an expert in the particular branch of geology for which the site is notified, provided that high quality site management documents exist. There are, however, exceptions where monitoring may require more expert assessment. Active process sites (IA) are one example where this simple approach to monitoring may not be sufficient and expert assessment may be necessary. Mine dumps (FD) are another example where assessment of site condition by an expert mineralogist may be required, as a non-

River South Tyne and Tynebottom Mine SSSI, Cumbria, is an example of a site with active process, mine dump and underground mineral interests.
Mick Murphy/English Nature

expert is unlikely to be able to identify the minerals of interest and the overall condition of the resource.

For the purpose of basic condition assessment and statistical reporting, a site can be considered to be in favourable condition if it matches the general criteria of the favourable condition table. If any of the attributes of the site do not meet the criteria, the site may not be in favourable condition and a further assessment may be required. Because there is often a significant degree of subjectivity involved in using the generic tables, it is important to produce site-specific objectives against which future site condition can be measured.

The cliffs at Tintagel, Cornwall. Mick Murphy/English Nature

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Annex E: Finding out more about geological conservation

Organisation	Function	Website
Countryside Council for Wales	Government agency responsible for geological conservation in Wales	www.ccw.gov.uk
English Nature*	Government agency responsible for geological conservation in England	www.english-nature.org.uk
Scottish Natural Heritage	Government agency responsible for geological conservation in Scotland	www.snh.gov.uk
Environment and Heritage Service, Northern Ireland	Government department responsible for geological conservation in Northern Ireland	www.ehsni.gov.uk
Joint Nature Conservation Committee	Government agency responsible for the Geological Conservation Review (GCR) and for UK-wide geological conservation issues.	www.jncc.gov.uk
Countryside Agency*	Government Agency responsible for countryside issues including landscape protection	wwwcountryside.gov.uk
UKRIGS	Association of RIGS groups in the UK	www.ukrigs.org.uk
The Geology Trusts	A partnership of RIGS groups working as 'trusts'	Various websites, for example www.glosgeotrust.org.uk
GeoConservation Commission of the Geological Society of London	The GeoConservation Commission is a forum for geological conservation in the UK. The major organisations and groups interested in geological conservation are represented on the commission	www.geoconservation.com
ProGEO	European association for geological conservation	www.progeo.se
British Institute for Geological Conservation	An independent group of geoscientists committed to geological conservation	See ProGEO website
Geologists' Association	An organisation serving the interests of both amateur and professional geologists in the UK	www.geologist.demon.co.uk
Geological Society of London	UK national society for professional geoscientists, hosts the GeoConservation Commission	www.geolsoc.org.uk
Dorset and East Devon Coast World Heritage Site Team	Management of the Dorset and East Devon Coast World Heritage Site	www.jurassiccoast.com
UNESCO	Selection and inscription of World Heritage Sites	whc.unesco.org
European Geopark Network	Coordination of European Geoparks	www.europeangeoparks.org
Geological Curators Group	An organisation dedicated to improving the status of geology in museums and raising the standard of geological curation	www.hmag.gla.ac.uk/gcg
Natural History Museum	Promotion and curation of world class rock, fossil and mineral collections	www.nhm.ac.uk
British Geological Survey	National geological survey for Great Britain	www.bgs.ac.uk
Quaternary Research Association	Organisation for Quaternary research	www.qra.org.uk
British Geomorphological Research Group	Professional organisation for geomorphologists in Great Britain	www.bgrg.org
British Caving Association	Organisation for British caving	www.british-caving.org.uk
Palaeontological Society	Professional organisation for palaeontologists	www.palass.org
Rockwatch	Nationwide club for young geologists	www.rockwatch.org.uk

* From October 2006, the current roles of English Nature, the Landscape, Access and Recreation division of the Countryside Agency and the environment activities of the Rural Development Service will be brought together to form a new independent body – *Natural England.*

ENGLISH NATURE

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Mick Murphy/English Nature
Main: High Force, County Durham.
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