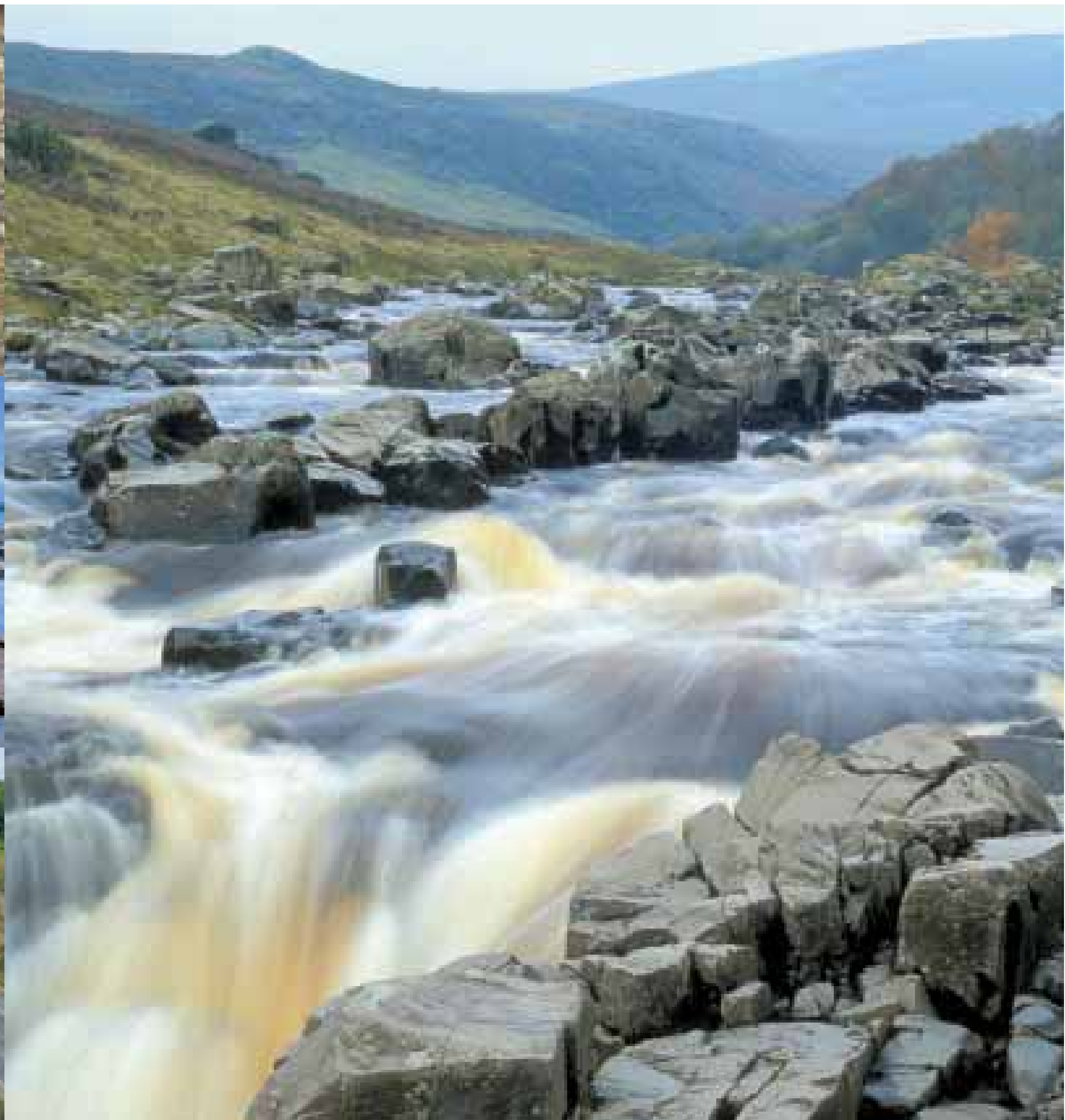
ENGLISH NATURE

Geological conservation

a guide to good practice



working towards *Natural England*
for people, places and nature

Roche Rock, Cornwall.
Mick Murphy/English Nature

Contents

Geological conservation: a guide to good practice

By: Colin Prosser, Michael Murphy and Jonathan Larwood

Drawn in part from work undertaken for English Nature by Capita Symonds (Jane Poole and David Flavin).

Trenching at Tideswell Dale, part of the Wye Valley SSSI, Derbyshire. Mick Murphy/English Nature

Foreword

Geology plays an essential role in all of our lives. Geology is of immense scientific importance, providing us with a means of studying and understanding the history of our planet and the evolution of life. It provides us with the foundations on which we have built our society and with many of the natural resources which support our day-to-day existence. It underpins the diversity of our natural environment and gives character to some of our most iconic landscapes. At its heart, geology is a field-based subject, and conservation and enhancement of the existing geological resource is vital for current and future scientific, educational and recreational use.

The subject of this *Guide to good practice* is geological and geomorphological conservation. For the purpose of brevity, however, the terms 'geology' or 'geological conservation' are used to include both geology and geomorphology, except where specific reference is being made to geomorphology or geomorphological conservation.

The *Guide to good practice* aims to capture and share the experience of English Nature and many of our partners involved in geological conservation. It is aimed at anyone involved or interested in the practice of geological conservation. It touches on most aspects of geological conservation but is focused on site-based conservation.

Geological conservation has traditionally had a lower profile than wildlife conservation, but continues to grow in both profile and number of people involved. This is partly due to an increased recognition of the importance of geology to society, science and education, and as a recreational and inspirational resource. It is also a reflection of the increasing threat of damage and destruction faced by the natural environment, including geological sites.

For those involved in geological conservation, the task of safeguarding and managing our most valued sites is a growing challenge. It is vital that we have effective conservation legislation and policies, but it is equally important that we share good practice in terms of practical techniques for safeguarding and managing our geological heritage. The support of decision makers and the general public for geological conservation is also essential, emphasising why more initiatives to promote and raise awareness of the importance and value of geology and geological sites are needed.

In 1990, the Nature Conservancy Council published *A handbook of earth science conservation techniques*. This handbook set out to demonstrate practical techniques for undertaking geological conservation, relying largely on theoretical guidance rather than actual case studies. Although the handbook, which has been extensively used by conservation practitioners in Great Britain and overseas, is still useful, changes in the political, policy and legislative context, along with learning gained from 15 years of site management experience, mean that it is now timely to publish new guidance to help support geological conservation on a practical level.

This new *Guide to good practice* builds on the 1990 handbook. It is based on a revised and updated Earth Science Conservation Classification scheme and draws on recent practical experience to present revised site conservation and management guidance. Key issues are illustrated through the use of real case studies, which illustrate principles, issues and solutions. The studies are drawn primarily from experience in England but demonstrate challenges and solutions that should be of relevance throughout the world.

Acknowledgements

We are greatly indebted to a large number of people who have contributed to the planning, writing and production of this guide to good practice. In particular, we thank Jane Poole and David Flavin of Capita Symonds, whose commissioned work for English Nature (Capita Symonds 2004) provided the basis for this *Guide to good practice*. Some people attended an initial workshop in December 2001, others contributed to the drafting of case studies or to checking text, and others have contributed through sharing their experience of geological conservation more generally. Our sincere thanks go to everyone who has contributed to this work, but in particular we would like to thank the following people for their contribution: Peter Austin (The Geologists' Association), Findlay Bennett, John Gordon, Debbie Green and Colin MacFadyen (Scottish Natural Heritage), Cynthia Burek (University of Chester), Mark Campbell (Gloucestershire Geoconservation Trust), Stewart Campbell (Countryside Council for Wales), Lawrence Crump (Hanson Aggregates), Richard Edmonds (Dorset County Council), Neil Ellis (Joint Nature Conservation Committee), Ian Enlander (Environment and Heritage Service, Northern Ireland), John Galloway (British Mountaineering Council), Patrick McKeever (Geological Survey of Northern Ireland), Murray Gray (Queen Mary and Westfield College, London), Malcolm Hart (University of Plymouth), John Pethick (University of Newcastle), Danielle Schreve (Royal Holloway, University of London), Mark Skelton, Alan Thompson and Jessica Ward (all Capita Symonds), Mick Stanley (Geodiversity consultant), Graham Worton (Dudley Metropolitan Borough Council), Natalie Bennett, Bob Corns, Bob Edgar, David Evans, Nicola Evans, Sue Evans, Rob Lloyd, Hannah Townley and Anna Wetherell (all English Nature).

The contents of this *Guide to good practice* represent the opinions of English Nature and any inaccuracies or mistakes are the responsibilities of the authors alone.

Colin Prosser, Michael Murphy and Jonathan Larwood
January 2006

Copper mineralisation, County Cork, Ireland.
Mick Murphy/English Nature

1 Why conserve geology?

1.1 What are geology and geomorphology?

In simple terms, geology is the study of the origin, history, structure and composition of the Earth, and, through the fossil record, the study of ancient life. Geomorphology is the study of the structure, origin and development of the surface features of the Earth and of the processes which act to shape it. Thus, geology and geomorphology together include the physical constituents of the Earth and also its surface, its landforms and the processes which operate to change it through time.

As discussed in the Foreword, for the purpose of brevity throughout this document, the terms 'geology' or 'geological conservation' are used generically to include both geology and geomorphology, except where specific reference is being made to geomorphology or geomorphological conservation.

1.2 Why is geology important?

Geology is of great scientific importance, providing us with a means of studying and understanding both the history of our planet and the evolution of life. Geology records billions of years of history, during which time the Earth formed and evolved. Rocks, fossils and minerals record how continents have drifted, how life has evolved, how climates and sea-levels have changed and how natural processes such as volcanism, mountain building and erosion have shaped and continue to shape the landscape.

The Giant's Causeway on the north coast of Northern Ireland was formed around 60 million years ago during a period of intense volcanism.
Mick Murphy/English Nature.

Peterborough Cathedral was built mainly from Jurassic limestone, quarried from nearby Barnack.
Mick Murphy/English Nature

The study of geology is not only important for its own sake but is also immensely important for several practical reasons. Firstly, geology underpins society's need for the natural resources and raw materials which support our day-to-day existence. Geological knowledge is fundamental to the successful exploration for natural resources such as oil, gas, water, stone for aggregate and building, and metal ores. Although not everyone realises it, society depends, and always has depended, on geology.

Secondly, geology and geomorphology play a fundamental role in shaping the landscape and influencing the location of the cities, towns and villages in which we live. The distribution of soil types and habitats, which determine land-use, are also strongly influenced by geology and geomorphology. The landscape around us is a product of a complex and dynamic relationship between the underlying geology, natural processes which shape the land, soil types and the nature and distribution of habitats (soils and ecosystems are closely related to the rocks from which they are derived), and the interaction of man with all of these elements. The role of man in shaping the landscape, through interacting with geology and natural processes has, for example, given rise to the dry stone walls, hill forts and vernacular buildings which have come to characterise many well-loved landscapes.

Aggregates are an essential ingredient in the making of roads, without which motor transport would not be possible. Mick Murphy/English Nature

The South Downs derive their distinctive character from the Cretaceous Chalk from which they are formed.
Mick Murphy/English Nature

Another very important practical application of geology is in trying to understand the dynamic nature of the environment, as evidence from the geological record demonstrates how our climate has changed, how sea-levels have risen and fallen, and how numerous species have appeared, evolved and become extinct. An understanding of these past environmental changes is of great practical value, enabling us to better understand and plan for current and future environmental change and associated hazards.

House made of dolerite in Fife, Scotland.
Colin MacFadyen/Scottish Natural Heritage

We can also learn by studying the dynamics of present day natural systems such as rivers and coastlines. This can help us to better predict and manage flooding events, coastal erosion and other potential environmental hazards. The study of recent sediments found in lakes and bogs provides a record of the environmental effects of human activities, such as vegetation changes (including forest clearance), soil erosion and pollution. These records enable us to assess and understand the effects of our activity on the environment in which we live.

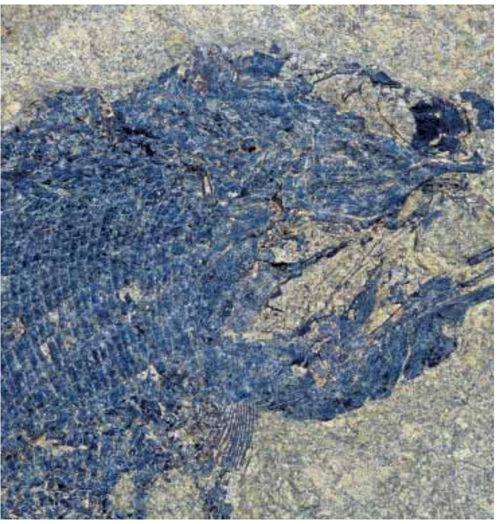
The Red Crag sandstones of Suffolk record fluctuations in sea-level which demonstrate that sea-level was significantly higher in the geologically recent past than today. Mick Murphy/English Nature

Land's End granite and sea arches.
Mick Murphy/English Nature

1.3 Why conserve geological features?

Geological features the world over provide a fascinating scientific and educational resource, recording millions of years of history in which continents have moved, climates have changed, sea-levels have risen and fallen, and animals such as dinosaurs and mammoths have appeared, evolved and eventually become extinct.

Permian fossil fish from County Durham.
Mick Murphy/English Nature



In Great Britain, our geology is diverse and visually impressive, representing all the major divisions of geological time, illustrating a wide range of rock types, structures, natural processes and landforms, and yielding an outstanding array of fossils and minerals. The geology of Great Britain has also been of great historical importance in the development of the science of geology. Geological features, exposed in coastal cliffs, disused and active quarries, road and railway cuttings and in upland streams and crags, have been studied for hundreds of years, have played a key role in the development of geological science and continue to be important in modern geological study. Great Britain was the birthplace of the science of geology and a great deal of pioneering work took place here. Consequently, numerous internationally recognised divisions of geological time have been named and defined from British strata and many geological sites are of international significance.

Geology is essentially a field-based subject and the existence of well-exposed geological features is critical for scientific study, educational use and recreational enjoyment. If advances in geological science and the educational and the recreational study and enjoyment of geology are to continue, important sites need to be conserved. Researchers need sites on which to undertake their research, and teachers and students need sites on which to demonstrate the principles of geology and the processes of landscape evolution. In order to locate and utilise the Earth's natural resources and to give advice on the management of natural hazards, trained Earth scientists are needed. This training requires access to high quality geological sites to provide field-based experience. Consequently, it is necessary to conserve our geological heritage so that it remains available for future scientific, educational and recreational use (Nature Conservancy Council 1990a, O'Halloran and others 1994, Wilson 1994, Gray 2003).

Student field trip to Purfleet Chalk Pits SSSI, Essex. There are few geological exposures in the London area because of the enormous development pressures in this densely populated region. Mick Murphy/English Nature

Rocks, landforms and natural processes are subject to a wide range of threats, which unless deflected or managed, will result in serious loss or damage to some of our most important geological sites. Within Great Britain, the biggest threats to geological sites are:

- Loss of geological exposure through burial under coastal protection schemes, landfill or other developments, such as housing.
- Loss of geological exposure as a consequence of vegetation encroachment.
- The removal of irreplaceable features such as caves, landforms or finite deposits of fossils or minerals through quarrying.
- Removal of fossil or mineral specimens through irresponsible collecting.
- Damage to geomorphological features or processes, for example, as a result of coastal protection or river management schemes.

Coastal defences at Porthleven, Cornwall, have concealed important geological features formed during the Variscan Orogeny. Mick Murphy/English Nature

The barrier beach system at Dungeness SSSI, Kent, has both active and static geomorphological components which are threatened by extraction and development.
Peter Wakely/English Nature

In understanding geological conservation, it is important to appreciate that the objective is to conserve rather than preserve. The distinction here is that conservation allows ongoing scientific and educational usage of the resource, whereas preservation implies that the resource is completely protected from any form of further depletion. Thus, the emphasis is placed on the management of a particular feature to retain a particular ‘quality’ by managing change, rather than on preservation of the feature with no change at all. However, in very rare cases when the geological features are extremely finite and limited in extent, some degree of preservation may be sought.

It is only through the existence of visible exposures in coastal cliffs and foreshore, inland outcrops, quarries, cuttings and river sections that we can actually see and study the geological record. A major threat in terms of geological conservation arises from proposals that could result in burial of geological exposures under coastal protection schemes, stabilisation works or landfill. This is especially likely where exposures are located on eroding coastal cliffs or in quarries.

Geomorphological features are even more vulnerable to damage than geological exposures because they usually need to be conserved in their entirety. Landforms were either created in the geological past (eg by the action of ice during glaciations) or are still being shaped by ongoing processes (eg rivers and coastlines). A geomorphological feature created by past processes, over long periods of time, is clearly vulnerable to damage, as it cannot be recreated or replaced if damaged or destroyed. A currently active geomorphological feature, which is still being created by ongoing geomorphological processes, is also very sensitive to interference, and can easily be damaged or destroyed if the processes on which it depends are interrupted or stopped.

For these reasons, the conservation of our geological heritage requires a substantial and rigorous effort, aimed at safeguarding, managing and raising awareness of the geological features that are threatened by the ever increasing influence of man’s activity. Failure to do this will result in geological sites being lost through burial or removal, or damaged through disruption of natural processes.

1.4 Who benefits from geological conservation?

Many organisations, public bodies, societies, industries, communities and individuals benefit from geological and geomorphological conservation. These include:

- Those involved in geological and geomorphological research, seeking to understand the Earth and the environmental change impacting on it.
- Geologists working in those industries seeking to find, utilise and manage our mineral and water resources, or manage the natural environment around us.
- Land owners, land managers, public utilities, planning authorities and others, who require some understanding of geology and geomorphology to better inform their decisions and actions.
- Ecologists and those involved in nature conservation more generally, who need some understanding of geology, to help, for example, in planning habitat re-creation projects.
- Universities and schools that need well-exposed sites on which to undertake fieldwork.
- Amateur geological societies and groups that enjoy geological fieldwork in their leisure time.
- The general public for recreational or educational purposes.
- Communities in geologically interesting, unusual or spectacular areas which benefit from tourism based on local geology and landscape.

Geology students at Bardon Quarry SSSI, Leicestershire.
Mick Murphy/English Nature

Bradgate Park, Leicestershire.
Mick Murphy/English Nature

2 Geological site conservation

2.1 Introduction

Geological site conservation can be considered as a three stage process:

- site audit and selection
- site designation through a statutory or non-statutory framework
- site safeguard, positive management and promotion.

There is a cyclic element to this entire process in that there is an ongoing need to ensure that the site coverage remains up-to-date both from a scientific perspective and also because some sites may lose their original value through damage or loss of interest features. The main focus of this *Guide to good practice* is on safeguard and management, but other aspects of the process are also considered briefly in this chapter.

2.2 Site audit and selection

The site audit and selection stage is fundamental to the whole process of geological site conservation. There should be a definite strategy underlying the audit and selection process in order to obtain a robust site coverage which is defensible against the challenges and threats faced by sites.

Pitch Coppice in Mortimer Forest SSSI, Herefordshire, is the international stratotype for the base of the Ludlow Series of Silurian age. Dave Evans/English Nature

The Geological Conservation Review (GCR) is an excellent example of an audit and selection process. The main phase of the GCR was undertaken in Great Britain between 1977 and 1990 to identify a large suite of sites suitable for designation as Sites of Special Scientific Interest (SSSIs). The purpose of the GCR was to systematically identify the key geological sites in Great Britain. The series as a whole reflects the great range and diversity of British geology. Responsibility for coordination and publication of the results of the GCR lies with the Joint Nature Conservation Committee (JNCC). The GCR process is described in detail by Ellis and others (1996).

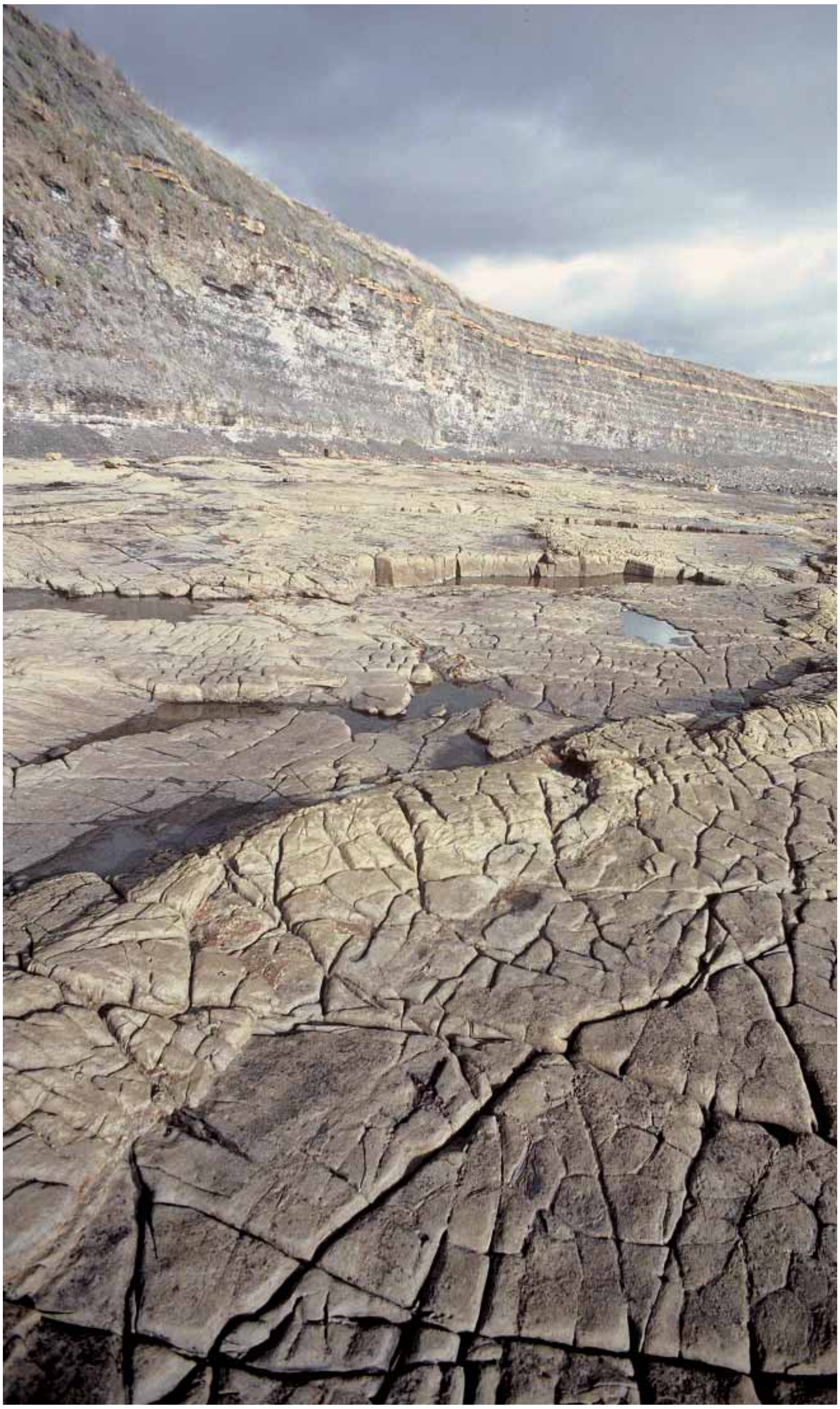
GCR sites were selected on the basis of their scientific value rather than their educational or historical importance. Three criteria were applied in selecting the GCR sites:

- sites of international geological importance
- sites that are scientifically important because they contain exceptional features
- sites that are nationally important because they are representative of a geological feature, event or process, which is fundamental to understanding Britain's geological history.

Chesil Beach, Dorset, is an exceptional geomorphological feature.
Colin Prosser/English Nature

Assessment and subsequent selection of sites was undertaken on the basis of a series of subject 'blocks' which are based on divisions of time, subject, regional divisions or combinations thereof. Examples of GCR blocks include Precambrian of England and Wales, Mineralogy of the Lake District, Cambrian, Aalenian-Bajocian, Marine Permian, Tertiary Mammalia, Quaternary of South-West England, Caves of Great Britain and Karst of Great Britain.

Sites were selected in consultation with academic experts in the various fields. Large numbers of sites were considered but, in general, only one site was selected as the best example of each aspect of geology under consideration. Once selected, a GCR site was then proposed as a potential SSSI for approval by the council of the relevant statutory conservation agency (see Section 2.3). In England, it is only when a site is approved as an SSSI by English Nature's Council that it receives full legislative protection.



The exposures at Kimmeridge Bay, Dorset, have been selected to represent the Jurassic Kimmeridge Clay Formation. Richard Cottle

While the main phase of the GCR process formally ended in 1990, there is, in practice, a need to regularly review the site coverage for a number of reasons. Firstly, if interest features on a site become damaged or destroyed, there may be a need to find a replacement site. Secondly, new sites may be discovered which were not known at the time of the original audit and these may be superior to existing sites. Thirdly, geology is a dynamic science and new scientific understanding may require modification of the original site coverage.

In Great Britain, site audits are also undertaken on a local or regional level and may subsequently result in sites being designated as RIGS (Regionally Important Geological and geomorphological Sites). There are a many areas where county level audits have been undertaken for selection of RIGS. Site audits are also an important part of the Geodiversity Action Plan (GAP) process (Chapter 5).

In contrast to GCR sites which were selected purely on their scientific importance, there is a wider range of criteria to be taken into consideration in selecting RIGS:

- value of site for educational purposes in life-long learning
- value of site for study by both professional and amateur Earth scientists
- historical value of the site in terms of important advances in Earth science knowledge, events or human exploitation
- the aesthetic value of the site in the landscape, particularly in relation to promoting public awareness and appreciation of Earth sciences
- access and safety.

The existence of a well-defined rationale behind site selection provides an important tool in conserving sites should they be subject to development or other pressures. For example, a site may not possess spectacular geology but it may represent a vital part of a network of sites, and the loss of the site may be detrimental to the network as a whole. This type of argument is frequently used in protecting geological SSSIs from development.

People of all ages enjoy fossil hunting at King's Dyke RIGS, near Peterborough. Colin Prosser/English Nature

2.3 Legislation and site designation

Proposals to protect the infrastructure at Black Rock, Brighton, from falling rock, threatened to obscure important geological features in the cliff.
Colin Whiteman/University of Brighton

In Great Britain, the primary statutory mechanism for protecting a nationally important geological site is designation as a Site of Special Scientific Interest (SSSI). The background legislation is outlined in Annex A.

It is only when a site is approved as an SSSI that it receives full legislative protection. Only sites selected by the GCR are designated as SSSIs. GCR sites have no formal legal protection before they are notified as SSSIs.

The SSSI designation provides a high degree of protection for sites although it does not guarantee their long-term conservation. In England, as part of the designation process, site owners and occupiers are informed of the geological importance of their land and provided with a generic list of operations likely to damage the interest features. If a site owner or occupier intends to undertake any of these activities, formal consent must be sought from English Nature. Failure to do so can result in the owner or occupier being required to rectify any damage at their own expense and can lead to prosecution. If English Nature refuses consent for an activity, the owner or occupier has the right to appeal to the Secretary of State for the Environment.

In England, English Nature is a statutory consultee on any planning proposal which may affect an SSSI. This allows English Nature to comment and, if necessary, object to development proposals which could adversely affect an SSSI. Early consultation, prior to submission of any plans, is preferable so that the developer has a clear idea of what may or may not be acceptable. This also provides an opportunity to work out acceptable compromise solutions at the pre-submission stage which is likely to be more cost effective than having to redraft plans at a later stage.

If English Nature objects to a planning application and no compromise or resolution can be achieved, a public inquiry may be called. This can be an expensive process for all parties involved and is only undertaken as a last resort. There have been some high profile public inquiries in recent years on coastal geological sites in East Sussex, which have had positive conservation outcomes (see the Birling Gap case study in Chapter 4).

Damage to SSSIs by third parties is also covered in the legislation. Prior to the Countryside and Rights of Way (CRoW) Act 2000, the legislation was weak in relation to third party damage, but there is now the power to prosecute third parties who cause damage to SSSIs. The new legislation provides for stiff penalties which can act as a strong deterrent. The main source of third party damage on geological SSSIs is specimen collecting, which can result in severe damage or total destruction of interest features on certain sites.

Irresponsible fossil collecting demonstrated by the use of a rock saw in attempting to remove ammonites from the foreshore at Monmouth Beach, Devon.
Jonathan Larwood/English Nature

Local or regional conservation designations for geology are generally called RIGS (Section 2.2). RIGS have no statutory protection, but many local planning authorities, on the advice of the local RIGS group, include RIGS within their local development plan. These plans usually have policies for the protection of RIGS and their importance is taken into account in making planning decisions.

2.4 Site safeguard and management

2.4.1 The Earth Science Conservation Classification (ESCC)

The Earth Science Conservation Classification (ESCC) is at the heart of geological conservation. The ESCC is used by all of the UK statutory conservation agencies as the basis of site safeguard and management work.

The ESCC was developed in order to rationalise the practical approach to conservation of the various types of geological site. It was first described in the Nature Conservancy Council's strategy document for geological conservation (Nature Conservancy Council 1990a).

A revised ESCC, introduced in 2004, forms the basis of this *Guide to good practice.* Annex B presents the reasoning behind the modifications. The rationale behind the original classification is discussed in detail in the 1990 strategy document (Nature Conservancy Council 1990a, 1990b) and in Wilson (1994). The principles of the revised classification are fundamentally the same as the original.

The ESCC uses site type as the basic unit of classification (Table 2.1). 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 quite distinct from the issues on most coastal sites.

In the revised ESCC, there are 16 site types divided into three major categories: exposure or extensive (E), integrity (I) and finite (F). The distinctions between the three main categories are important, reflecting fundamental differences in conservation strategies.

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 significant depletion of 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. The main threats are activities which result in long-term or permanent concealment of the geological interest features. These include landfill, building development and coastal protection. Vegetation management and removal of scree are important issues on many inland sites where erosion rates are too low to maintain fresh exposures.

Table 2.1 The Earth Science Conservation Classification

	Type of site	Site code
Exposure or extensive	Active quarries and pits	EA
	Disused quarries and pits	ED
	Coastal cliffs and foreshore	EC
	River and stream sections	EW
	Inland outcrops	EO
	Exposure underground mines and tunnels	EU
	Extensive buried interest	EB
	Road, rail and canal cuttings	ER
Integrity	Static (fossil) geomorphological	IS
	Active process geomorphological	IA
	Caves	IC
	Karst	IK
Finite	Finite mineral, fossil or other geological	FM
	Mine dumps	FD
	Finite underground mines and tunnels	FU
	Finite buried interest	FB

Integrity (I) sites are all geomorphological under the revised classification and are often more sensitive than exposure sites. Holistic management is the key to conservation of integrity sites. The recognition that damage to one part of a site may adversely affect the whole site is important. For some integrity sites, it is essential to recognise the potential impacts that activities outside of a site may have on the interest features. Building development, coastal protection and quarrying are among the most serious threats.

Ketley Claypit SSSI, West Midlands, is an active quarry and a typical example of an exposure (E) site where removal of material exposes new material of the same type. Colin Prosser/English Nature

Finite (F) sites contain geological features that are limited in extent so that removal of material may damage or destroy the resource. In some cases, the features may be unique and irreplaceable. 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. Irresponsible collecting of geological specimens is a serious threat on many sites. Other threats include building development, coastal protection, and quarrying.

Drumlin field at Clew Bay, County Mayo, Ireland, an example of a large integrity (I) site. Mick Murphy/English Nature

Table 2.2: Geological site types with associated potential threats and issues and conservation techniques. Column 5 lists relevant case studies (Chapter 4)

	Type of site	Site code	Main potential threats and issues	
Exposure or extensive sites	Active quarries and pits	EA	• Scientific access to geological features • Storage of quarry waste • Quarry floor development • Restoration	
	Disused quarries and pits	ED	• Landfill • Development • Vegetation encroachment • Tree planting • Instability and slumping of faces	
	Coastal cliffs and foreshore	EC	• Coastal protection • Development • Vegetation management • Dredging	
	River and stream sections	EW	• River management • Bank stabilisation • Vegetation encroachment • Development • Tree planting and afforestation	
	Inland outcrops	EO	• Vegetation encroachment • Tree planting and afforestation • Development • Inappropriate recreational activities	
	Exposure underground mines and tunnels	EU	• Scientific access to geological features • Depletion of resource • Resource becomes finite after mine closure • Flooding after mine closure • Collapse after mine closure	
	Extensive buried interest	EB	• Inappropriate agricultural practices • Tree planting and afforestation • Development • Quarrying • Inappropriate recreational activities	
	Road, rail and canal cuttings	ER	• Vegetation encroachment • Slumping of faces • Face stabilisation • Tree planting • Development • Road widening schemes • Re-grading of slopes	

Conservation techniques	Case studies
• Consultation with the quarry operator to promote best conservation practice and gain ongoing access for scientific study • Early and ongoing consultation with planners and quarry operators to consider and promote geological conservation during and after the working life of the quarry • Include conservation sections within the restoration plan	Barrington Chalk Pit (Cambridgeshire) Broadway Quarry (Worcestershire) Clee Hill Quarries (Shropshire) Clock House Brickworks (Surrey)
• Conservation voids or conservation sections above or adjacent to the landfilled area • Restrict development adjacent to and within quarry • Vegetation management • Avoid tree planting near geological features • Removal of rock debris and slumped material • Re-excavation in soft sediments	Asham Quarry (East Sussex) Clee Hill Quarries (Shropshire) Dryhill Quarry (Kent) Eartham Pit, Boxgrove (West Sussex) Lime Craig Quarry (Stirling, Scotland) Robin's Wood Hill (Gloucestershire) Teindland Quarry (Moray, Scotland) Webster's Claypit (West Midlands) Weybourne Town Pit (Norfolk) Wren's Nest (West Midlands)
• Maintain natural coastal processes • Avoid developments in front of or on cliffs or foreshore • Discourage development on eroding coasts that may require coastal protection • Vegetation management is usually only required where natural processes are inhibited • Use shoreline management plans for holistic coastal management	Chewton Bunny (Hampshire) Dimlington Cliff (Humberside) Hengistbury Head (Dorset) Lee-on-the-Solent (Hampshire)
• Maintain natural processes • Avoid installation of engineering structures • Discourage developments on cliff tops • Vegetation management • Avoid tree planting and afforestation near geological features	Betton Dingle (Shropshire) Browgill and Stockdale Becks (Cumbria) Doe Lea (Derbyshire) Onny River (Shropshire) Skelghyll Beck (Cumbria)
• Vegetation management • Avoid tree planting and afforestation near geological features • Developments such as roads, paths and buildings should be sited away from geological features • Promote good recreational practice	Burrington Combe (Somerset) Mam Tor (Derbyshire) Raw Head (Cheshire)
• Consultation with the mine operator to promote best conservation practice and gain ongoing access for scientific study • Providing there are sufficient reserves of material, mining activities are generally beneficial for conservation • Develop sustainable pumping methods once mining has ceased • Develop stabilisation solutions after mine closure	Florence Mine (Cumbria)
• Promote appropriate agricultural practice • Avoid tree planting and afforestation near buried geological features • Restrict development close to buried geological features • Restrict removal of the buried geological features • Promote good recreational practice	Little Oakley Channel Deposit (Essex)
• Removal of rock debris and slumped material • Avoid engineering solutions such as concreting or meshing which conceal or prevent access to interest features • Vegetation management • Avoid tree planting near geological features • Built developments should be sited away from geological features • Include conservation sections within the final design on new road sections	Brewin's Canal (West Midlands) Farley Dingle (Shropshire)

Table 2.2: Continued

	Type of site	Site code	Main potential threats and issues	
Integrity sites	Static (fossil) geomorphological	IS	• Coastal protection • Development • Quarrying and dredging • Infilling of natural depressions • Vegetation encroachment • Tree planting and afforestation • Inappropriate recreational activities • Irresponsible specimen collecting	
	Active process geomorphological	IA	• Coastal protection • River and land management schemes • Development • Quarrying and dredging • Tree planting and afforestation • Inappropriate recreational activities	
	Caves	IC	• Quarrying • Inappropriate agricultural practices • Changes in the water environment • Development • Irresponsible recreational activities • Irresponsible specimen collecting	
	Karst	IK	• Quarrying • Inappropriate removal of rock • Infilling of natural depressions • Vegetation encroachment • Development	
Finite sites	Finite mineral, fossil or other geological	FM	• Irresponsible specimen collecting • Quarrying and mining • Development • Vegetation encroachment • Tree planting and afforestation	
	Mine dumps	FD	• Irresponsible specimen collecting • Large-scale removal of spoil • Re-profiling and levelling • Reworking of spoil • Development • Vegetation encroachment • Tree planting and afforestation	
	Finite underground mines and tunnels	FU	• Flooding • Collapse of mine passages • Stabilisation by infilling of mines • Irresponsible specimen collecting • Fly-tipping	
	Finite buried interest	FB	• Inappropriate agricultural practices • Tree planting • Development • Quarrying • Removal of material • Irresponsible specimen collecting • Inappropriate recreational activities	

Conservation techniques	Case studies
• Maintain natural processes • Restrict quarrying and dredging • Restrict development • Avoid dumping and infilling of natural depressions • Vegetation management • Avoid tree planting and afforestation • Promote good recreational practice • Promote good collecting practice	Ainsdale Sand Dunes (Merseyside) Birling Gap (East Sussex) Blakeney Esker (Norfolk) Rusthall Common (Kent)
• Maintain natural processes • Use holistic management strategies such as shoreline management plans • Avoid tree planting and afforestation on or near active process sites • Restrict development on or near active process sites • Avoid quarrying and dredging on or near active process sites • Promote good recreational practice	Ainsdale Sand Dunes (Merseyside) Birling Gap (East Sussex) River Feshie (The Cairngorms, Scotland) Wootton Bassett (Wiltshire)
• Avoid quarrying of cave systems • Promote good agricultural practice to restrict pollution • Avoid activities such as dumping of effluent which can affect groundwater quality • Restrict activities that affect the water table within the catchment of cave systems • Promote good caving practice through caving clubs • Control access through responsible caving clubs • Promote good collecting practice	Bagshaw Cavern (Derbyshire)
• Avoid quarrying of important karst features • Avoid removal of limestone pavement (usage of Limestone Pavement Orders) • Avoid dumping and infilling of natural depressions • Vegetation management • Avoid development on important karst features	Cheddar Gorge (Somerset)
• Promote good collecting practice • Avoid quarrying or mining of finite interest features • Avoid development near finite interest features • Vegetation management	Birk Knowes (Lanarkshire, Scotland) Globe Pit (Essex) Hope’s Nose (Devon) Purfleet Chalk Pits (Essex) Skiddaw (Cumbria)
• Promote good collecting practice • Restrict access where appropriate • Rescue collecting and removal of material to a safe area if dump threatened • Vegetation management • Avoid tree planting and afforestation near mine dumps	Clock House Brickworks (Surrey) Skiddaw (Cumbria) Writhlington (Somerset)
• Development of sustainable engineering solutions • Restrict access where appropriate • Promote good collecting practice	Alderley Edge (Cheshire) Seven Sisters Mine (West Midlands) Skiddaw (Cumbria)
• Promote appropriate agricultural practice • Avoid tree planting and afforestation near buried geological features • Avoid development near buried geological features • Avoid removal of the buried geological features by quarrying • Promote good collecting practice • Promote good recreational practice	Purfleet Chalk Pits (Essex) Wadsley Fossil Forest (Sheffield)

Mineral veins in granite at Cligga Head SSSI, Cornwall, represent a finite (F) resource. This site is also designated for the granite itself, which has an exposure (E) classification. Mick Murphy/English Nature

Sites may fall into more than one ESCC category. For example, a disused quarry with an exposure stratigraphic interest would be classified as ED (Table 2.1), but localised mineral veins within the same site would have an FM classification.

The main potential threats and issues and associated safeguard and management techniques for each site type are listed in Table 2.2. These are discussed in more detail in Chapter 3. Relevant case studies, presented in Chapter 4, are also listed in Table 2.2. These have been selected to illustrate the range of threats and management issues associated with each site type.

2.4.2 Site safeguard and threat deflection

The main threats and issues on geological sites are:

- development, including coastal protection and general construction
- restoration, landfill and backfill of quarries
- quarrying in some circumstances
- afforestation and tree planting
- vegetation encroachment and face instability
- irresponsible specimen collecting
- inappropriate recreational activities.

The focus of this section is on the first four items in the list on page 26. The next section (Section 2.4.3) considers the last three list items under positive management. The first four items are dealt with mainly through the planning system and the statutory requirement on site owners or occupiers not to undertake any damaging activities. Essentially the emphasis is on prevention of damaging activities through the use of planning and conservation legislation.

Coastal protection is one of the most serious threats to geological sites in England. Coastal geological sites form a very important part of England's geological resource and large sections of coastline are designated as SSSIs. Any development which conceals rock exposures can result in the effective loss of the geological interest. In addition, any development which prevents or slows natural erosion can have a damaging effect, as erosion is necessary to maintain fresh geological exposures. Reducing the rate of erosion usually results in rock exposures becoming obscured by vegetation and rock debris.

Coastal protection on the Palaeogene Highcliffe to Milford Cliffs SSSI in Hampshire.
Mick Murphy/English Nature

Furthermore, coastal processes are complex and no section of coastline exists in isolation. This means that coastal protection in one area may have indirect effects on other parts of the coast. For example, cliff protection in one area may starve other beaches of sediment, accelerating cliff retreat in these areas. Therefore, developments do not necessarily have to take place within the boundary of a site to cause damage and it is important to take a broad view in judging the likely impacts of coastal protection.

Landfill, driven by the demand for waste disposal sites, is a serious threat to the conservation of geological features in many quarries. Landfill, inappropriate restoration and backfill can effectively destroy the scientific value of a site by permanently concealing the features of interest.

Quarrying is generally a positive activity from a geological conservation perspective. Quarries often provide the only rock exposures in some areas, particularly in lowland Britain, and they typically provide much better exposure of geological features than comparable natural exposures. Quarrying, however, can be a serious threat to integrity or finite sites (Table 2.2), where the interest features need to be conserved in a holistic way and/or they are of finite extent.

Landfill at Kirkham's Silica Sandpit SSSI, Derbyshire. Despite the unsightly appearance of the site, the small gap between the landfill and the conservation face is sufficient to enable access to the geological features. Mick Murphy/English Nature

Clawthorpe Fell, Cumbria, where quarrying of limestone pavement has taken place in the past.
Peter Wakely/English Nature

Afforestation can be a serious threat to geological and, in particular, geomorphological features, although it is not currently a major issue in England. Tree planting on SSSIs usually requires the landowner to seek formal consent from the statutory nature conservation body.

All of the above threats are dealt with through the planning system. Early consultation is important in ensuring that planning submissions and decisions take full account of geological conservation.

2.4.3 Site management

Geological site management can include some or all of the following processes:

- production of site management plans and measurable conservation objectives
- regular monitoring of the condition of the interest features
- physical maintenance of features
- proactive threat deflection
- production of interpretative materials.

Deformed rocks on Anglesey, Wales.
Mick Murphy/English Nature

2.4.3.1 Site management plans and conservation objectives

Site management plans are important as they can clearly define what actions are required to manage and maintain geological sites. Site management plans should be specific, identifying particular interest features and measurable objectives for the features. They should clearly define how and when objectives are to be met and who is responsible for meeting these objectives. Detailed conservation objectives provide simple frameworks for condition assessment.

The following should be considered within the development of a site management plan:

- detailed description of the important geological interest features
- detailed map of the site showing the location of the interest features
- photographs of the site and interest features
- consultation with site owner and other stakeholders
- potential threats and management issues, including risk assessments
- other conservation interests, such as biological or archaeological features
- measurable conservation objectives for each interest feature
- responsibilities for achieving and maintaining the conservation objectives
- details of how the site is used and its potential for education
- details of management processes, including timescales for initial remedial works and frequency of subsequent maintenance works
- frequency of monitoring required
- the resources needed to deliver the management plan
- periodic review of management plan.

In English Nature, site-specific conservation objectives are produced by tailoring generic favourable condition tables (Annex C) to individual sites. The generic tables are based on the ESCC (Section 2.4.1) and can be easily modified into site-specific documents. It is important to set feasible objectives, weighing up the ideal against the practically realisable. For example, in a disused quarry, dense vegetation may be concealing the features of interest. While the ideal from a geological perspective may be to maintain total exposure along the entire site, the cost of clearing and maintaining the whole face permanently free of scrub may be prohibitive and a more realistic objective could be to maintain a small section or sections of face. This approach may be sufficient to maintain the site in an acceptable condition.

The cliff sections at Pegwell Bay, Kent, became very overgrown after construction of the now disused hoverport, which prevented normal marine erosion from maintaining clear faces.
Mick Murphy/English Nature

The production of conservation objectives has the potential to remove much of the subjectivity associated with geological site condition assessment. For example, if measurable targets have been set for the length of section that needs to be maintained free of scrub for a site to be in favourable condition, it is a relatively straightforward process to check if these targets are being met.

Site management plans should ideally include objectives for any other conservation interests on the site, such as wildlife and archaeology. It is important to take a holistic view and integrate the requirements of all of the interest features.

On sites where there is public access, the management of visitors and associated health and safety requirements should be incorporated into the management plan. A visitor management strategy may also help to avoid damage to the geological interest. Where appropriate, a strategy for managing specimen collecting should be part of the management plan.

A short section of face at Pegwell Bay has been cleared to expose the Palaeogene Thanet Sands, which form one of the designated interest features. Other features are exposed elsewhere on the site.
Mick Murphy/English Nature

2.4.3.2 Site monitoring

Site monitoring is a vital part of the process of geological site conservation as it is essential to regularly check that the interest features are not degrading and that there are no damaging activities occurring. Regular monitoring is necessary to determine whether conservation objectives are being met and to identify what management actions may be required.

Annex C details the methodology used by English Nature for monitoring geological sites. As with production of conservation objectives, the ESCC (Section 2.4.1) is used as the basis for identifying generic threats and issues associated with each site type. Generic forms can be devised for the different site types. As long as the geology has already been documented in the conservation objectives or a site management plan, it is often a straightforward exercise to check on the condition of a geological site.

Photographic monitoring is strongly recommended for keeping track of changes to sites over time. Photographs taken at regular intervals from a fixed point provide a visual record of changes, which is much more useful than a written record in demonstrating actual changes in vegetation, scree cover or site use. With the advent of high quality, low cost digital cameras, photographic records can be readily stored in electronic form. Digital images are most effectively stored as part of searchable electronic databases, together with other relevant site information. It is important that the fixed point is clearly described and identified so that the process can be repeated at regular intervals. The use of a low cost global positioning system (GPS) can greatly facilitate this process. It is also important to take photographs at a similar time of year and day so that vegetation and light conditions are comparable.

2.4.3.3 Physical maintenance of sites

Ensuring that the features of interest are in good condition and can be readily studied and enjoyed by site users is an important part of geological site management. Site maintenance can include vegetation control, scree clearance, face scaling, re-excavation, rubbish removal, fencing and access management.

Inland sites, particularly in lowland areas, generally require the most maintenance, as erosion rates are low and faces tend to become obscured by vegetation and sometimes by scree from the face itself. Upland sites often require less maintenance because of slower vegetation growth. Coastal sites are often self-maintaining as long as natural erosion processes are allowed to continue without human interference.

Richmond Farm Pit SSSI, Suffolk, before vegetation clearance. Mick Murphy/English Nature

Richmond Farm Pit SSSI, Suffolk, after vegetation clearance. Mick Murphy/English Nature

It may often be financially impractical to maintain full exposure on inland sites, particularly those which have already become very overgrown. Depending on the site and the type of geology, it may be possible to select particular areas of a site to be maintained clear of vegetation and scree. For example, if the geology is laterally uniform, it may be sufficient to keep a single section of face clear. If the geology is laterally variable, it may be necessary to maintain several sections to demonstrate the range of features. Vegetation management can be undertaken with machinery, by hand or by the use of grazing animals.

A terrace was created using an excavator at Tilton Cutting SSSI, Leicestershire, to facilitate access to higher levels of the face and to inhibit rapid collapse of the upper parts of the face. Mick Murphy/English Nature

Face collapse is especially problematic on soft-sediment sites. Regular scraping of faces may be required to maintain exposures but this may not be feasible on many sites where continued scraping of faces can cause depletion or eventual removal of the resource. On such sites it may be necessary to accept that permanent exposure cannot be maintained. Temporary exposures need to be created on these sites for study purposes. In some cases, it may be necessary to artificially stabilise faces by grading.

Fly-tipping at Gipsy Lane Pit SSSI, Leicester.
Hannah Townley/English Nature

Fencing may be required on some sites as a safety measure to prevent close access to unstable faces or to keep visitors away from the tops of high faces. Fencing may also be necessary to enclose grazing animals which are being used for vegetation control. Installation of secure fencing and gates may be required on sites which are prone to fly-tipping, where the resource is threatened by collecting or where the site is dangerous. Access management can include fencing as well as the construction and maintenance of pathways for site users so that they can readily access the interest features.

English Nature's Face Lift Programme funds works on SSSIs throughout England. Face Lift was initiated in 1999 and, at the time of writing, is now in its seventh year. Since its inception, more than 250 projects have been undertaken to enhance geological SSSIs. The majority of these works involve vegetation control in disused quarries and cuttings in lowland areas.

2.4.3.4 Management aimed at threat deflection

Specimen collecting and recreational damage, inadvertent or otherwise, can be a serious problem on some sites. While legislation provides protection against third-party activities, it is generally more effective to prevent damage before legislative measures are required.

As long as specimen collecting is undertaken in a responsible and sustainable manner, it should not present a serious conservation problem. It is important, however, that management of collecting reflects the available resource and associated collecting pressure. In particular, where the resource is finite, careful management of collecting is required. A range of site-based mechanisms can be used to manage collecting, including signage, fencing, managed access and permit systems, and, in extreme circumstances, the burial or removal of a resource to a safer locality.

During the construction of the Charmouth Bypass, a fossil recording scheme ensured that important fossils were not lost and were recovered for scientific study and deposition in local and national museums.
Kevin Page

One of the most effective methods of preventing irresponsible collecting is to educate people about the value of and need to conserve the geological resource. This will often lead to collectors developing a sense of responsibility towards the resource from which they collect. This involves devising good practice collecting policies in collaboration with collecting groups and societies, who can then communicate agreed policies with their members (Bassett and others 2001, Townley 2003). English Nature has worked with various collecting groups and landowners to develop mutually acceptable collecting policies. This involves promoting the concept of responsible collecting and recognising the important role that fossil and mineral collectors can play in advancing the sciences of palaeontology and mineralogy. Peer pressure to conform to acceptable good practice collecting policies can often be much more effective than attempting to apply more draconian policies which may be practically unenforceable.

Recreational activities, such as caving, rock climbing, mountain biking and off-road driving, can sometimes cause inadvertent or incidental damage to sensitive geological features. For example, irresponsible caving can result in damage to important underground features and rock climbing can cause damage where important geological features are located on the rock surface. As with specimen collecting, the most effective means of preventing damage through caving and rock climbing is to educate the practitioners, by working with caving and climbing groups to develop codes of good practice.

English Nature has worked with caving groups, both national and local, for several years in developing and promoting codes of good practice for caving. Many local caving groups are now taking direct responsibility for managing caves and implementing cave conservation plans in their areas. This can be highly effective in controlling access and visitor numbers, as well as in dissemination of good practice. The direct involvement of caving groups and sense of value that this develops helps to ensure long-term conservation of the caves and their features.

2.4.3.5 Site interpretation

Site interpretation is an important means of promoting and raising awareness of geology and geological conservation (Larwood & Durham 2005). Public support is important in influencing decision makers. The public tends to support only what it values and better understanding helps to establish value. Site interpretation is a powerful tool in helping to provide this understanding.

Site interpretation can be undertaken on a range of scales from single interest features to whole regions. It is essential to have a clear concept of the target audience before embarking on an interpretation project, as this will determine the level at which the interpretation is aimed.

Interpretation methods typically include interpretation boards, leaflets, booklets, electronic resources and guided tours. Interpretive material must be scientifically accurate but comprehensible by the target audience.

Interpretation board at Hunstanton Cliffs SSSI, Norfolk.
Mick Murphy/English Nature

Interpretation boards should be simple and concise, with minimal wording and a strong graphic element. Most people, geologists included, will spend very little time reading and attempting to understand a detailed scientific description on an interpretation board. For maximum benefit, interpretation boards should be sited in full view of the features they are describing.

Leaflets, booklets and electronic material can provide more detailed information and can be targeted at a wider range of audiences than interpretation boards. More than one method can be used to provide a more comprehensive resource of interpretive material. For example, interpretation boards can be combined with leaflets and web-based material. In this way, interpretation can also be aimed at multiple levels and therefore be of interest to geologists and the general public alike.

The Knockan Wall rock sculpture Knockan Crag, near Ullapool, Scotland.
Colin MacFadyen/Scottish Natural Heritage

Factors to consider when choosing sites for interpretation include:

- potential interest of the site to visitors
- agreement of the landowner
- nature and sensitivity of the resource
- accessibility
- safety.

Interpretive materials can also play an important role in site management. For example, they can be used to direct visitors away from sensitive features, inform them about site management activities such as vegetation clearance and provide advice about appropriate collecting methods.

Sites need not be interpreted in isolation. They can be connected through geology trails that cover a number of sites and linked to museum collections. Building stone trails can be used to demonstrate the links between local geological sites and the built environment. In some cases, geological interpretation can be more effective if linked with historical, archaeological or ecological interests.

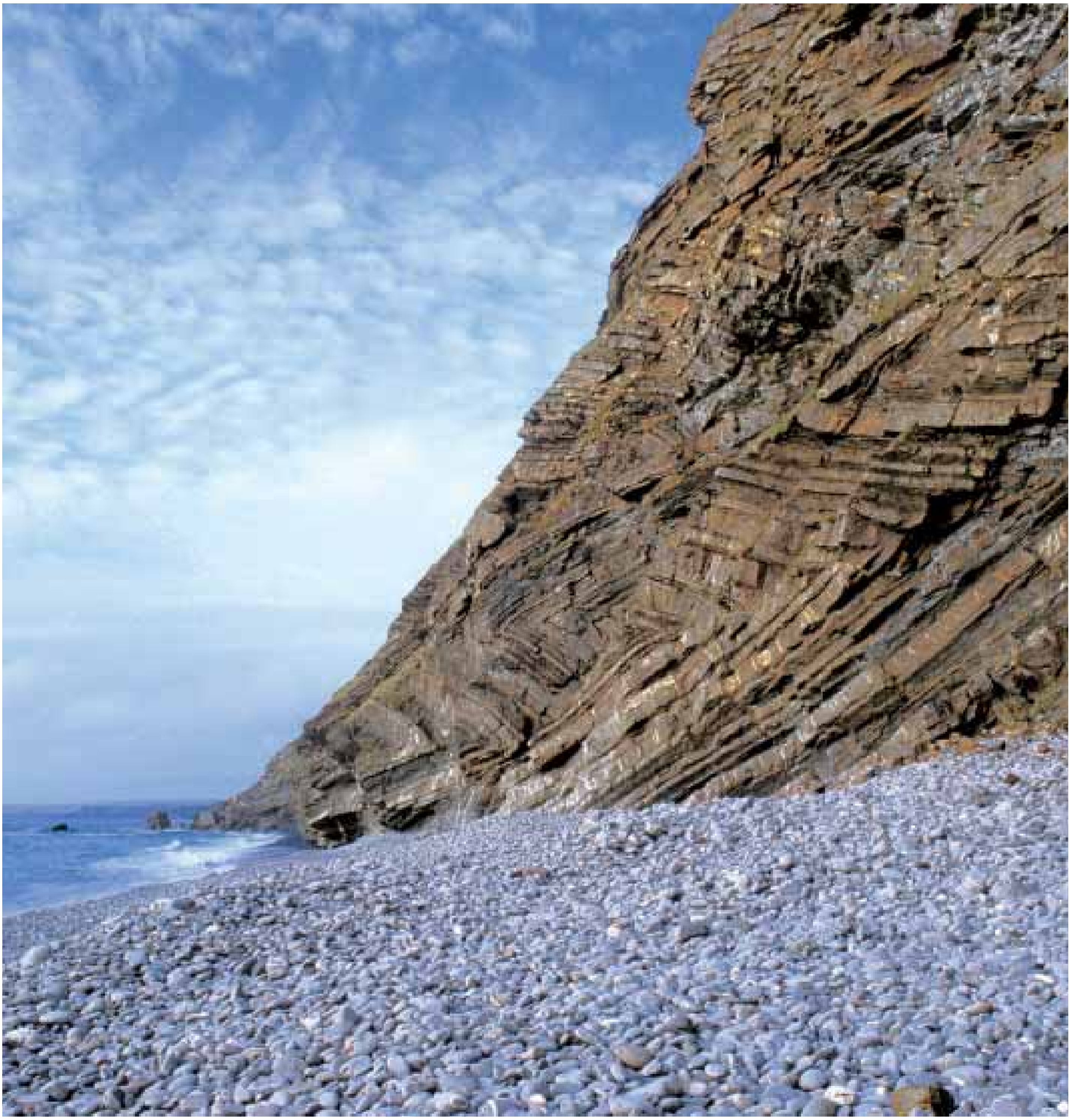
Enjoying a building stone trail through Ledbury, Herefordshire. Colin Prosser/English Nature

Electronic resources, the Internet in particular, are becoming increasingly popular as a means of providing interpretive material. One of the main advantages is that websites can often be produced more cheaply and they are more easily modified and sustained than traditional media. Another advantage is that there is the opportunity to provide links to additional scientific material and other electronic resources.

3 Management guidance by site type

This chapter provides a series of illustrated descriptions of the main threats and management issues for each of the Earth Science Conservation Classification (ESCC) site types. Threats and issues are listed and illustrated examples of appropriate and inappropropriate practice are provided for each site type.

Spectacular folding at Millook, Cornwall. Mick Murphy/English Nature



3.1 Active quarries and pits

EA

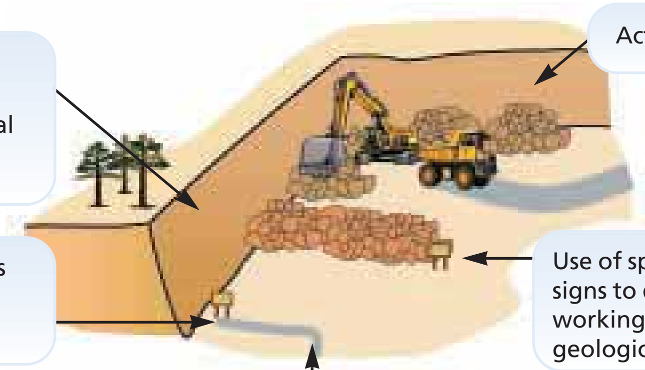
Potential threats and management issues

- **Scientific access to geological features**
- **Storage of quarry waste**
- **Quarry floor development**
- **Restoration**

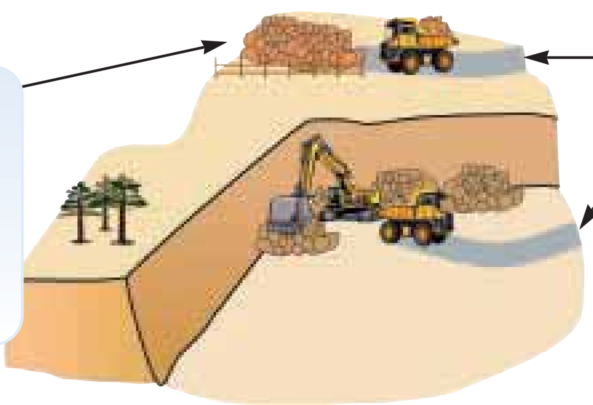
Active quarries can provide unique opportunities to study otherwise unexposed geological features. As such, they can be of great scientific and educational importance, as they provide a continuously replenished resource of geological material. Safe access to newly exposed geological features for research purposes is generally desirable, as this provides the greatest opportunity for scientific study.

Some quarry operators provide off-site rock and fossil stores where geological study can be safely undertaken. Storage of quarry waste against important geological features should be avoided. Quarry floor developments such as buildings should not obstruct access to geological features. Restoration which takes account of important geological features should be considered early in the planning process.

Access to geological exposures during the working life of a quarry



Geological recording alongside ongoing quarry operations



3.2a Disused quarries and pits

ED

Potential threats and management issues

- **Landfill**

Disused quarries often provide unique opportunities to study geological features which are otherwise unexposed. They are, therefore, of great scientific and educational importance in many areas. However, disused quarries also present opportunities for waste disposal. Infilling typically results in the effective destruction of the geological interest but there are compromise solutions which may be acceptable in some cases. These include conservation voids and conservation sections above or adjacent to the landfill. If the geology is laterally variable, several conservation sections or voids may be required.

Conservation void

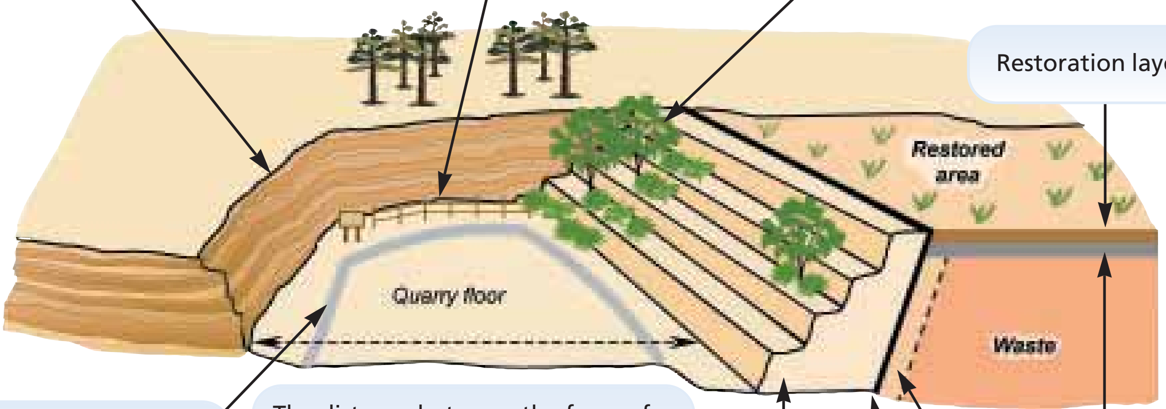
Where bedding is horizontal, the development of a conservation void may be an appropriate solution to maintain exposure of a complete geological section.

Horizontally bedded geological section, conserved at the edge of the landfill.

If required, fences may be used to restrict access to high faces for health and safety reasons.

Hydro-seeded faces for visual effect. Vegetated faces may also help stabilise slopes.

Restoration layer.



Paths and trails can be used to encourage access to the geological features of interest, including the use of interpretation panels where appropriate.

The distance between the faces of geological interest and the landfill should be sufficient to allow clear visibility and machine access.

Reinforced soil structure. Other designs to enable the retention of accessible quarry faces with landfill may be appropriate, including appropriately engineered soil slopes and retaining walls.

Capping layer.

Granular drain.

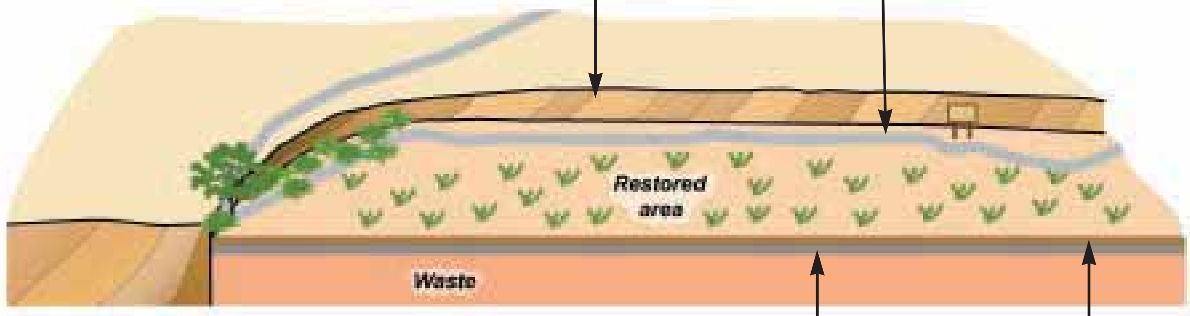
Impermeable membrane.

Conservation section above the landfill

Where the beds are steeply dipping, a conservation section above the landfilled area may be appropriate.

Geological section conserved above the landfill in steeply dipping strata. This method may also be appropriate where the geological interest is contained within the uppermost layers when bedding is horizontal.

Paths and trails can be used to encourage access to the geological features of interest, including the use of interpretation boards where appropriate.



Capping layer.

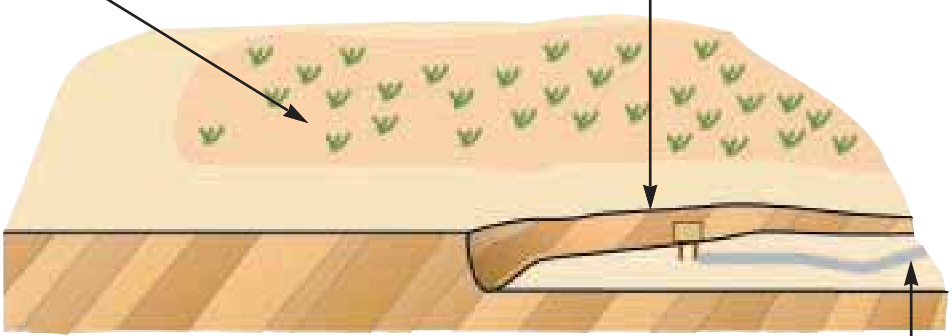
Restoration layer.

Conservation section adjacent to the landfill

Where the beds are steeply dipping, or where the geological interest is contained within the uppermost layers of horizontally bedded strata, the excavation of a conservation section within a relatively shallow void, adjacent to the landfilled area, may also be appropriate.

Restored, landfilled area.

Geological section exposing steeply dipping strata conserved in a relatively shallow void, excavated adjacent to the landfilled area. This method may also be appropriate where the geological interest is contained within the uppermost layers when bedding is horizontal.



Paths and trails can be used to encourage access to the geological features of interest, including the use of interpretation boards where appropriate.

3.2b Disused quarries and pits

Potential threats and management issues

- **Development**

Development in the base of a disused quarry may be compatible with geological conservation, providing that exposure of the geological features of interest in the quarry walls, and access to the features, are retained. Restricting development above the quarry faces avoids a potential conflict of interest between the need to protect the development against potential instability and the need to maintain clean quarry faces for geological conservation. Early and ongoing consultation in the planning process assists in these principles being incorporated into the development plan design.

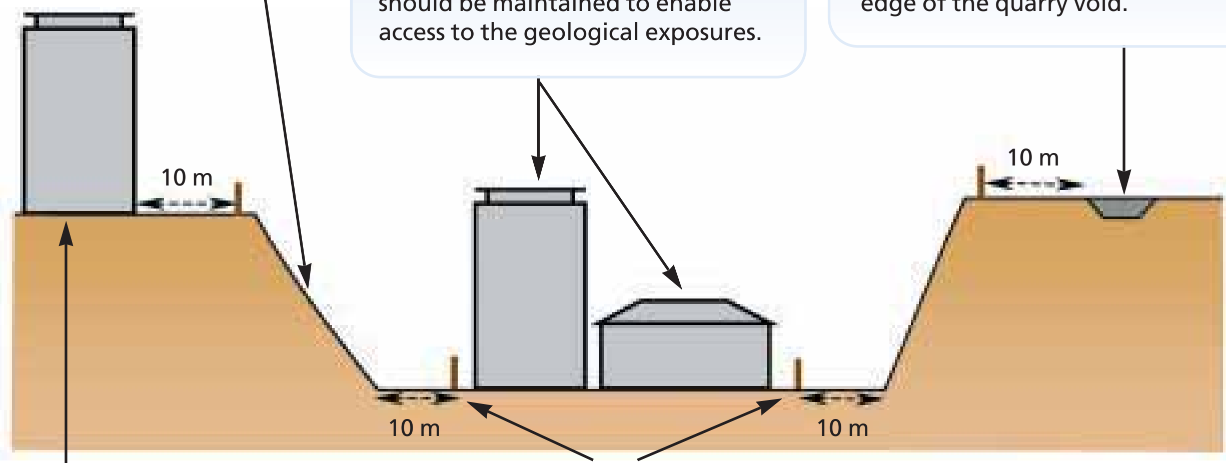
Maintaining conservation sections adjacent to development within former quarries

Where bedding is horizontal, the development of a conservation void may be an appropriate solution to maintain exposure of a complete geological section.

Geological section conserved adjacent to the development.

Built development in the base of the quarry. This may include buildings, roads and pipelines. A minimum of 10 m distance from the quarry walls should be maintained to enable access to the geological exposures.

Other forms of built development including, for example, roads, railways and pipelines, should be restricted to areas away from the edge of the quarry void.



Fences should be used to demarcate conservation areas.

Buildings above the quarry faces should be restricted to areas well away from the edge of the quarry void and away from areas of potential instability.

These stand-off distances of approximately 10 m above and below the quarry faces will depend on height and stability constraints. Different stand-off distances are likely to be required for hard rock exposures compared to exposures in soft sediments, which are more liable to collapse or slumping. The stand-off distances will also depend on the nature of the geological interest features. Some features need to be viewed from a distance and their scientific or educational value could be diminished if views are significantly restricted.

3.2c Disused quarries and pits

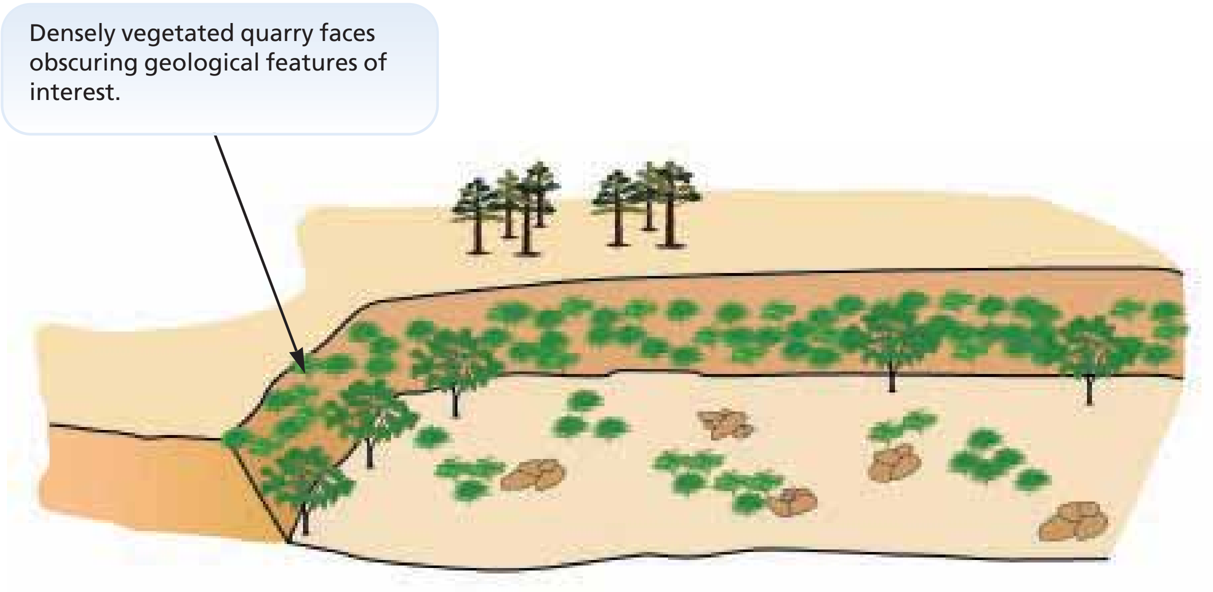
ED

Potential threats and management issues

- **Vegetation encroachment**
- **Tree planting**

Natural vegetation can grow rapidly on and in front of disused quarry faces, concealing the interest features. Ongoing vegetation management is necessary in many disused quarries to maintain clean faces. Tree planting should be avoided close to geological features. In particular, some geological features need to be viewed from a distance and trees can obscure such views.

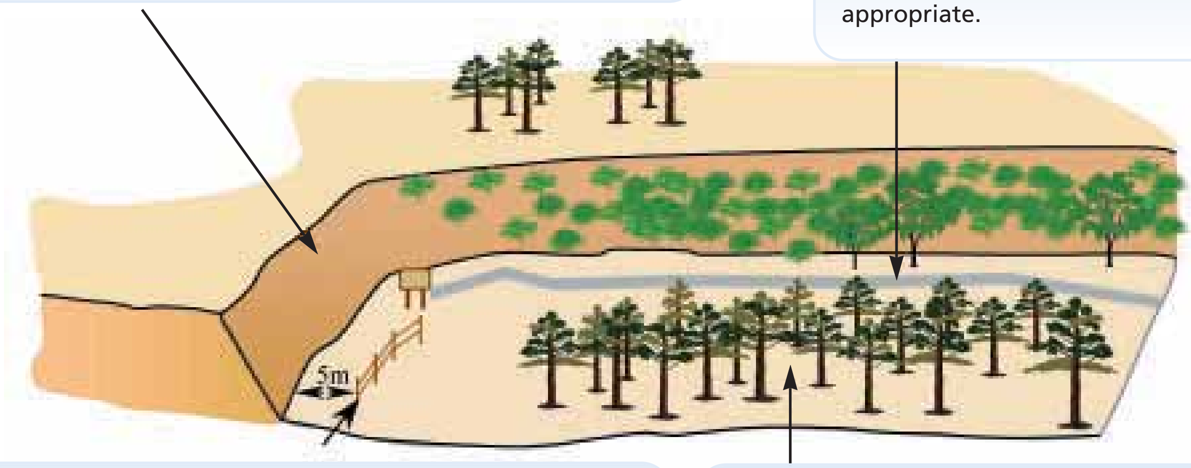
BEFORE vegetation management



AFTER vegetation management

Vegetation cleared in the vicinity of the geological interest. Ongoing management is required to ensure that a clean conservation section is maintained.

Paths and trails can be used to encourage access to the geological features of interest, including the use of interpretation boards where appropriate.



If required, fences should be placed to restrict access to high faces for health and safety reasons. These fences should be at least 5 m from the face to allow machine access.

New tree planting restricted to the quarry floor, well back from quarry faces. On sites where the interest features need to be viewed from a distance, tree planting on the quarry floor may be incompatible with conservation of the geological features.

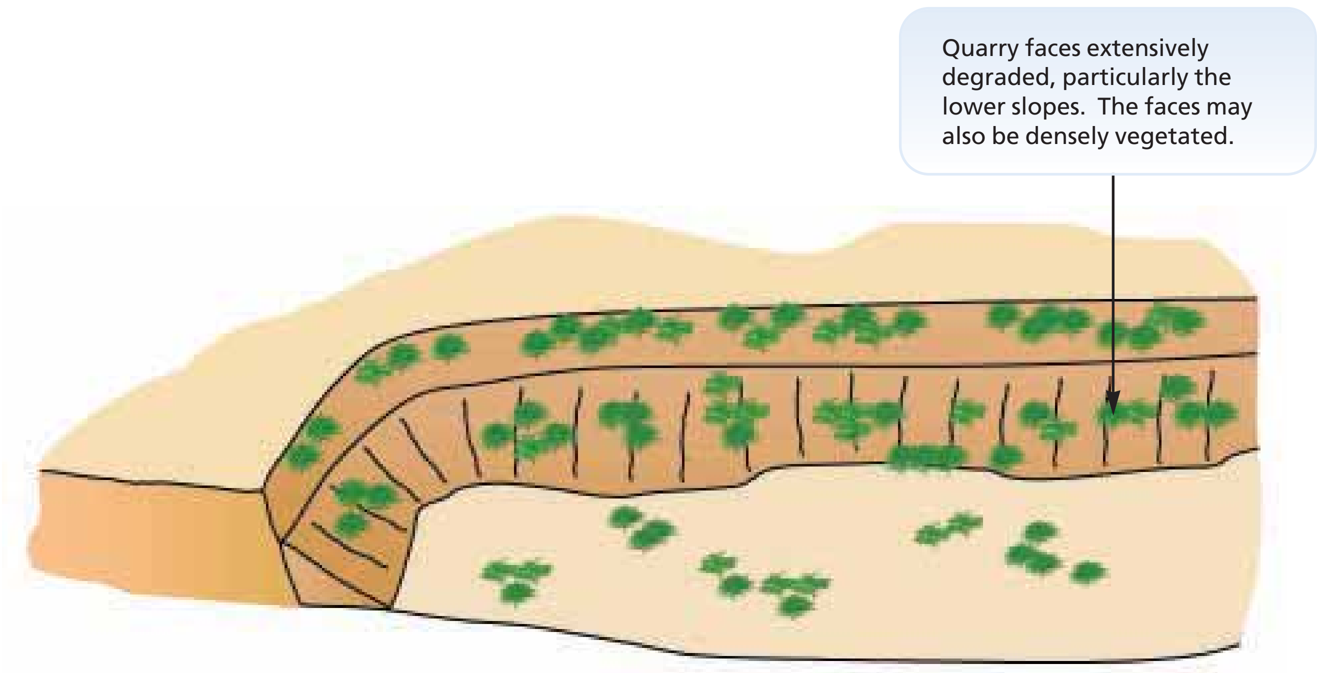
3.2d Disused quarries and pits

Potential threats and management issues

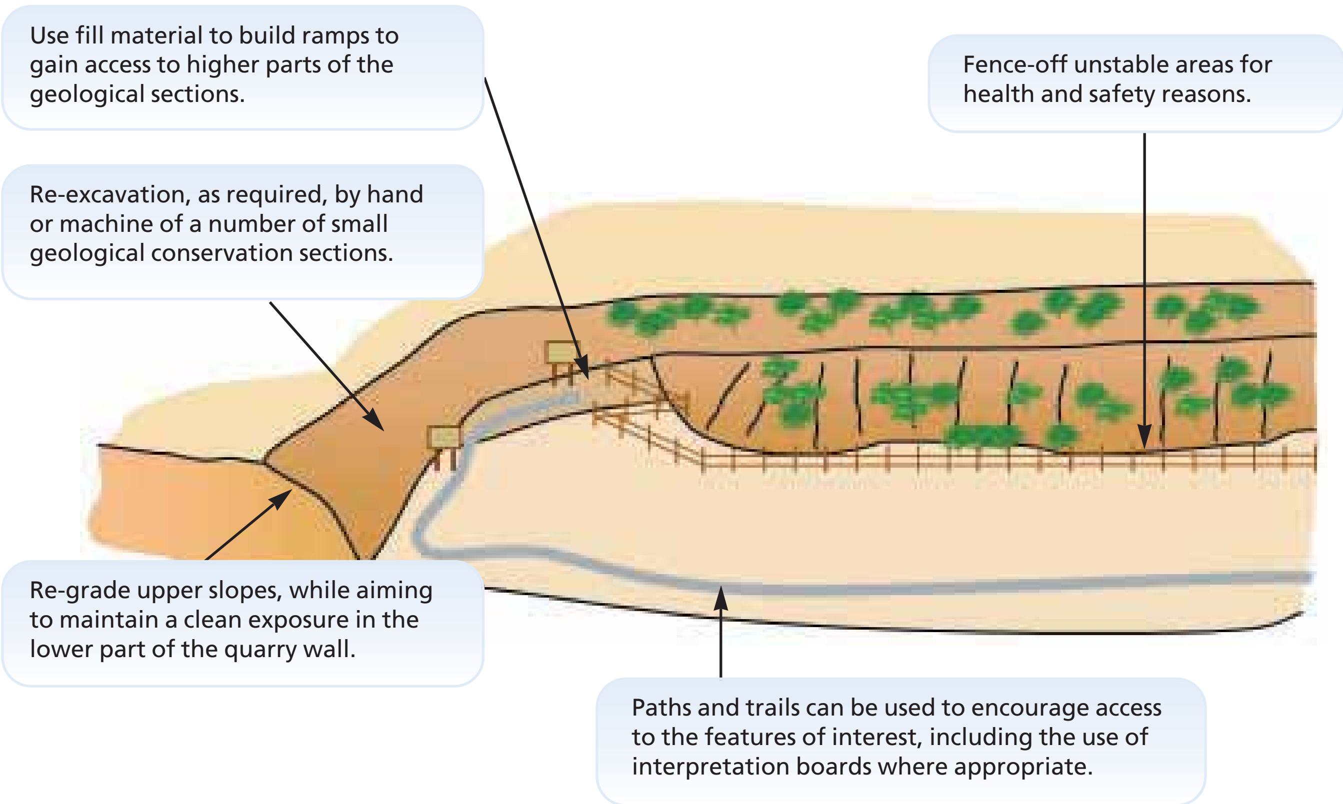
- **Instability and slumping of faces**

Disused quarry faces are often unstable and prone to slumping or collapse. In general, hard engineering solutions such as concreting and meshing are incompatible with conservation of the geological features. Scaling of faces and removal of fallen rock debris may be necessary to maintain the geological exposures in good condition. The re-excavation of a number of small sections can be a useful technique when the conservation interest is located within soft sediments, where retaining a high section may lead to slope instability. Ongoing management, including re-excavation and vegetation clearance, is generally required to maintain these sections.

Quarry faces in soft sediments:
BEFORE re-excavation of a number of small sections



Quarry faces in soft sediments:
AFTER re-excavation of a number of small sections

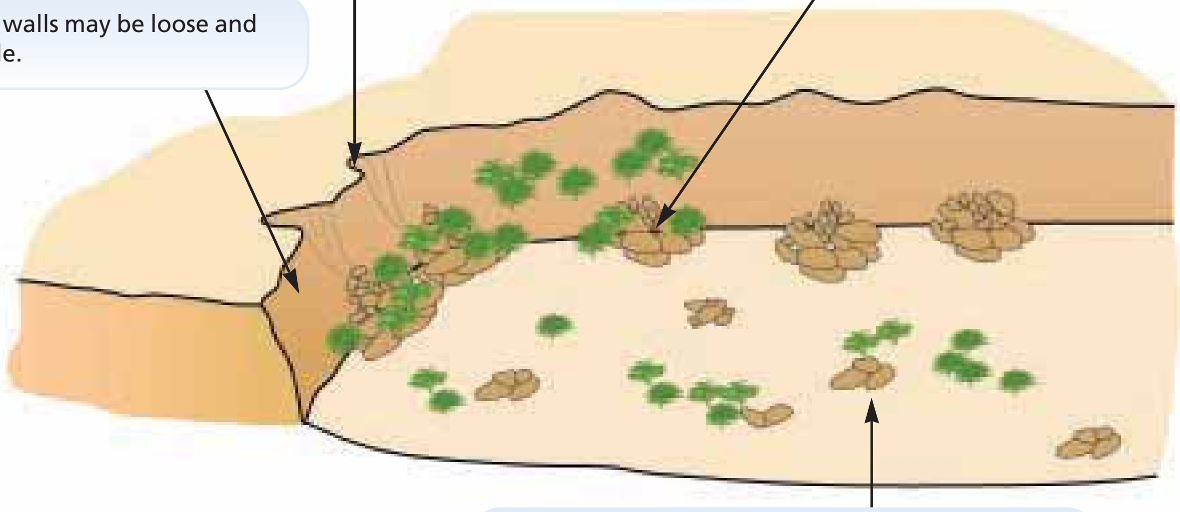


Quarry faces in hard rock: BEFORE appropriate management

Upper faces of quarry may be unevenly bevelled and unsafe.

Rock falls and/or landslides may be present. Older falls may be vegetated.

Quarry walls may be loose and unstable.



The quarry floor may be uneven and contain loose, unstable blocks.

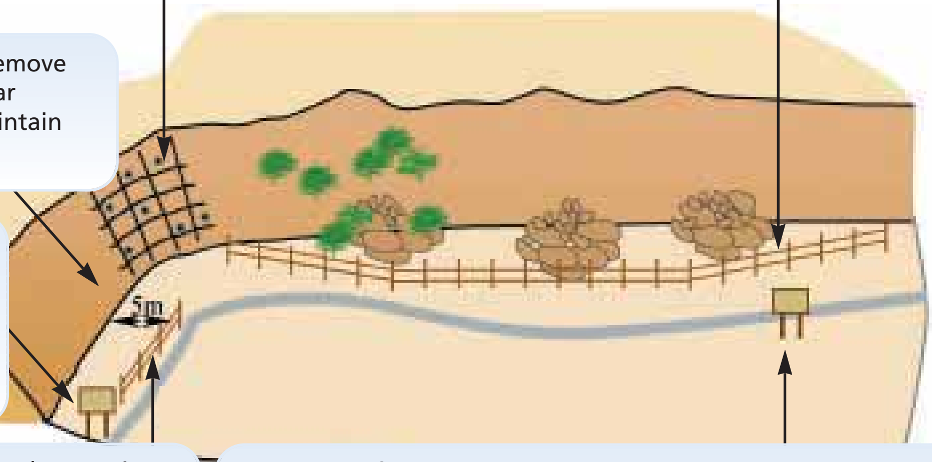
Quarry faces in hard rock: AFTER appropriate management

The use of rock bolts and mesh may be appropriate in certain limited areas for health and safety reasons. Mesh should not be applied to valued geological features.

Fence off unstable areas for health and safety reasons.

Scale down selected faces to remove loose rock and carry out regular cleaning and inspection to maintain a clean conservation section.

Paths and trails can be used to encourage access to the features of interest, including the use of interpretation boards where appropriate.



If required, fences should be used to restrict access to high faces for health and safety reasons. These fences should be a minimum of 5 m from the face to allow machine access for clearance work.

The quarry floor may require clearing and levelling in certain areas for health and safety reasons. Features of geological interest may also be exposed in the quarry floor and the use of interpretation boards can be used to promote these features.

3.3 Coastal cliffs and foreshore

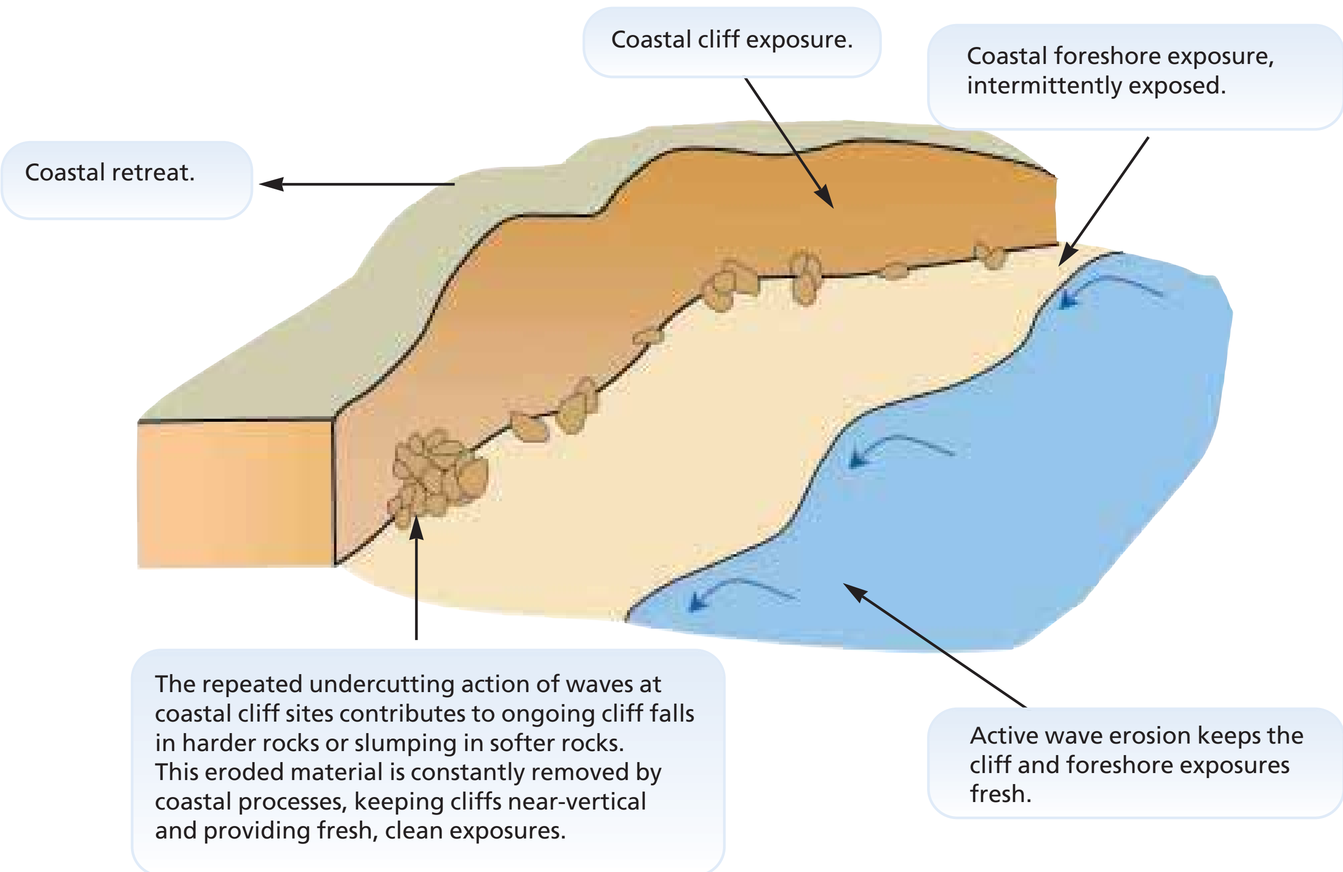
EC

Potential threats and management issues

- **Coastal protection**
- **Development**
- **Vegetation encroachment**
- **Dredging**

Coastal processes should be allowed to proceed without interference. Eroding coastal cliffs provide fresh geological exposures. If erosion is prevented by coastal protection, exposures become concealed by vegetation and rock debris. Hard engineering structures in front of cliffs directly conceal the exposures and should be avoided. Other schemes, such as offshore berms, may be less directly damaging but can result in concealment of features by inhibiting natural processes. Developments on or in front of cliffs or foreshore exposures conceal the features and should also be avoided. Vegetation is usually only a problem where coastal protection or developments are preventing natural erosion. Dredging can impact on natural coastal processes which in turn can affect cliff and foreshore exposures.

Maintaining natural coastal processes

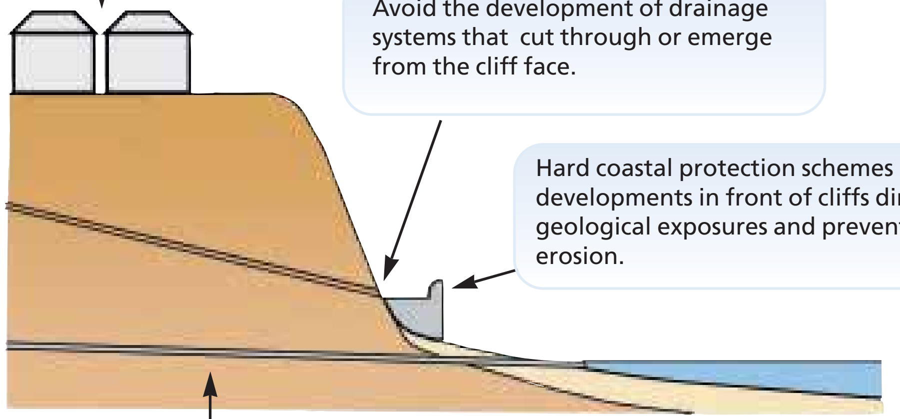


INAPPROPRIATE coastal protection schemes and development

Keep development away from the cliff top to avoid potential conflict of interest between the need to protect the development against coastal erosion and the need to maintain clean geological exposures.

Avoid the development of drainage systems that cut through or emerge from the cliff face.

Hard coastal protection schemes and developments in front of cliffs directly obscure geological exposures and prevent natural erosion.



Avoid structures that cut across the foreshore, obscuring the geological interest.

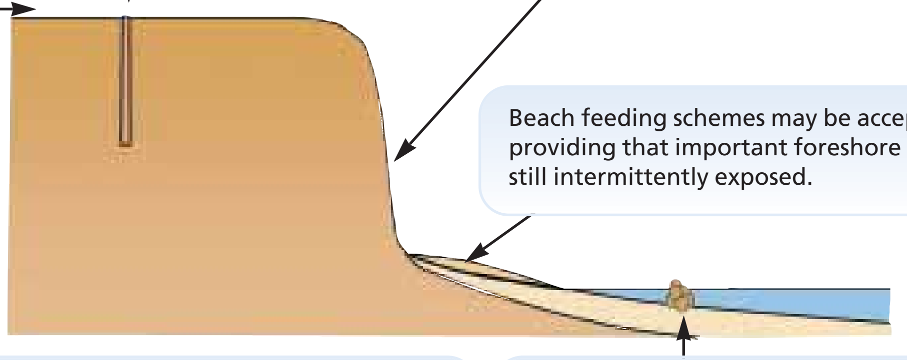
APPROPRIATE coastal protection schemes

Cut-off type drains may be appropriate in controlling the rate of slumping or slipping of the cliff in certain water-environment conditions, where high pore-water pressures are contributing to cliff instability.

Cliff top developments are avoided.

Clean geological exposure maintained.

Beach feeding schemes may be acceptable, providing that important foreshore exposure is still intermittently exposed.



During the construction of coastal protection schemes, care should be taken to avoid damage to foreshore exposures. Access for vehicles and equipment should be carefully managed.

Although the best option is no coastal protection, beach feeding or offshore berms are better options than hard engineering works against the cliff.

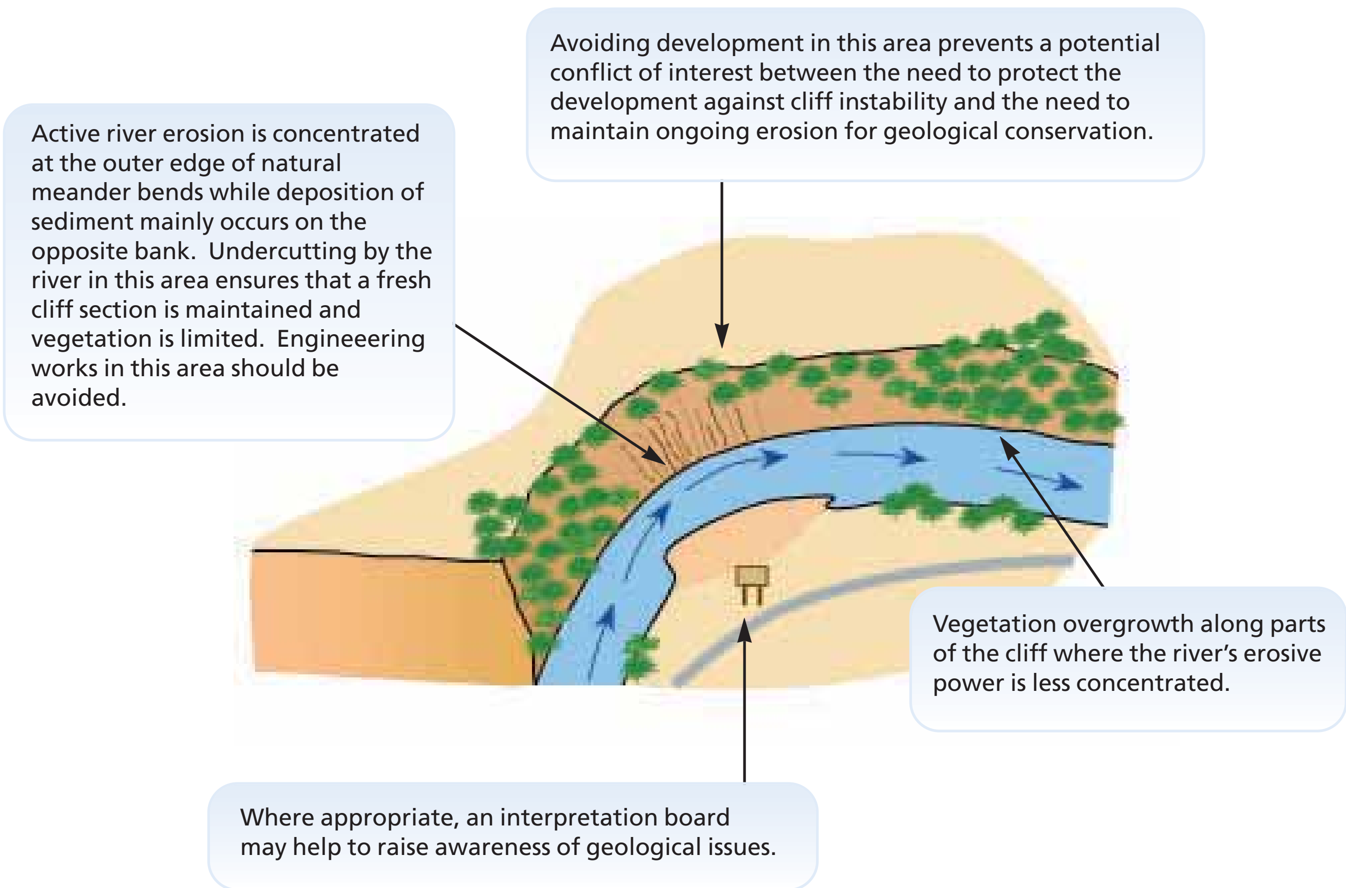
3.4 River and stream sections

Potential threats and management issues

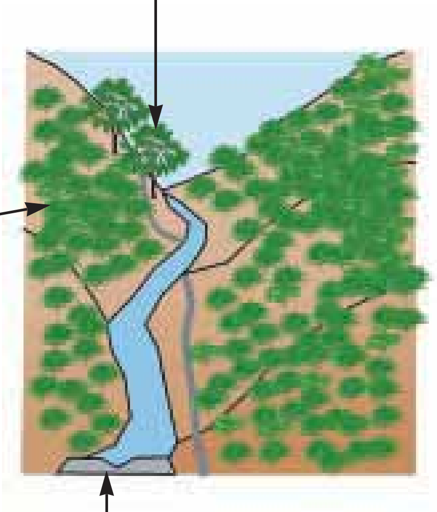
- **River management**
- **Bank stabilisation**
- **Vegetation encroachment**
- **Development**
- **Tree planting and afforestation**

Natural processes should be allowed to proceed without interference to maintain geological exposures in river and stream sections. Activities which interfere with the natural erosion regime are generally inappropriate. The installation of engineering structures to stabilise cliffs can conceal the geological features. Vegetation management may be required on some sites, particularly if erosion is inhibited. Developments should be sited away from geological features and should be discouraged on cliff tops to avoid the need for stabilisation works. Tree planting and afforestation should be avoided near geological features.

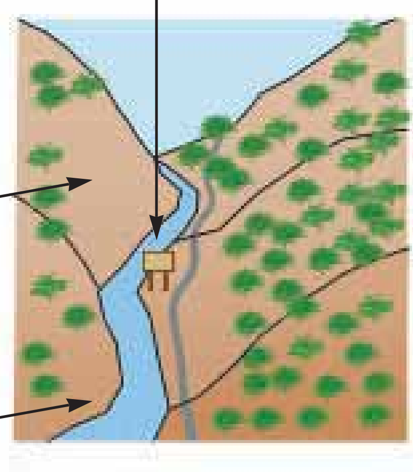
Maintaining natural processes at river cliff sites



Stream sections: BEFORE appropriate management



Stream sections: AFTER appropriate management



3.5 Inland outcrops

EO

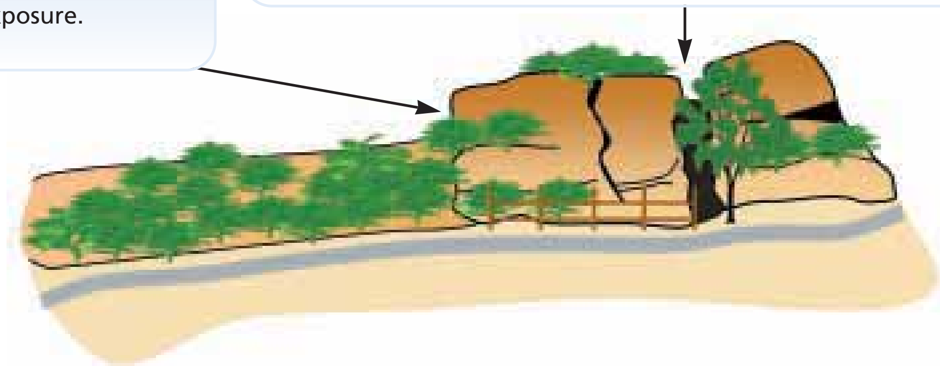
Potential threats and management issues

- **Vegetation encroachment**
- **Tree planting and afforestation**
- **Development**
- **Inappropriate recreational activities**

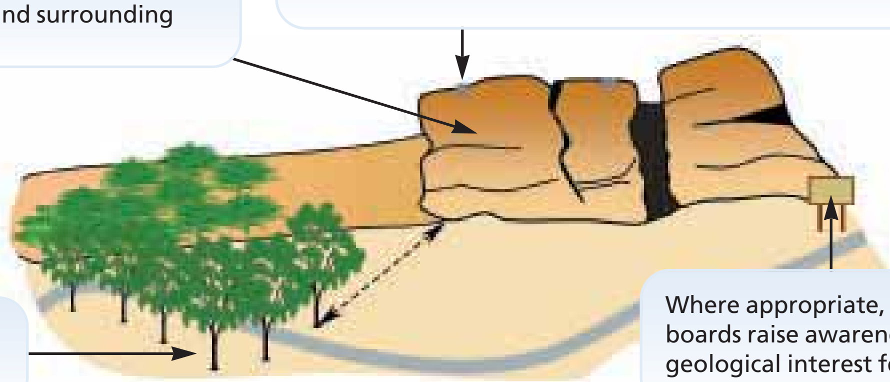
Vegetation management is necessary to maintain many natural inland exposures where erosion rates are low. Without vegetation management, geological features can become obscured. Tree planting and afforestation should be avoided close to geological features.

Developments such as roads, paths and buildings should be sited away from geological features. Climbing is not normally damaging but may be so where rocks are relatively soft and particularly where surface features on the rocks are of scientific importance.

BEFORE appropriate management activities



AFTER appropriate management activities



3.6 Exposure underground mines and tunnels

EU

Potential threats and management issues

- **Scientific access to geological features**
- **Depletion of resource**
- **Resource becomes finite after mine closure**
- **Flooding after mine closure**
- **Collapse after mine closure**

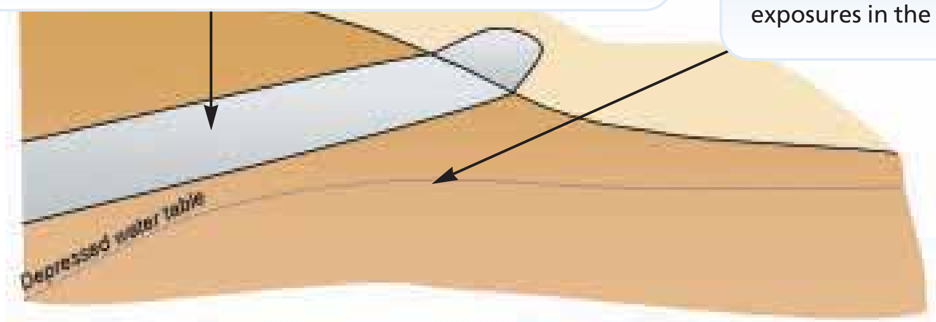
Operational mines provide a constantly renewed supply of fresh rock exposures, as material is being removed. Providing there are extensive reserves of the material of interest, ongoing mining operations are generally beneficial for conservation. Safe access to newly exposed geological features for research purposes is generally desirable, as this provides the greatest opportunity for scientific study.

Some mines may also be suitable for educational use. The main problems arise when mines cease to operate. The resource of material of interest becomes effectively finite as fresh exposures are no longer being created. Flooding and collapse are often serious problems after mine closure and the costs of pumping and maintenance of stable passages are typically prohibitive in achieving effective conservation.

Benefits of ongoing mining

Providing there are extensive reserves of the material of interest, continuation of mining activities creates a constant supply of fresh rock exposure. These exposures can potentially be accessed for study, where appropriate.

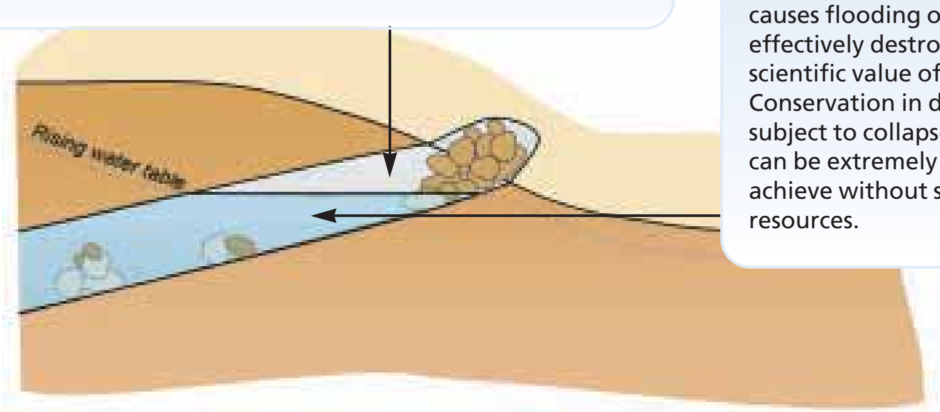
Ongoing pumping to lower groundwater water levels allows continual access to rock exposures in the mine.



Potential problems after mine closure

Rising groundwater levels exacerbate the instability of mine passages. Collapse of mine passages limits access to geological features.

Ceasing pumping allows groundwater levels to rise. This causes flooding of the mine and effectively destroys the scientific value of the site. Conservation in disused mines, subject to collapse or flooding, can be extremely difficult to achieve without substantial resources.



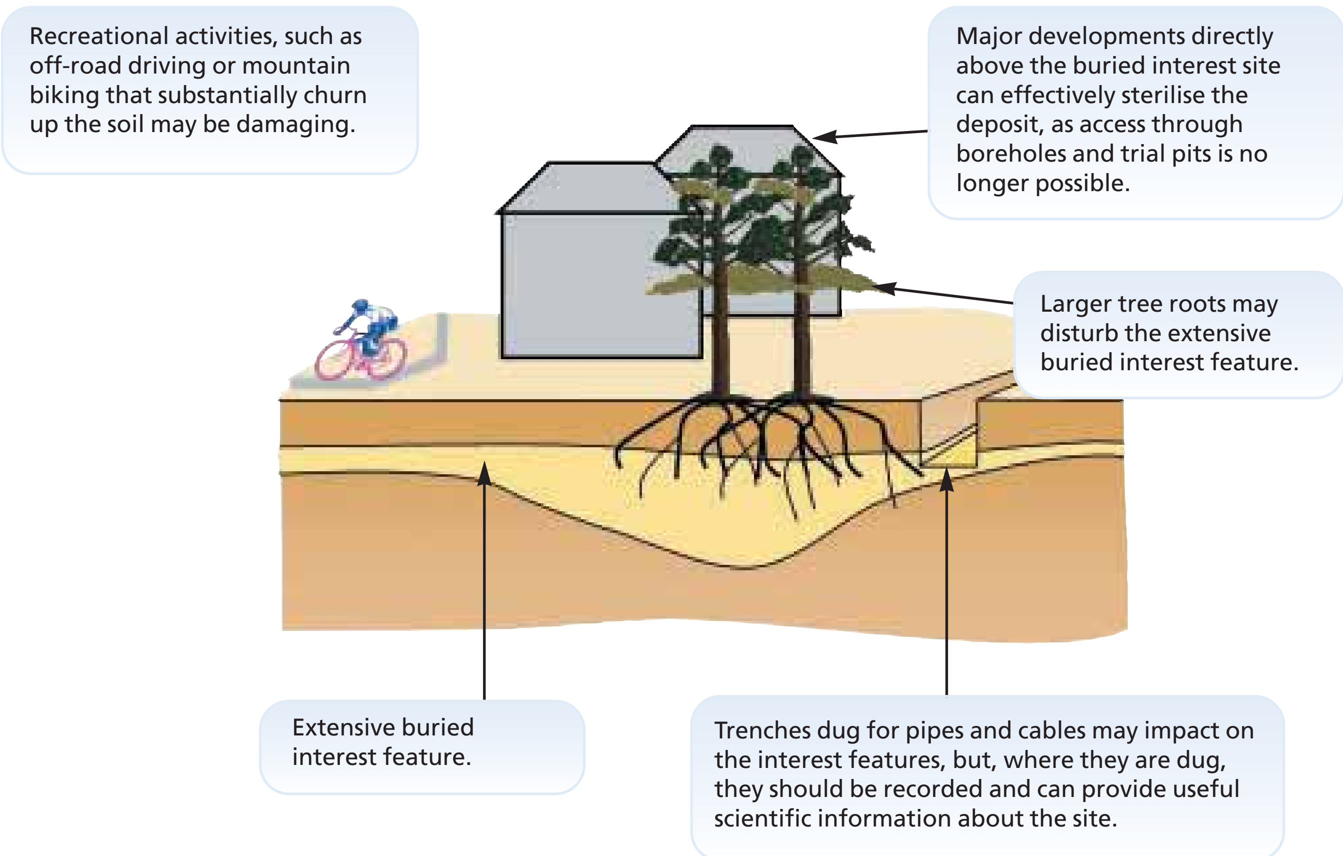
3.7 Extensive buried interest

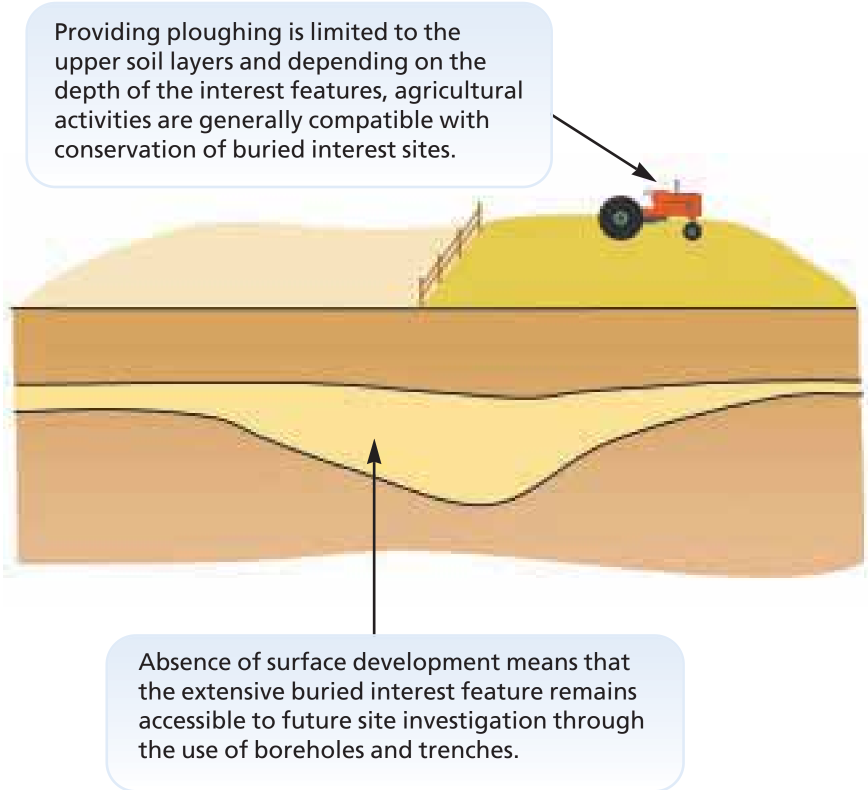
Potential threats and management issues

- **Inappropriate agricultural practices**
- **Tree planting and afforestation**
- **Development**
- **Quarrying**
- **Inappropriate recreational activities**

The primary management principles on buried interest sites are to limit disturbance or removal of material of interest and to maintain the sites in a condition whereby it is possible to access the interest features by boreholes and temporary trenches. Activities which can cause permanent damage to buried interest sites include deep ploughing, digging of drains, tree planting, afforestation, quarrying and general development works, such as construction of buildings on top of the interest features. Recreational activities such as off-road driving and mountain biking may be damaging if they disturb the buried interest features. When assessing the potential impacts of such activities on extensive buried sites, it is important to understand the distribution of the interest features, as these may be laterally variable.

INAPPROPRIATE use of extensive buried interest sites




Providing ploughing is limited to the upper soil layers and depending on the depth of the interest features, agricultural activities are generally compatible with conservation of buried interest sites.
Absence of surface development means that the extensive buried interest feature remains accessible to future site investigation through the use of boreholes and trenches.

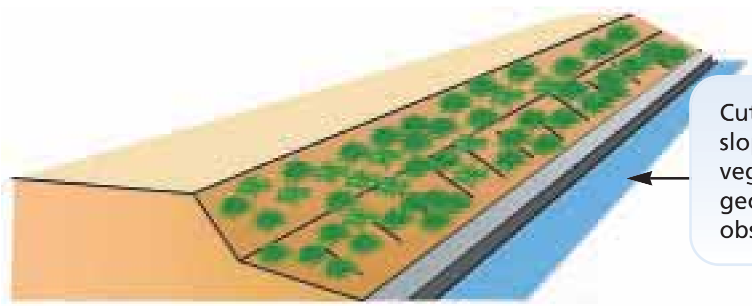
3.8a Road, rail and canal cuttings

Potential threats and management issues

- **Vegetation encroachment**
- **Slumping of faces**
- **Face stabilisation**
- **Tree planting**
- **Development**

Ongoing vegetation management and removal of slumped material is often required at road, rail and canal cuttings to maintain geological exposures. Face stabilisation is an important safety issue at many cuttings. Engineering solutions, such as meshing and concreting, which prevent access to or conceal geological features, should be avoided. Cut-off drains placed behind an exposed face may help to alleviate the effects of slumping and degradation. Tree planting should be avoided close to geological features. Developments should be sited so as to avoid concealing geological features.

BEFORE appropriate management

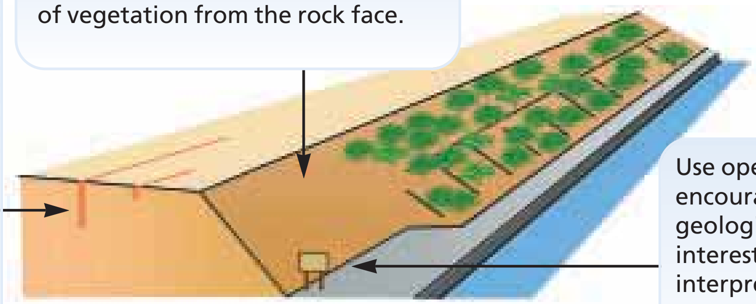


Cutting with degraded slopes and dense vegetation. The geological interest is obscured.

AFTER appropriate management

Interceptor cut-off drains behind the exposed face may help to reduce slumping and instability, especially where the original section has been steepened or binding vegetation has been removed. Drainage systems located within the exposed face are generally not appropriate.

Cleared, fresh, geological section within cutting, with periodic clearing of vegetation from the rock face.



Use open space and paths to encourage access to the geological features of interest, including the use of interpretation boards where appropriate.

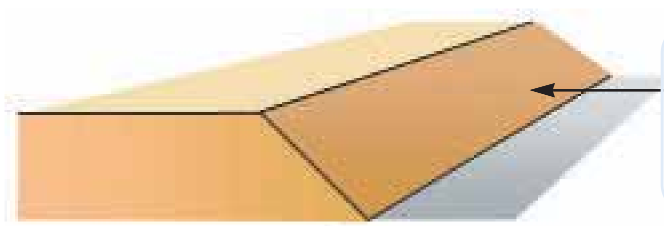
3.8b Road, rail and canal cuttings

Potential threats and management issues

- **Face stabilisation**
- **Road widening schemes**
- **Re-grading of slopes**

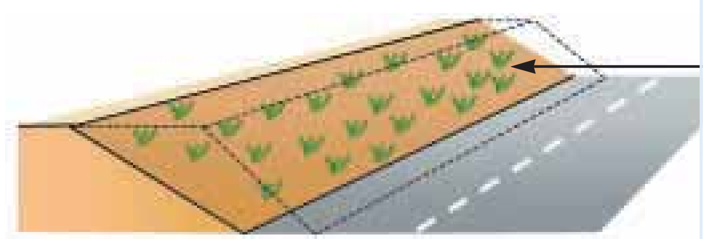
Road widening schemes may affect existing geological sites and may also create new exposures. Any activities which result in concealment of the exposure should be avoided. Ideally, the faces should be steep to inhibit scrub growth. Steep faces, however, are more likely to be unstable, particularly if the rocks are relatively soft. Stepped sections, with vertical faces and horizontal benches, may satisfy conservation and safety requirements and also facilitate access to the exposures.

Road widening schemes: BEFORE construction work



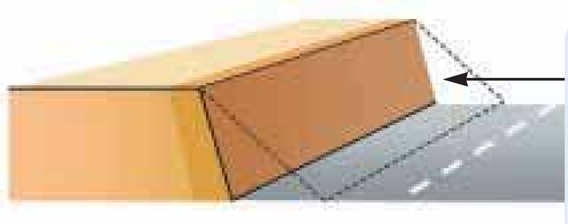
Road cutting with relatively steep slopes exposing geological features of interest. The slope is likely to degrade over time.

Road widening schemes: AFTER INAPPROPRIATE construction work, re-grading slopes



In areas where sufficient land is available, slope re-grading may be carried out, as part of a road widening scheme, to ensure stability. Re-graded slopes quickly vegetate and may even be hydro-seeded to assist in stabilising the slope and for visual effect. The stability of the cutting is improved but the geological interest is obscured.

Road widening schemes: AFTER INAPPROPRIATE construction work, reinforcing steep slopes



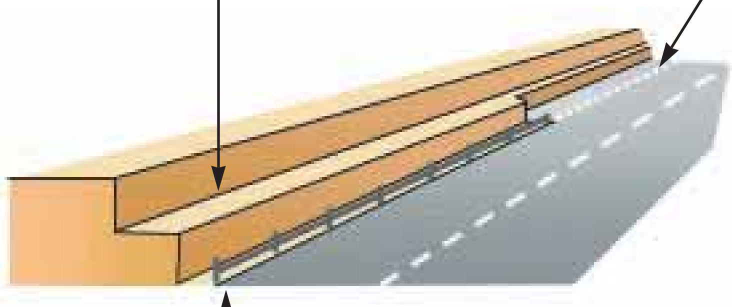
In areas where there has to be limited land-take, slopes are often over-steepened in road-widening schemes, using a reinforced soil structure or covering the slope in concrete. The stability of the cutting is improved but the geological interest is obscured.

Road widening schemes: AFTER APPROPRIATE construction work, using stepped sections

Local ground conditions, including the type of rock and the angle and direction of dip of the beds will influence the design of a stepped section. Very hard or massive rocks can support high, near-vertical cuttings, with long-term stability, often without the need for benching, using smooth blasting techniques to provide good quality geological sections. In softer rock, stepped sections improve stability and ensure the geological interest remains visible. The use of cut-off type drains behind the exposure may be needed in certain conditions to help reduce slumping and instability. Drainage systems located within the exposed face are generally not appropriate.

Stepped section constructed as part of a road widening scheme. Stability of the cutting is improved and the geological interest is visible. Access to the upper parts of the geological section is possible via the higher benches. The stepped sections can often be limited to short discrete lengths to avoid unnecessary cost and land-take.

Where safety permits, a lay-by, included as part of a road widening scheme, can assist in improving access to the geological exposure.



Consider the use of crash barriers to protect visitors from traffic and to prevent loose rock material from falling onto the road. Sufficient room should be left to allow access to clear any build-up of debris.

3.9 Static (fossil) geomorphological

IS

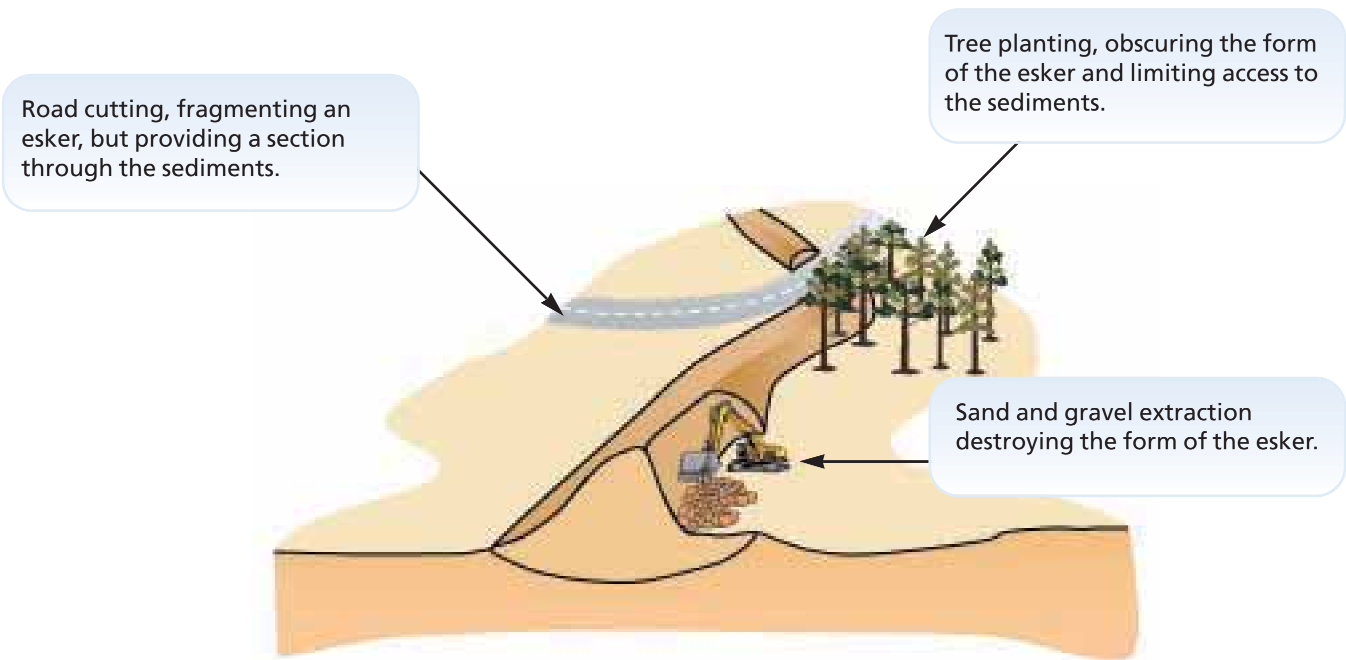
Potential threats and management issues

- **Coastal protection**
- **Development**
- **Quarrying and dredging**
- **Infilling of natural depressions**
- **Vegetation encroachment**
- **Tree planting and afforestation**
- **Inappropriate recreational activities**
- **Irresponsible specimen collecting**

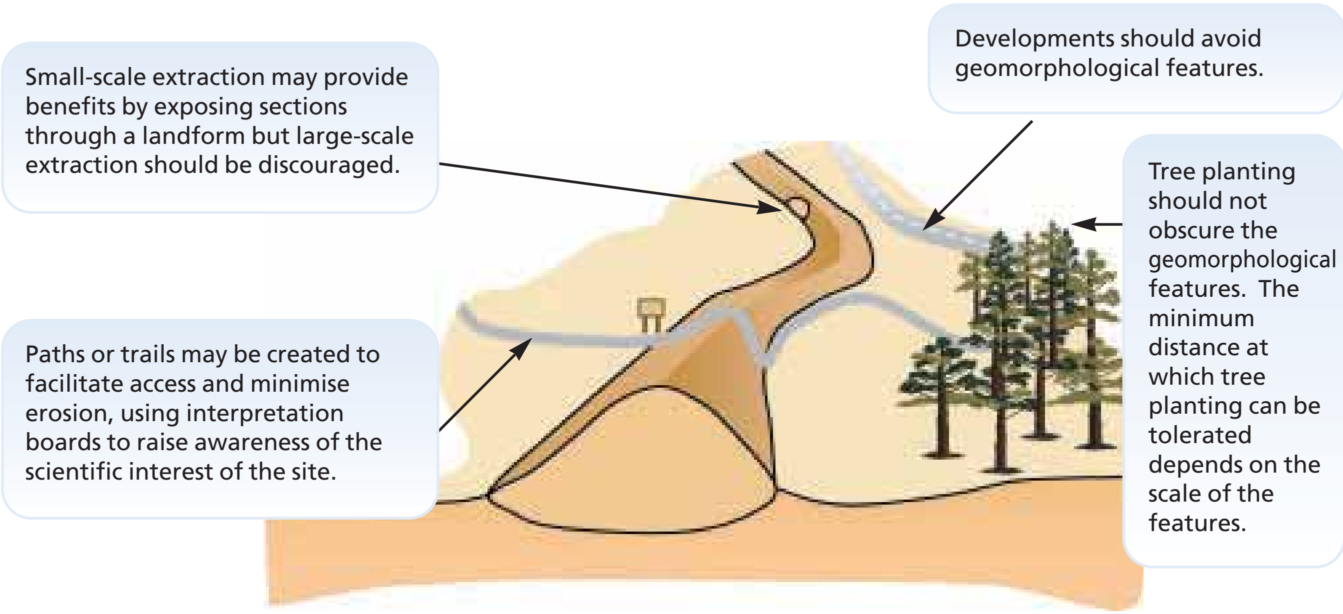
Static geomorphological sites consist of landforms or features where the processes that produced them are no longer operating. They are irreplaceable if destroyed. There is a large range in scale between sites, but the general management principle is to minimise human interference with the features of interest. Developments, coastal protection schemes and quarrying may damage or obscure interest features. Dumping of waste and infilling of depressions is highly damaging. Vegetation management may be necessary on some sites. Tree planting and afforestation should be avoided.

Certain recreational activities such as off-road driving, mountain biking and irresponsible rock climbing may be damaging. Some smaller-scale features could be damaged by collecting of geological specimens.

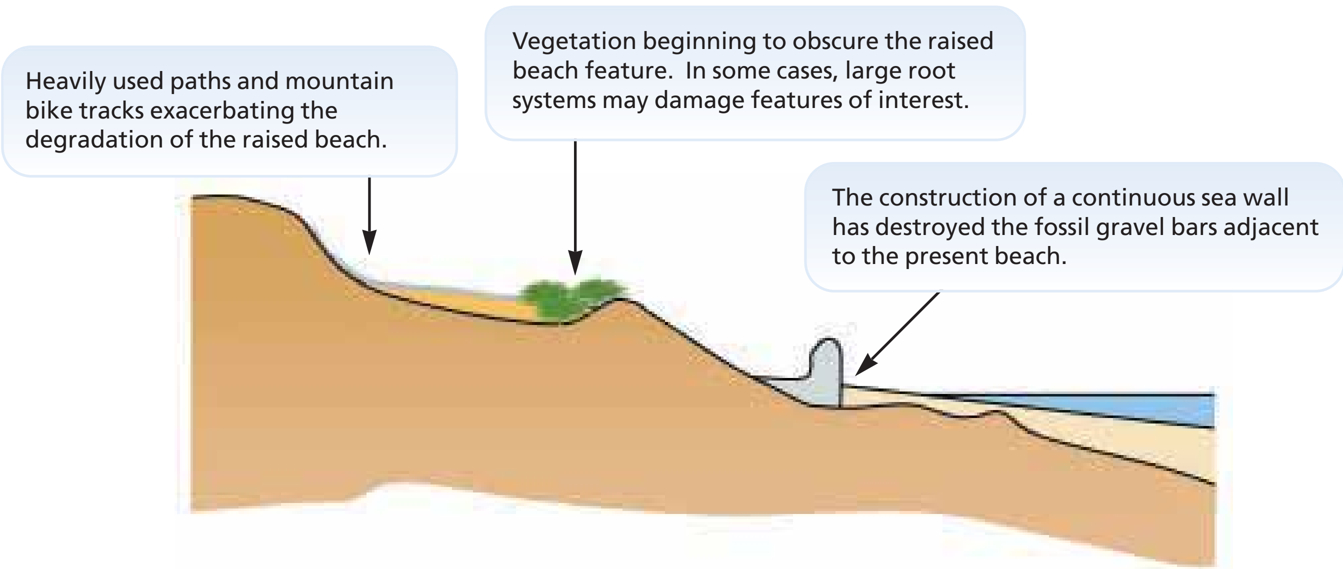
INAPPROPRIATE activities on an esker



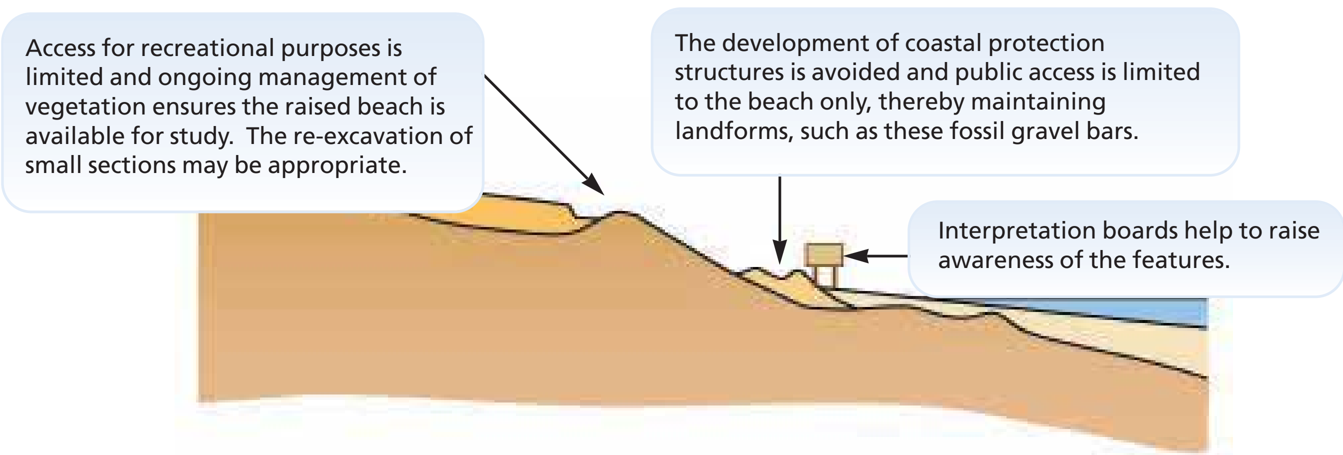
APPROPRIATE management of an esker



INAPPROPRIATE activities on a raised beach



APPROPRIATE management of a raised beach



3.10 Active process geomorphological

IA

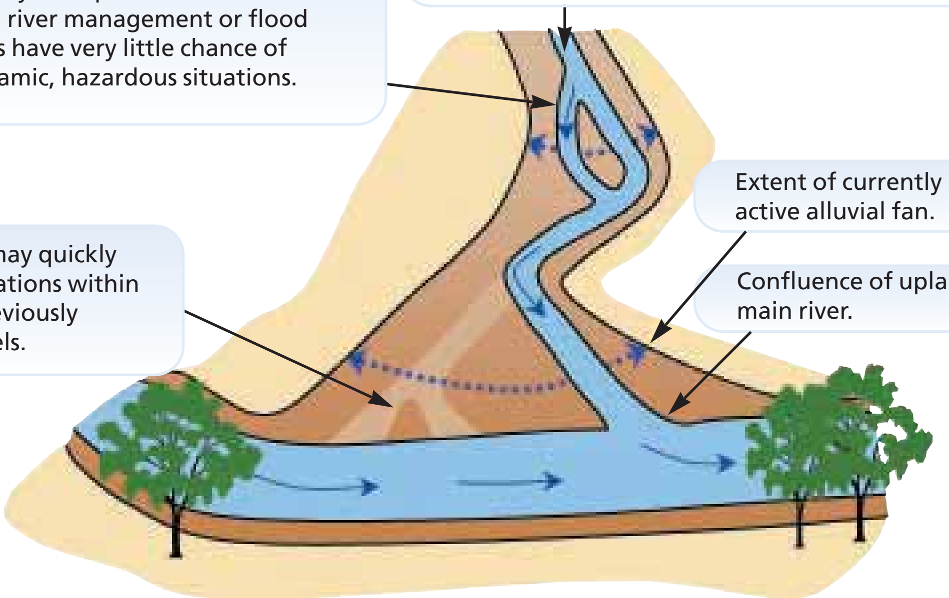
Potential threats and management issues

- **Coastal protection**
- **River and land management schemes**
- **Development**
- **Quarrying and dredging**
- **Tree planting and afforestation**
- **Inappropriate recreational activities**

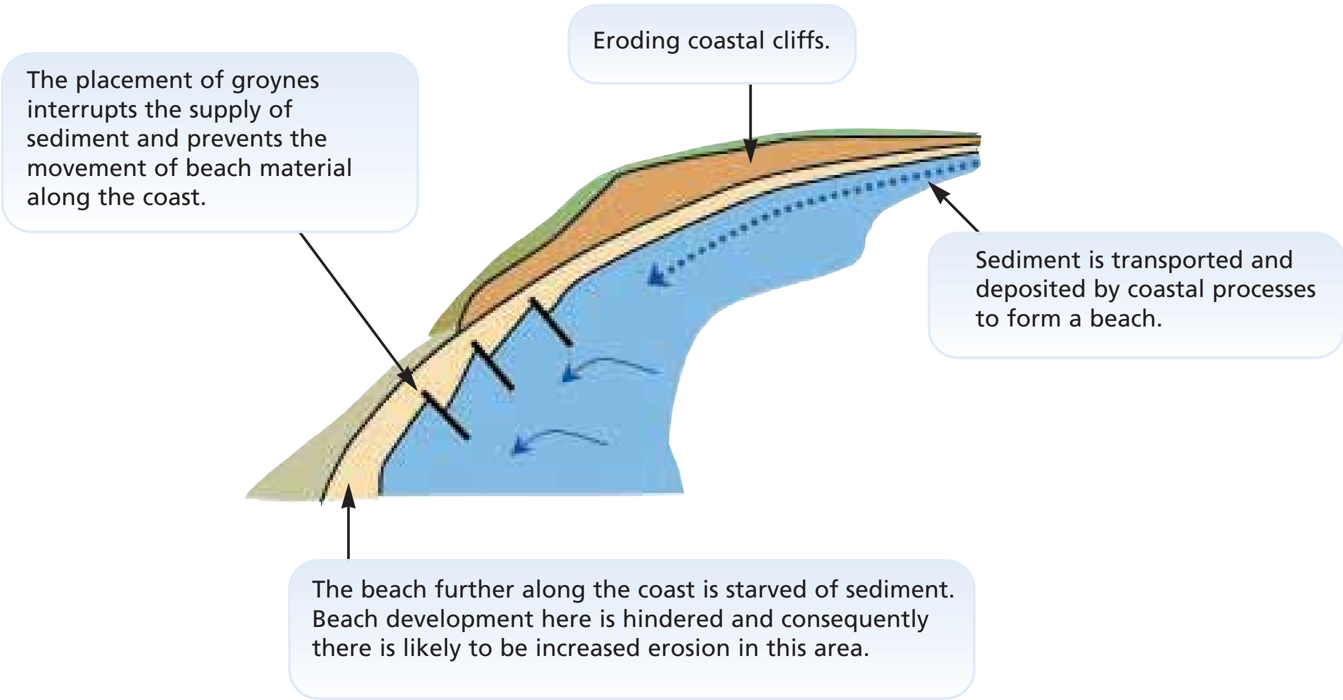
Active process sites include coastal systems, rivers and mass movement sites. The common factor is that the natural processes, which have produced the important scientific features, are still occurring. The primary management principle is to minimise interference with the features and associated natural processes. Any development or activity, such as coastal protection, quarrying or tree planting, that inhibits natural processes, is likely to damage the interest features. Damaging activities do not necessarily have to take place within the boundary of a site. For example, coastal protection outside a site can have indirect effects within a site. In extreme cases inappropriate recreational activities may be damaging.

Active process river site: the need for non-intervention

Development should be avoided in the river floodplain to avoid future demand for protective engineering works. Upstream, within the river catchment, changing land management practices may still have an effect on the catchment processes and, thereby, the dynamics of the river. For example, forestry plantations may change the surface run-off and chemistry of the river.

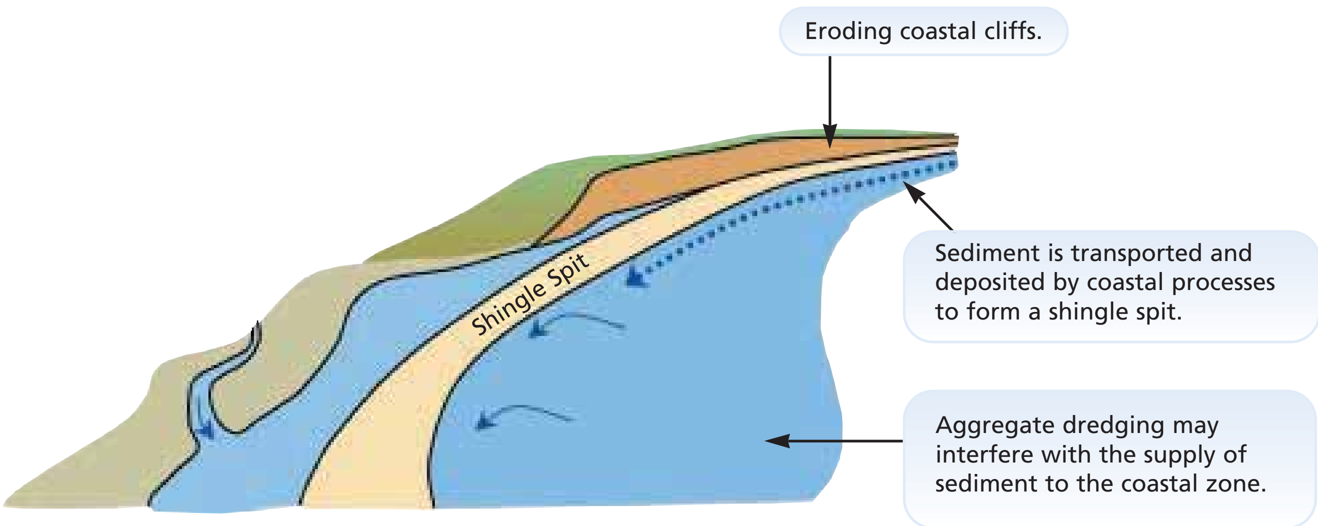


Active process coastal site:
the impacts of INAPPROPRIATE intervention



Active process coastal site:
the need for non-intervention

A shingle spit is formed by the ongoing transport and deposition of sediment by coastal processes. The entire system is delicately balanced and may be susceptible to interference by, for example, coastal protection schemes and off-shore dredging. Such artificial changes in sediment supply may be reflected in changes to the morphology of the spit, and may allow it to become breached.



3.11 Caves

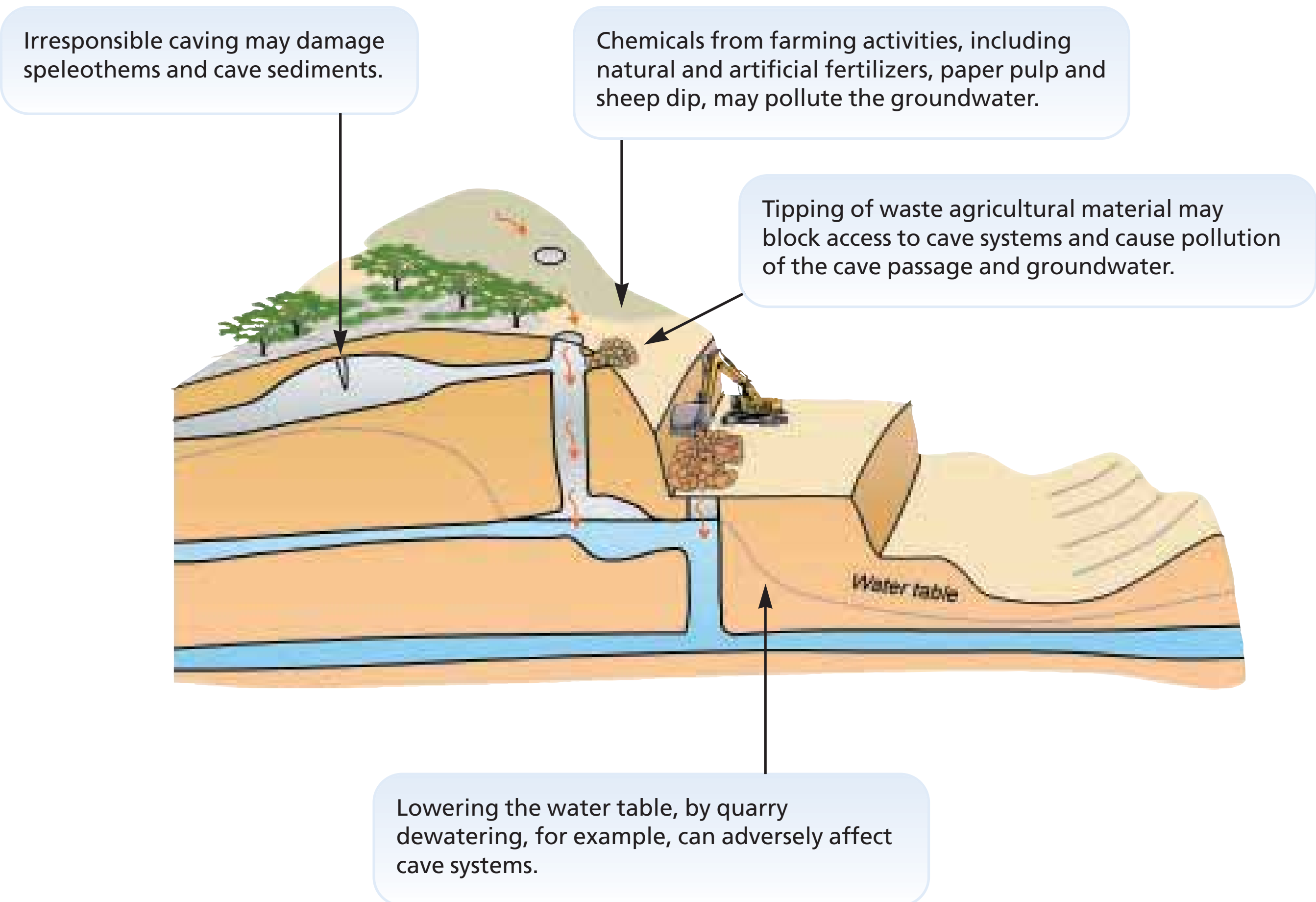
IC

Potential threats and management issues

- **Quarrying**
- **Inappropriate agricultural practices**
- **Changes in the water environment**
- **Development**
- **Irresponsible recreational activities**
- **Irresponsible specimen collecting**

Caves are sensitive systems which can be affected directly and indirectly by a range of processes. Quarrying can directly destroy cave systems. Indirect effects, which may originate outside of site boundaries, can be difficult to pinpoint and manage. Any process which affects the water table level or causes water pollution can damage or destroy cave systems. These include water abstraction, inappropriate use of fertilisers, distribution of certain types of waste material on farmland and dumping of effluent. Caves are also susceptible to damage by inappropriate caving activities, such as irresponsible removal of cave sediments. Irresponsible collecting of speleothems and minerals can also be a serious problem.

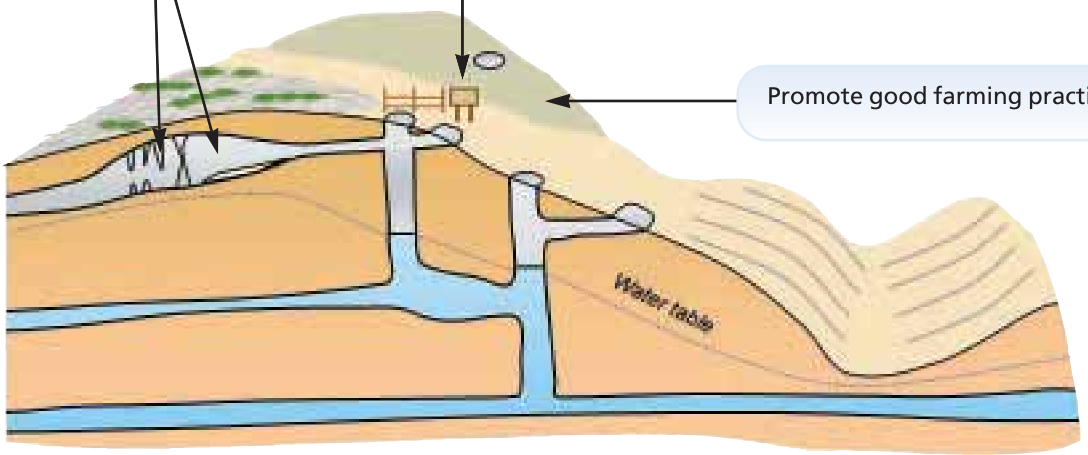
INAPPROPRIATE activities for caves



Speleothems and cave sediments should be left in situ and intact.

Promote good conservation practice through responsible caving groups. Access management by local caving groups is often effective in controlling visitor numbers. Literature and signs are useful in promoting good practice.

Promote good farming practices.



In areas near a cave system, conservation should be a prime consideration during any development planning to avoid direct or indirect damage to the cave systems.

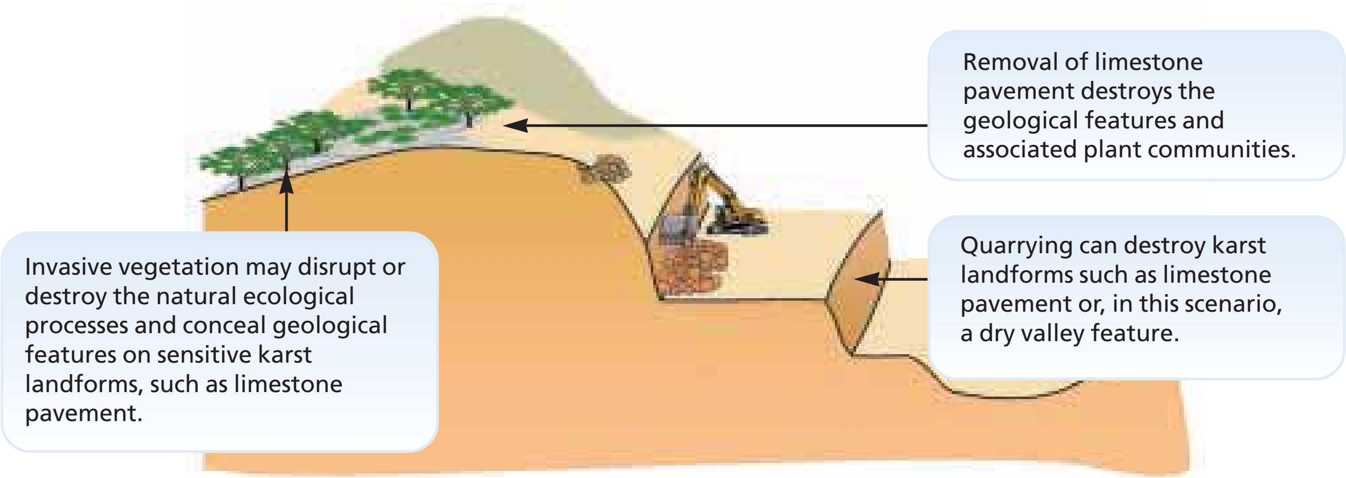
3.12 Karst

Potential threats and management issues

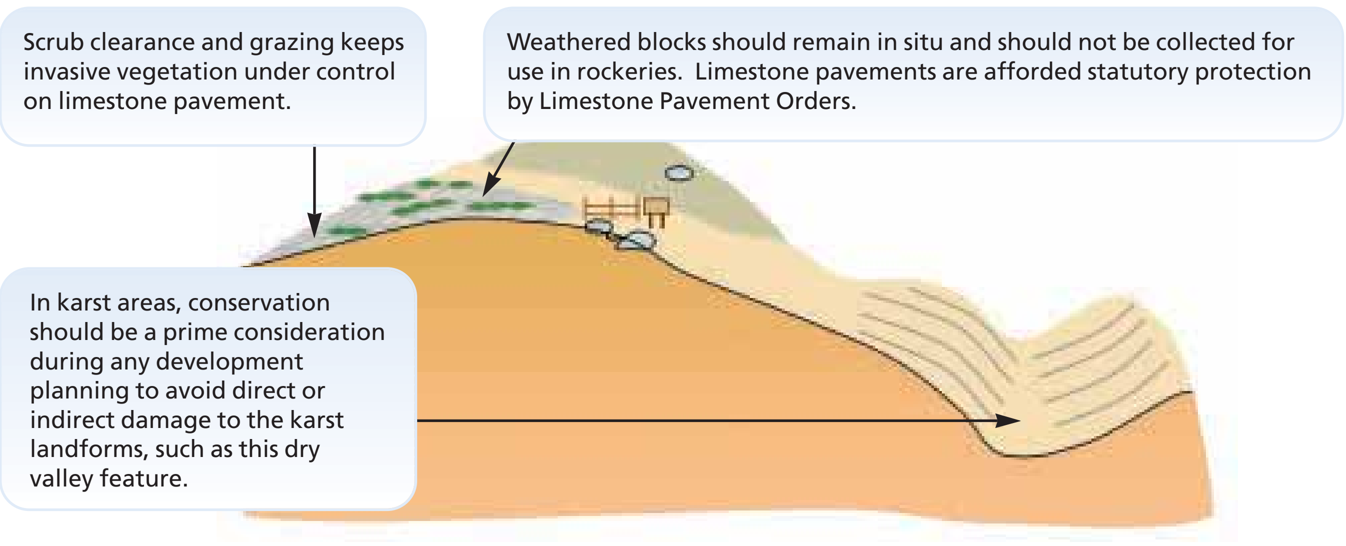
- **Quarrying**
- **Inappropriate removal of rock**
- **Infilling of natural depressions**
- **Vegetation encroachment**
- **Development**

Features in karst landscapes range from small-scale solution features to large landforms, such as dolines, limestone pavements and dry valleys. Karst features are sensitive and essentially irreplaceable if removed. Quarrying and any other forms of rock removal are generally highly damaging activities on karst. Limestone pavement is a particularly sensitive type of karst and is completely destroyed by removal of rock. Dumping of waste and infilling of karstic depressions is highly damaging. Vegetation management, including controlled grazing where appropriate, is often necessary. Developments, such as buildings, may be damaging and should be sited away from important or sensitive features.

INAPPROPRIATE management of karst



APPROPRIATE management of karst



3.13 Finite mineral, fossil or other geological

FM

Potential threats and management issues

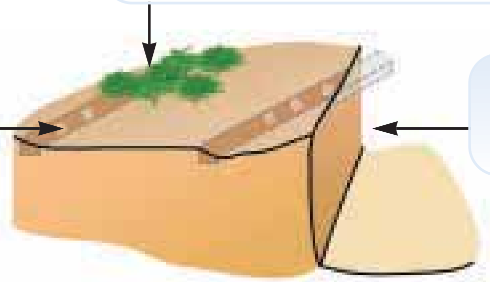
- **Irresponsible specimen collecting**
- **Quarrying and mining**
- **Development**
- **Vegetation encroachment**
- **Tree planting and afforestation**

These sites have a finite and irreplaceable resource. In some cases, the interest is unique and represents the only known example of a particular feature. The main management principle is to conserve the resource in the long-term, while permitting controlled scientific usage, which often involves specimen collecting. Integrating these opposing principles is the key to positive management. Irresponsible collecting is the main threat and, in extreme cases, can result in complete destruction of a site. Any other activity which requires removal of part or all of the interest features can cause irreparable damage or destruction. Vegetation can conceal the interest features and can occasionally be damaging. Tree planting and afforestation should be avoided near finite geological features.

INAPPROPRIATE activities

The growth of vegetation may obscure the interest features. In some cases, roots may damage the interest features.

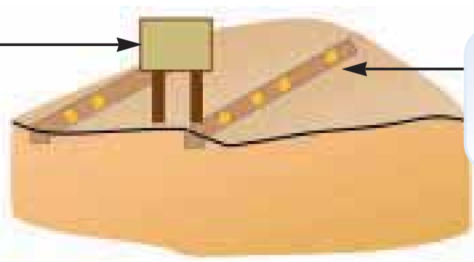
Rare mineral within a vein of limited extent completely removed by irresponsible collecting.



Quarry excavations or developments may destroy the geological interest.

APPROPRIATE management

Notice boards may help to deter collecting on sites where it is likely to damage the interest. Promotion of responsible collecting practices through notice boards and/or leaflets can be an effective conservation tool. Site wardens and fencing can be effective in deterring irresponsible collectors.



Rare minerals occurring within a vein of limited extent. The resource should remain in situ for future scientific study.

3.14 Mine dumps

FD

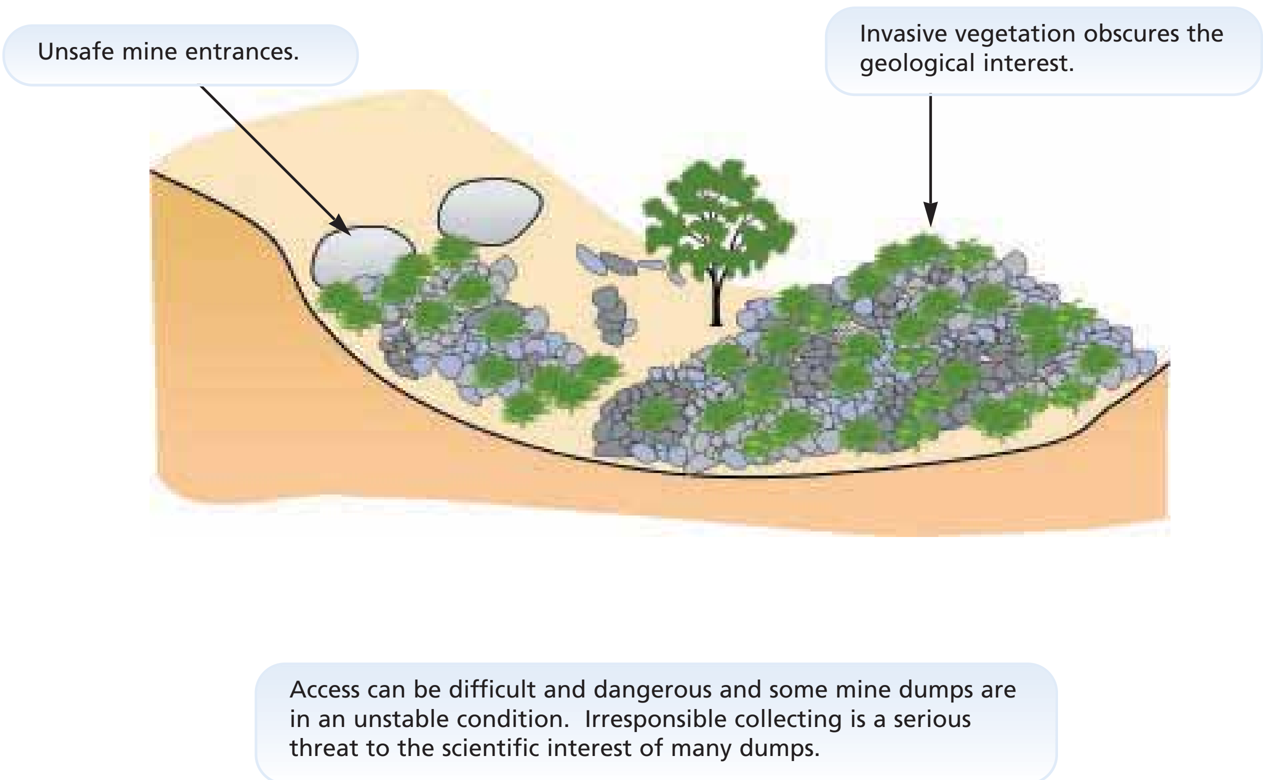
Potential threats and management issues

- **Irresponsible specimen collecting**
- **Large-scale removal of spoil**
- **Re-profiling and levelling**
- **Reworking of spoil**
- **Development**
- **Vegetation encroachment**
- **Tree planting and afforestation**

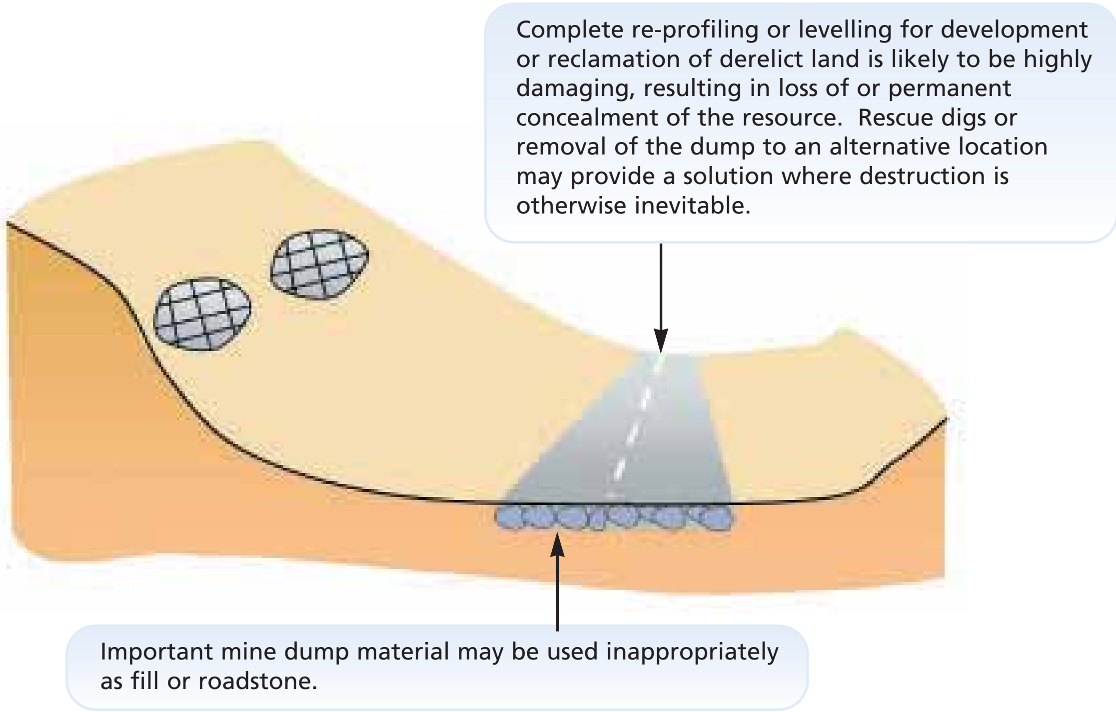
Mine dumps represent a finite and irreplaceable resource. Irresponsible collecting is a major threat to conservation of mine dumps. Tolerance to collecting depends on the extent of the resource, not necessarily the size of the dump. The use of permits, collection days and site wardens can help in deterring irresponsible collecting. Because important mineralogical material is often localised in particular parts of a dump, it is necessary to understand the distribution and quality of this material within the dump.

Removal of spoil for construction, for example, is likely to be highly damaging. Reworking, re-profiling and levelling are likely to severely damage or destroy the interest. Developments such as roads and buildings are also likely to be severely damaging. However, as context is often not geologically significant, removal of material to a rock store can be used as a last resort if destruction is inevitable. Vegetation management is often necessary. Avoid tree planting and afforestation near mine dumps.

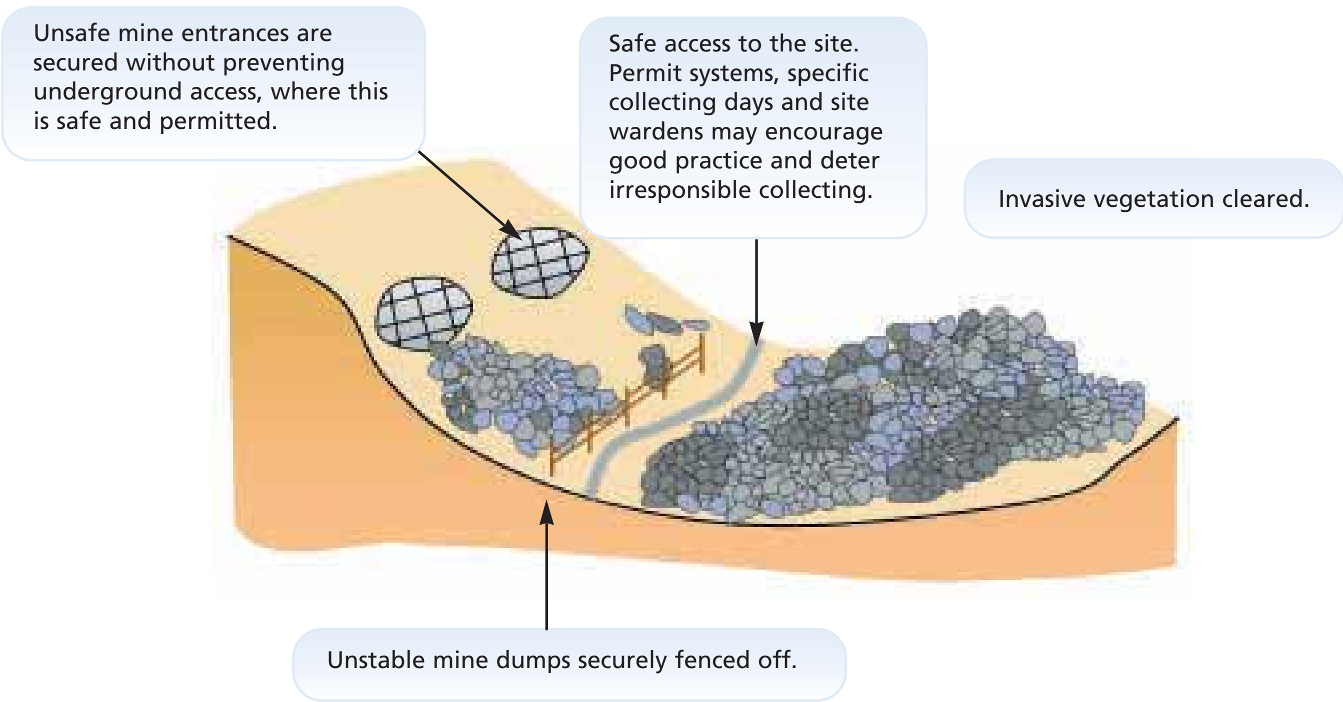
BEFORE appropriate management



INAPPROPRIATE re-profiling, levelling and development



APPROPRIATE management



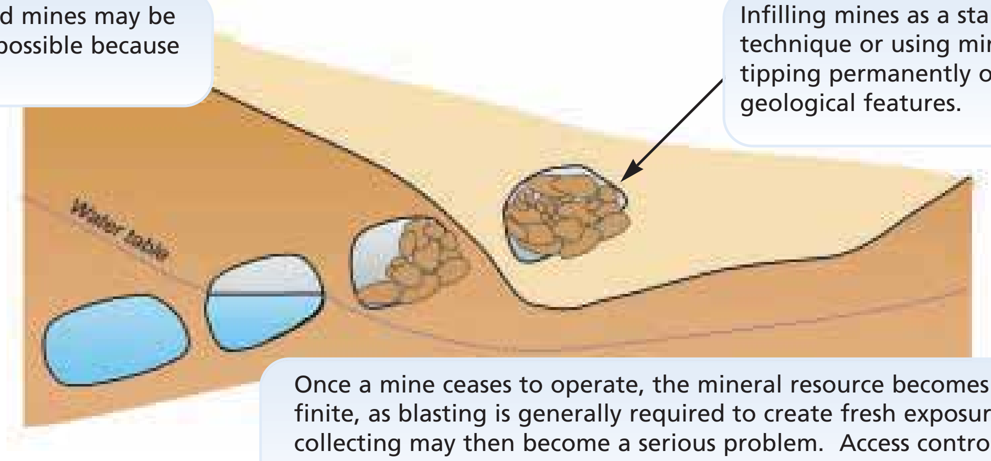
3.15 Finite underground mines and tunnels

Potential threats and management issues

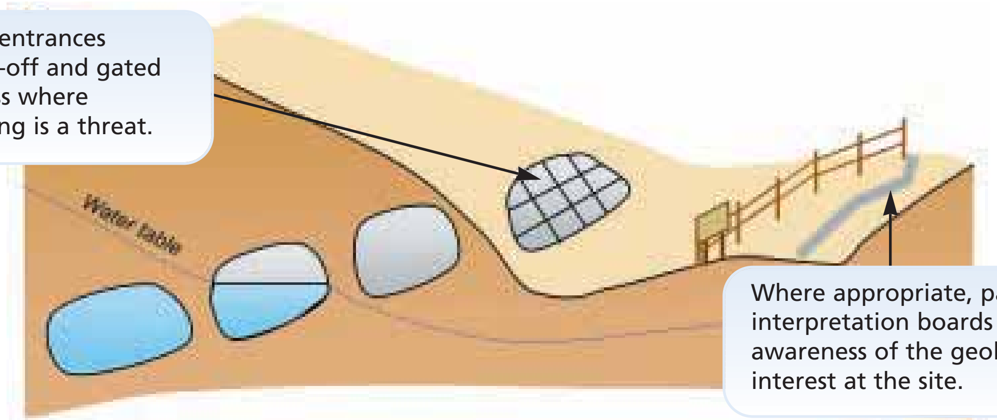
- **Flooding**
- **Collapse of mine passages**
- **Stabilisation by infilling of mines**
- **Irresponsible specimen collecting**
- **Fly-tipping**

Disused mines are often unstable and flooded and, therefore, very difficult and expensive to manage. It is usually not financially feasible to pump out disused mines and to maintain passages in a safe and stable condition. Stabilisation methods involving infilling the mines should be avoided, as this permanently obscures the geological features and prevents any future access for study. Irresponsible mineral collecting can be problematic on some sites, as the mineral resource usually becomes effectively finite once mining operations cease. Fly-tipping may be a problem in some cases. Effective conservation in disused mines, subject to collapse or flooding, can be extremely difficult to achieve without substantial resources.

INAPPROPRIATE use of finite underground mines



APPROPRIATE use of finite underground mines



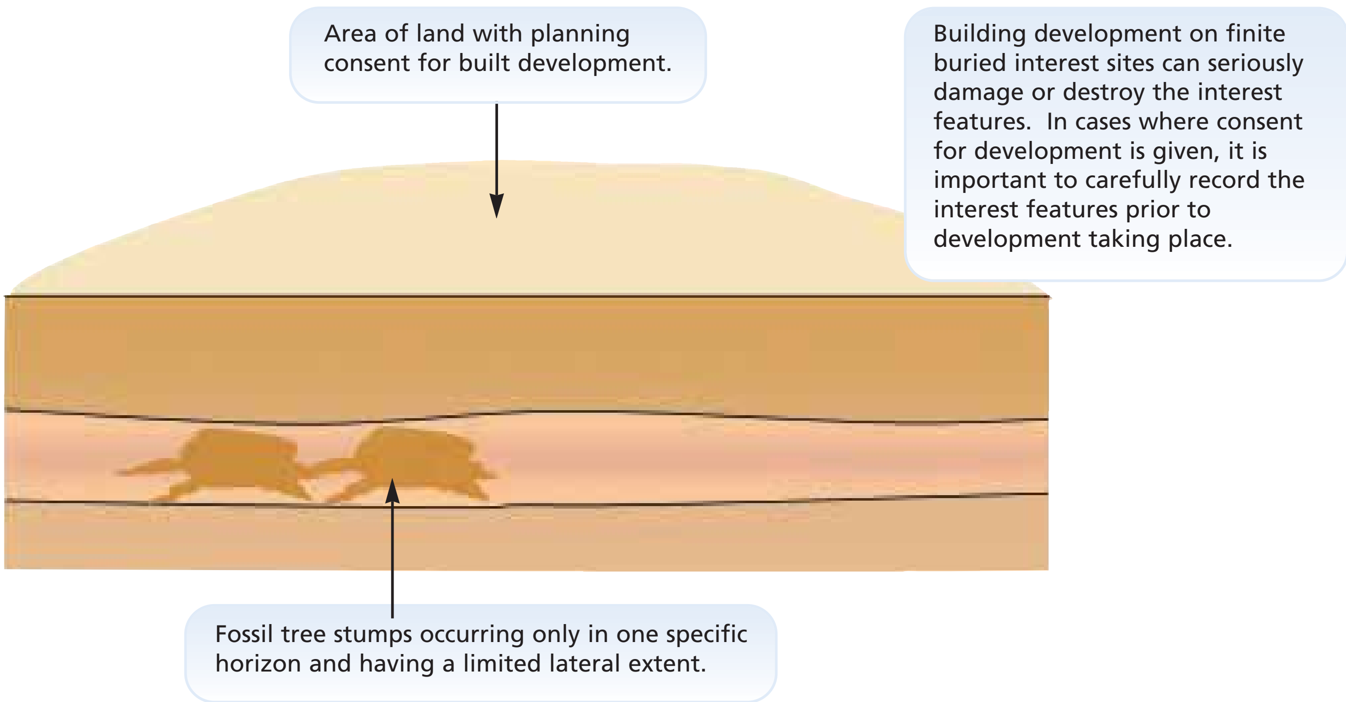
3.16 Finite buried interest

Potential threats and management issues

- **Inappropriate agricultural practices**
- **Tree planting**
- **Development**
- **Quarrying**
- **Removal of material**
- **Irresponsible specimen collecting**
- **Inappropriate recreational activities**

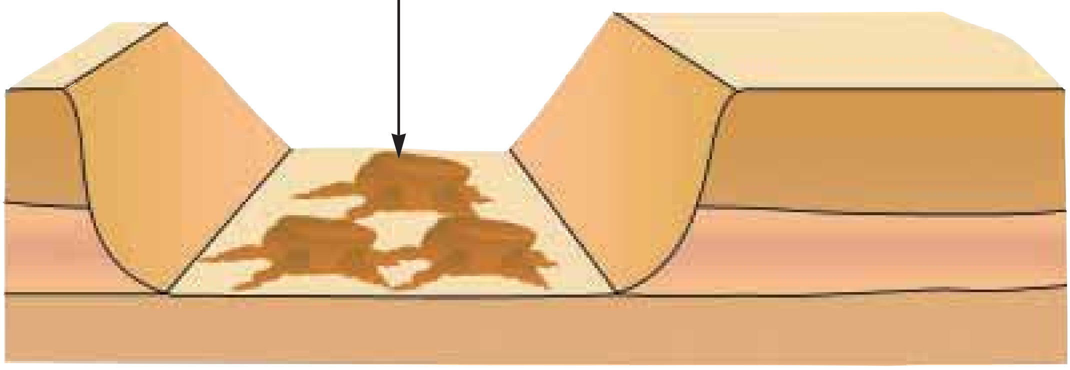
The primary management principles on buried interest sites are to limit disturbance or removal of the interest features and to maintain the sites in a condition whereby it is possible to access the interest features by boreholes and temporary excavations. Activities which can cause permanent damage to buried interest sites include deep ploughing, digging of drains, tree planting, quarrying and general development works, such as construction of buildings on top of the interest features. Recreational activities such as off-road driving and mountain biking may be damaging if they disturb the buried interest features. Finite features are particularly sensitive to removal of material and other activities which can deplete or conceal the resource. When assessing the potential impacts of such activities, it is important to understand the distribution of the interest features, as these may be laterally variable.

The stages in recording finite buried interest sites



The stages in recording finite buried interest sites

Planning conditions can ensure that a full programme of scientific excavation and recording of the finite interest features is carried out.



The stages in recording finite buried interest sites

After recording and sampling has been undertaken, re-burial of the remaining interest features ensures their future preservation.

Planning conditions or legal agreements can assist in ensuring development is avoided directly on top of or immediately adjacent to the finite buried interest features. This allows continued access should further re-excavation be required.

Activities causing deep rutting, as well as deep ploughing and tree planting, are also inappropriate directly above the buried interest features.