Strategic Environmental Assessment

Guidance for Practitioners

SEA Topic: Soil

Countryside Council for Wales

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Foreword

This Guidance Note forms one of a series which covers six of the topics which need to be taken into account when undertaking Strategic Environmental Assessment (SEA) of plans and programmes. The topics covered are:

- Air
- Biodiversity
- Cultural Heritage
- Landscape
- Soil
- Water

CCW will also be producing guidance on climate change for internal use and in the specific context of Wales and CCW's remit, whilst guidance on the 'Material Assets' topic is under discussion with the DCLG and the other SEA consultation bodies.

Guidance Notes on the SEA 'Topics of Population' and 'Human Health' have not been produced as these topics are largely outside the remit of CCW.

The aim of the Guidance Notes is to highlight the key topic related issues that need to be considered by practitioners who are carrying out or providing input into SEA. The notes have been written in non-technical language in order that they are accessible to a wide audience.

The Guidance Notes have been produced for CCW by the Centre for Sustainability (C4S) with specialist input from environmental consultants ADAS for some of the topics. They have been written in consultation with the Environment Agency (Wales) and Cadw, the Welsh Assembly Government's historic environment service.

It is intended that the Notes will be updated periodically in order that they remain current and relevant, taking into account changes in legislation, guidance and baseline trends.

The authors would like to thank officers from CCW, the Environment Agency and Cadw for the topic specific input they have provided in the preparation of the Guidance Notes. They would also like to acknowledge the contributions provided by officers from DCLG and WAG in relation to the generic text and document structure, and to officers from local authorities for providing input from their perspective as potential users of the guidance.

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Purpose and Structure of the SEA Topic Guidance Notes

This is one in a series of guidance notes from the Countryside Council for Wales (CCW) on topics to be covered in Strategic Environmental Assessment (SEA) under the SEA Regulations for Wales[1] which implement the European Directive on SEA[2]. The aim of these notes is to provide guidance to Welsh **Responsible Authorities** (the authorities by which, or on whose behalf the SEA is prepared) and others conducting SEA of plans and programmes, how issues related to certain SEA topics can be considered in the SEA of plans and programmes. These Guidance Notes also aim to help Responsible Authorities provide robust and sound reports which will enable CCW to comment and advise during the SEA process.

CCW provides information and advice related to the Habitats Directive and Regulations, and to protected species, designated sites including Sites of Special Scientific Interest (SSSIs) (including geological SSSIs), National Nature Reserves (NNR), Special Areas of Conservation (SAC) and candidate SACs, Special Protection Areas (SPA) and proposed SPAs.

Consultation in the SEA Process

CCW, Cadw and the Environment Agency (EA), have been designated as statutory '**Consultation Bodies**' in Wales in relation to the SEA Directive, and must be consulted at a number of stages during the SEA process (adapted from *The Practical Guide*):

- ***Screening*** – Determining whether a plan or programme requires SEA (NB: this is only required in a small number of cases);
- ***Scoping*** – Deciding on the scope, extent and level of detail of the information that must be included within the Environmental Report;
- ***Reporting*** – During full public consultation on the draft plan or programme and the Environmental Report; and

The advice that the Consultation Bodies aim to provide during periods of consultation is detailed in the '*Consultation Bodies' Services and Standards for Responsible Authorities in Wales*' (Environmental Agency *et al*, 2005).

NB: Where a plan or programme is likely to have significant effects on the environment in another Member State of the European Union, the SEA Directive requires that transboundary consultation should take place.

Annex 1(f) of the SEA Directive outlines the environmental topics that should be covered by the SEA process wherever relevant. These include Air, Biodiversity, Climate Change, Cultural Heritage, Human Health, Landscape, Material Assets, Population, Soil and Water. CCW is the statutory body responsible for advising on countryside, access, landscape and wildlife conservation in Wales. As regards SEA, CCW is primarily responsible for providing SEA consultation feedback and information on Biodiversity (including flora and fauna), Landscape and some aspects of Cultural Heritage issues, but also has an interest in the Soil, Water, Air, Climate Change and Material Assets topics.

Particular reference has been made to the requirements of "The SEA Regulations for the implementation of the Directive in Wales" and to the "Practical Guide to the SEA Directive" produced by ODPM[3], the Administrations in Wales, Scotland and Northern Ireland (referred to hereafter as *The Practical Guide*). This guidance note uses the SEA process as set out in *The Practical Guide* as a framework for the topic-related guidance (see Figure 1).

[1] The SEA Regulations for the implementation of the Directive, '*Welsh Statutory Instrument 2004 No. 1656 (W.170): The Environmental Assessment of Plans and Programmes (Wales) Regulations 2004*'.
[2] '*Directive 2001/42/EC of the European Parliament and of the Council on the Assessment of the Effects of Certain Plans and Programmes of the Environment*' (June, 2001)
[3] ODPM, the Office of the Deputy Prime Minister, was superseded by DCLG, the Department for Communities and Local Government, in May 2006

Link to the Environment Strategy for Wales

The Environment Strategy for Wales was published in May 2006 and includes a series of procedural and environmental 'outcomes' which the Welsh Assembly Government aims to achieve in the period up to 2026. Many of the Environment Strategy 'outcomes' are closely linked to the SEA topics and they have indicators which will be used to measure progress towards achieving the 'outcomes'.

The Strategy is supported by an Action Plan that provides details of the actions that will be taken to deliver the Strategy. This Action Plan includes milestones and responsibilities. It is also accompanied by a policy map which identifies the various influencing factors that will help in successful implementation of the Strategy. One of the contributory tools that is listed is Strategic Environmental Assessment.

Environmental Strategy outcomes which are linked to the SEA topics include:

- Climate change (outcomes 7 & 8); Material assets (waste) (9, 10, 11 & 39);
- Material assets (resources) (12, 17 & 18); Water (13, 14, 15, 31, 32, 35 & 36);
- Soil (16); Biodiversity (19, 20, 21 & 22); Landscape (23); Cultural heritage (26);
- Air quality (33); Human health (37 & 38).

NB: There are also other outcomes which cut across more than one SEA topic.

The 'outcomes' from the Strategy could be used when developing objectives for the plan that is subject to SEA.

Where appropriate the Indicators that are included in the Strategy should be considered for incorporation into the SEA assessment and monitoring frameworks.

Environment Strategy outcomes and indicators relating to the Soil topic can be seen in Table 7.

The Environment Strategy can be found at:
http://new.wales.gov.uk/topics/environmentcountryside/epq/Envstratforwales/?lang=en

STAGE A: Setting the context and objectives, establishing the baseline and deciding the scope	**A1:** Identifying other relevant plans, programmes, and environmental protection objectives
	A2: Collecting baseline information
	A3: Identifying environmental problems
	A4: Developing SEA Objectives
	A5: Consulting on the scope of SEA
STAGE B: Developing and refining alternatives and assessing effects	**B1:** Testing the plan or programme objectives against the SEA objectives
	B2: Developing strategic alternatives
	B3: Predicting the effects of the draft plan or programme, including alternatives
	B4: Evaluating the effects of the draft plan or programme, including alternatives
	B5: Considering ways of mitigating adverse effects
	B**6:** Proposing measures to monitor the environmental effects of plan or programme implementation
STAGE C: Preparing the Environmental Report	**C1**: Preparing the Environmental Report
STAGE D: Consulting on the draft plan or programme and the Environmental Report	**D1**: Consulting on the draft plan or programme and the Environmental Report
	D2: Assessing significant changes
	D3: Decision making and providing information
STAGE E: Monitoring implementation of the plan or programme	**E1:** Developing aims and methods for monitoring
	E2: Responding to adverse effects

Figure 1: SEA Process and Stages (Adapted from *The Practical Guide*)

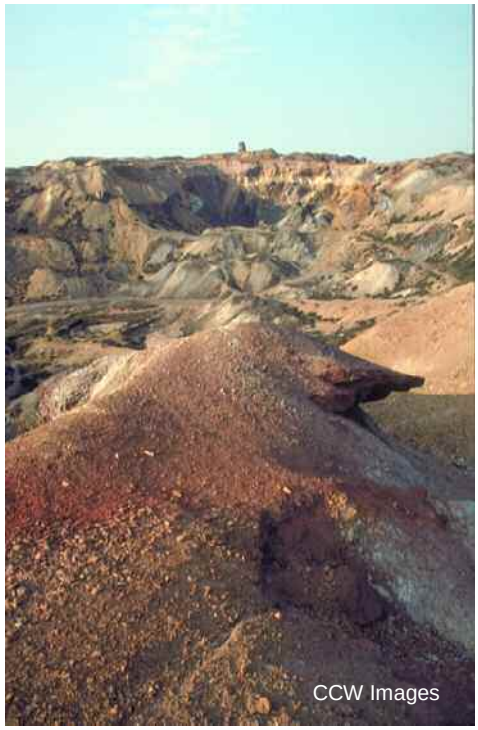
This Guidance Note focuses primarily on the topic specific advice at SEA Stages A, B and E and is supplementary to guidance on the SEA stages as set out in *The Practical Guide*.

Responsible Authorities should refer to *The Practical Guide* at all stages of undertaking SEA for Plans and Programmes, which sets out the SEA Directive legal requirements, procedures and methods.

See also *References and Further Reading* at the end of this note, for more topic specific information.

Soil in the context of the CCW Remit

In terms of the enhancement and promotion of soil protection, CCW advises on countryside, access, landscape and wildlife conservation aspects of soils in Wales. This includes providing government with advice that will enable emerging soil policies to take full account of natural heritage issues. CCW interest in soil protection relates to the intrinsic value of soil as part of the natural heritage and the functional value of soil in providing a broad range of ecological goods and services. For example, supporting plant communities and soil fauna, acting as a filter/buffer for pollutants or as a carbon store, repositories of palaeoenvironmental and cultural information and shaping the diverse landscapes of Wales. Soil protection measures will help in the management of key habitats, for example in our uplands where peat soils support heathland and blanket bog communities, healthy soils are a key factor in ecosystem services and habitat support. In these areas managing the risk of erosion and the degradation of soils through trampling and desiccation of peat soils will not only contribute to the maintenance of valued habitats, but will also limit the degradation of the wider environment caused by release of carbon dioxide to the atmosphere and dissolved organic carbon to watercourses. Good soil management is essential to sustain biodiversity and ecological functions in terrestrial, freshwater and coastal ecosystems.


CCW Images

CCW's focus is on nature conservation issues, but we also aim to participate, through working with our partners and the Welsh Assembly Government, to the wider, strategic delivery of sustainable use of soils in Wales. Issues of particular interest to CCW include the protection and conservation of peat and other high-organic soils that exist within Wales (Priority Habitats), contaminated land and how this should be remediated (air quality, including low-level ozone, water contamination, acid-mine drainage from mines etc), and the loss of permeable surfaces to development and non-porous surfaces.

Geodiversity issues, often associated with the Soil topic, are dealt with in the SEA Topic Guidance Note on Biodiversity and Geodiversity.

Background to the Topic: Soil

Soil and its Functions

Soil "*is a natural resource which provides an essential link between the components that make up our environment*" (DEFRA, 2004). There are six main functions of soil, as follows:

- *Support of ecological habitat and biodiversity:* Soil acts as an important habitat and genetic reserve for a wide variety of micro-organisms, invertebrates and larger soil dwelling animals (NB: 100 species of soil invertebrates and fungi are included in the UK Action Plan to protect biodiversity (UKBAP)).
- *Food and fibre production:* Soil is the basis for all agriculture and is vital to the production of food, timber and energy crops. Nutrients and water are stored in the soil, and it supports plant root growth.
- *Environmental Interaction:* Soil links the atmosphere, geology, water resources and land use. It can act as a filter, attenuates and immobilises pollutants, and takes up, stores and releases atmospheric gases. It also regulates the drainage of rain water to the groundwater, and influences river flows and flooding.
- *Providing a platform:* Soil acts as the foundation for building and other development. Natural landscapes reflect the different soil types that they contain.
- *Providing raw materials*: Soil is a direct source of minerals and resources, such as brick earth, peat and topsoil.
- *Protecting cultural heritage:* Soil stores and protects much of our cultural heritage, including archaeological remains (EA, 2004).

Soil Types

Soil type is determined by the parent material from which it is derived and the various natural processes that have acted on it over time (such as rainfall, temperature, groundwater level, soil organisms and plants). However, human activity (including agriculture, forestry, and development) can also have a significant effect on soil, leading to modification or damage. Where damage is severe, the soil may no longer be able to perform key functions.

Wales' landscape and geology is extremely diverse, and contains a wide range of soil types that are reflected in land use throughout the country. Variation in soil types is an important element of biodiversity, as soil type largely determines the range of plants and animal species in any one area. Therefore a lack of conservation of soil diversity will negatively affect attempts to preserve biodiversity (Conway, undated). Hard sedimentary rocks underlie the majority of Wales, which are then overlain by a characteristic suite of acid soils, characterised by a peaty surface horizon. Less than 5% of Wales' land area is covered by thicker peat, organic material of at least 40cm in depth (CEH *et al*, 2002). The major soil groups and their extents in Wales are shown in Table 1.

Table 1: Major Soil Groups and their extent in Wales (Adapted from CEH *et al*, 2002)

Major Soil Group (MG)	Extent in Wales (%)	Description
1. Terrestrial raw soils	<0.1	Very young soils with only a superficial organomineral layer
2. Raw gley soils	0.2	Unripened young soils of saltmarshes
3. Lithomorphic soils	2.2	Shallow soils without a weathered subsoil
4. Pelosols	0.1	Clayey 'cracking' soils
5. Brown soils	30.2	Loamy, permeable soils with weathered subsoil
6. Podzolic soils	32.3	Acid soils with brightly coloured iron enriched subsoil
7. Surface-water gley soils	24.7	Loamy and clayey seasonally waterlogged soils with impermeable subsoil
8. Groundwater gley soils	3.4	Soils associated with high seasonal groundwater
9. Man-made soils	0.4	Restored soils of disturbed ground
10. Peat soils	3.4	Soils in deep peat.
Unclassified land (urban)	3.0	

Peat covers 3% to 4% of Wales and is predominantly acid upland blanket peat, but with small areas of raised bog and fen peat scattered throughout lowland Wales. Peat land supports ecosystems of considerable biological interest and provides a record of vegetation, land use and human cultural activity.

By their nature, peat and other high organic matter soils are important reservoirs of carbon. Some of the deepest soil profiles in Wales have resulted from the widespread development of peat; estimates of the total extent of peat in Wales range between 70,600 (Rudeforth et al. 1984) and 84,200 ha (Taylor and Tucker, 1968). A reinterpretation of these studies estimated the area of blanket peat in Wales to range between 63,500 and 78,000 ha (Yeo, 1997). These estimates exclude organo-mineral soils with peaty upper horizons. In the present context, peat soils represent a special case for the following reasons:

- Peat soils are especially susceptible to erosion and degradation through trampling, overgrazing, burning, atmospheric nitrogen deposition and afforestation, and oxidative wastage in response to drainage and climate change. The consequences for peatland vegetation can be devastating, with knock-on effects for water quality, carbon sequestration, and the runoff characteristics of upland catchments;

- Many Welsh peatlands originated during periods climatically favourable for peat formation; the loss of peat is thus likely to be irreversible at many locations;

- Peat soils are one of the defining characteristics of a range of BAP priority peatland habitats in Wales. Any loss or degradation of the peat soil resource thus has a direct effect on habitat extent and quality;

- Peat soils preserve an irreplaceable record of vegetation and climate change and past human activity. This record is easily damaged by inappropriate management, even where this does not result in direct loss of the soil resource; and

- Damage to any part of a peatland unit can have wider consequences for the peat body as a whole.

Peat soils should be subject to particular attention in the undertaking of SEA assessments of plans which have the potential to affect these soils. Developments which result in the direct loss of peat or which have the potential to interfere with natural hydrological processes in peat are unlikely to be acceptable, and impact assessment studies at project level should include detailed assessments of peat depth, peat type, and hydrology, including the distribution and functionality of macroporous features such as peat pipes. Many areas of peat are 'protected' and, as detailed in the Mineral Planning Policy for Wales (WAG, 2000); peat extraction should only be allowed under exceptional circumstances.

In England and Wales, peat soil is classified as an organic deposit at least 40cm deep (although it can often be several metres in depth), which contains greater than 50% organic material (excluding leaf litter and moss) within the top 80cm of the profile or with more than 30cm of organic material over bedrock (Avery, 1980). Rudeforth et al (1984) use this definition to estimate some 70,600 ha or 3.4% of Wales' land area comprising peat soils. A map of the soils found in Wales can be found at http://www.countryside.wales.gov.uk/fe_maps/maps_browse.asp?imgcat_id=1.

'True' peat soils are not the only 'organic' soils of interest in terms of their natural heritage interest in Wales. For example, peaty topped organo-mineral soils are also of interest as they are characteristic of and support a range of UK BAP priority habitats and their associated wildlife.

The combination of high organic content and extent of organo-mineral soils (414,000ha or nearly 20% of Wales' land area) makes organo-mineral soils an important reservoir of carbon. There is evidence that turnover of carbon within these soils is rapid. Gley soil carbon stores in particular may be at risk from changes in climate.

In terms of agriculture, soil type is one of the factors affecting the quality of agricultural land as defined by the Agricultural Land Classification system. In general priority should be given to protecting land of higher quality (Grades 1, 2 and 3a) from development (see TAN6). Compared to England, Wales has a much lower proportion of Grade 1, 2 and 3a land. Much of this higher quality land lies within Wales' development 'hot-spots', in the north-east and south-east.

Soil Quality and Threats

Examples of threats to soil diversity and quality, which may include contamination, are provided in Table 2.

Table 2: Examples of Threats to Soil Quality and Quantity

Threats		Impact on Soils	Potential Mitigation
Agriculture	Draining Soils	Negative effects on diversity, structure and function of the soil. Biodiversity is reduced and soil erosion can occur.	Farmers participating in environmental schemes that encourage good soil management and reduce/make optimum use of fertiliser, farmyard manure, slurry, off-farm organic wastes and pesticides. Improvements can be made in soil management, including cross compliance with Good Agricultural and Environmental Condition and Entry Level (ELS) Soil Management plans
	Intensive agriculture regimes	Soil can become damaged where nutrients are removed from the soil and fertilisers are added, and water quality affected. Persistent chemicals or excess nutrients can accumulate in soils, therefore, land managers should take into account all inputs from land spreading and other sources	

	Changes in land management	Can lead to significant changes in the soil biota (invertebrate multicellular animals that live in the soil or in close contact with the soil). It can subsequently impact on biologically mediated processes and soil functions (SNIFFER, 2004).	
Development	Construction	Soil degradation and loss of topsoil during stripping and storage, contamination as a result of accidental spillage or the use of chemicals, compaction due to the use of heavy machinery, erosion by surface water runoff or by wind, changes in drainage, reduced oxygen and ultimately the death of soil organisms. Sealing of soils with new impermeable surfaces will result in reduced gaseous exchange and water storage. There is also a risk to soils through physical mis-management in construction, for example putting the sub-soil back on top of the topsoil (SNIFFER, 2004).	During the initial development stages of a construction site, care should be taken to strip and store topsoil, if necessary, separately from subsoil and other materials. Minerals Planning Policy (Wales) – Minerals Technical Advice Note 1: Aggregates (WAG 2004) provides advice on soil storage and handling). Plant cover can be established on soil piles if these are expected to be stored for an extended period; and trafficking on or moving soils when they are wet should be avoided, to help maintain their properties. The severity of chemical and oil spills can be reduced by prompt action using spill kits.
	Operational Phase	Deposition of gaseous emissions from industrial processes or vehicles, infiltration of polluted run-off and spray from roads and car parks and the use of fertiliser, herbicides or pesticides in landscape management (SNIFFER, 2004).	The implementation of Sustainable Urban Drainages Systems (SUDS) aids the management of surface water runoff in a more sustainable way than a more traditional drainage system. A SUDS system uses the natural drainage and filtering capacity of soils to slow the passage of water to rivers, so reducing pollution and flooding risk. This includes using the natural capacity of soils to help prevent increases in flood or water pollution risk downstream of development (CEH *et al*, 2002).

Contaminated Land and Contaminants

Due to the long industrial history of Wales, there is a substantial legacy of land contaminated by a range of toxic chemicals stored in the soil. These contaminants may include metals, hydrocarbons and other organic pollutants, pathogens and substances that acidify and/or enrich soils with pollutants. A survey in the 1980s identified more than four thousand hectares of potentially contaminated land in Wales, at 749 potentially contaminated sites. The survey revealed that the majority of contaminated land sites were in West Glamorgan and Mid Glamorgan, regions of the industrial south Wales, with 27% and 20% respectively (EAU, 1988).

Contaminants introduced into the soil can result in the decline or loss of ecosystem services provided by soil. When spoil or land becomes contaminated, a risk may be posed to groundwater quality and it becomes a deterrent to future development. It can also be a risk for surface water if there is run-off or leaching. Other risks associated with contaminated land relate to human health and ecology.

The Environment Agency and DEFRA have published *Soil Guideline Values* and the *Contaminated Land Exposure Assessment* model to provide an objective basis for decision making on options for clean up and use of contaminated land. In terms of potential impacts on ecosystems, the Environment Agency is developing an Ecological Risk Assessment framework for determining the risk of harm to defined eco receptors on contaminated land.

Some contaminated sites support habitats and species of high conservation value. Many sites also have cultural and archaeological importance and may need to be protected for these purposes. These issues are considered in the Metal Mine Strategy for Wales 2002.

Diffuse Soil Contamination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Diffuse pollution is distinct from local (point source) contamination of soil which originates from clearly defined sources. Diffuse pollution is typically linked to atmospheric deposition, some farming practices and inappropriate waste recycling and treatment.

Pollution from atmospheric deposition is due to emissions from industry, transport and agriculture. Soils are exposed to acidifying contaminants (sulphur dioxide, nitrogen oxides, and ammonia), heavy metals and man-made organic compounds. The Chernobyl accident in 1986 and global fall out from nuclear weapons testing have resulted in widespread radio active caesium contamination in Welsh soils.

Acidification of soils in Wales is extensive because of a combination of high 'acid deposition rates' and soils with low calcium and magnesium content which cannot neutralise the acid deposition. 59% of Welsh soils exceed 'critical loads' for acid pollutants.

Deposition of ammonia and nitrogen deposition from transport, industry and agriculture also result in unwanted nutrient enrichment and leads to a decline in biodiversity and habitats.

Although agricultural land use in Wales is generally less intensive than in England, a number of farming practises can also be regarded as a source of diffuse pollution. Nutrient imbalances in soil from fertiliser use can lead to contamination of ground and surface water. Soil erosion is also a significant source of diffuse water pollution and there are concerns relating to heavy metal accumulations.


CCW Images

Soil Sealing

Sealing of soil surfaces, by covering them with buildings and roads and other land developments reduces the area available for soil to carry out its many essential functions including filtering and absorbing rainwater (reducing surface run-off/flood control and replenishing groundwater), exchanging atmospheric gases and providing a habitat for soil organisms. Sealed areas also impact on surrounding soils and habitats by changing hydrology and increasing the fragmentation of biodiversity can lead to increased surface run-off. Where possible, porous materials (for example block surfaces instead of tarmac for roads) should be used in surfacing. The natural flood control functions of soil should be employed in rural and urban land use to ensure sustainable flood management (EA, 2004).

Soil Erosion

Soil erosion can be accelerated by human activities such as inappropriate cultivation, handling and storage of soil during development, construction on steep slopes, undercutting of steep slopes, overgrazing and excessive footpath or vehicle use. Consequences of soil erosion can include landslides, and pollution of watercourses.

Soil Compaction

Soil compaction occurs when soil is exposed to mechanical pressures, especially when wet. Heavy machinery, overgrazing and some recreational activities are the main contributing factors. Compaction results in the deterioration of soil structure which reduces its water storage and gaseous exchange capacity, fertility, biological activity and restricts root growth. In addition, compaction reduces the stability of soil and can increase the risk of erosion.

Soil, Water and Air quality

Soil, water and air are strongly interdependent, with soil being the essential link between the atmosphere, surface and ground-waters, above-ground habitats and human activity. Soil forms these links through its role in controlling the flow of water in the water cycle, by exchanging gases (e.g. carbon dioxide) with the atmosphere and by storing, degrading and partly transforming water, energy, mineral, organic matter, nutrients and contaminants that are introduced to the soil through natural processes and human activities or deposited through aerial pollution or flood waters.

In terms of interactions between soil and water, the main issues are nutrient leaching, erosion, water resources and flood risk. Eroded soil and any associated contaminants often end up in watercourses, changing water chemistry and ecology and smothering river bed gravels. Agricultural soils are a major source of water pollution.

Both ground and surface water resources are affected by soil type, land use and management which can affect how much water percolates into soils and recharges groundwater. Soil erosion can directly reduce surface water resources by reducing reservoir capacity. Soils also have an important role in reducing flood risk by slowing the passage of heavy rainfall to surface water. Soil sealing and soil structure degradation prevents soil from performing this essential function.


CCW Images

Air pollution and climate change are the most notable issues concerning interactions between soil and air. Air pollution and acid rain affect soils as the emissions of gases such as sulphur dioxide and nitrogen oxides contribute to the acidity of rainfall, and consequently affect soil and vegetation (Conway, undated). Deposition from air also causes widespread contamination of soil by heavy metals and persistent organic compounds (diffuse soil contamination).

In terms of climate change, over 90% of terrestrial carbon in the Welsh landscape is contained in soil. Changes in land use, such as draining peat and converting grassland to arable, cause oxidation of organic matter. This releases carbon dioxide into the atmosphere thus contributing to climate change. Soil also releases strong greenhouse gases such as nitrous oxide and methane into the atmosphere, although well drained aerobic soils can provide a sink for atmospheric methane. The production of nitrous oxide is enhanced when inorganic nitrogen fertilisers, farmyard manure, slurry are returned to the soil.

Where measures are undertaken to protect or maintain air and water quality, the functional burden on soils may increase, as soils are often the final recipients of any contaminants removed from these media. Soil functions are often impaired following contamination, which may also affect human health and food quality. It is important to avoid pollution swapping – that is by protecting one medium (i.e. water or air) the soils are not inappropriately damaged. Soils can also be damaged, often irreversibly, through using land for buildings and transport infrastructure.

Soil should be accorded the same priority in environmental protection as air or water. Contamination of soils from any source should be avoided whether localised or diffuse. In controlling emissions to air and water, full account must be taken for the implications for soils.

Climate Change and Soils

Climate change is likely to affect soil in a variety of ways and should be considered where appropriate in SEA. The effects are likely to modify the key soil processes that underpin the capability of soil to perform its many functions, and will have implications for agriculture, forestry, natural heritage, the environment, civil engineering and the preservation of cultural heritage. Temperature, rainfall and changes in atmospheric carbon dioxide directly influence soil processes, particularly as these also affect soil ecology and organic matter. This in turn affects soil structure, water regimes and plant growth. In addition, rainfall intensity, duration and amount could exacerbate soil erosion, and this would constitute a significant loss of stored carbon either as greenhouse gas emissions to the atmosphere or as particulate organic carbon affecting water quality. Organic soils could also increase significant amounts of dissolved organic carbon causing discolouration and nutrient enrichment of waters.

Soils are an important mediator of climate change as it stores large amounts of carbon and exchanges greenhouse gases (carbon dioxide, methane, nitrous oxide) with the atmosphere. The UK Climate Change Programme estimates that UK soil carbon stocks are in the order of 10,000 billion tonnes. Carbon dioxide is naturally released from soil by the decay of organic soil matter by soil organisms. The balance of these processes is greatly modified by human activities. Soil is also a source of the important greenhouse gases methane and nitrous oxide, which have 21 times and 310 times (respectively) greater Global Warming Potential per molecule than carbon dioxide on a 100 year horizon (IPCC, 2001).

Human activities that contribute to enhanced production of greenhouse gases from soil include drainage of peats and organic soils, use of nitrogenous fertilisers and manures etc.

There is growing evidence of increased carbon loss from Welsh soils. These changes are most critical in peatlands and organic soils. The ECOSSE report (Scottish Executive and Welsh Assembly Government, 2007), which focuses on the estimation of carbon in organic soil sequestration and emissions, presents new estimates about the carbon stored in organic soils in Wales (196Mt). The report reaffirms the view that development on peat/organic soils is rarely, if ever, acceptable.

Stage A: Setting the context and objectives, establishing the baseline and deciding on the scope

A1: Identifying other relevant plans, programmes and environmental protection objectives

Table 3 below lists relevant plans, programmes, policies and legislation that should be taken into account in relation to SEA work on the Soil topic and Table 4 provides an example of a review of one document. It should be noted that the list below is not definitive as legislation and guidelines are subject to change.

Table 3: Potential plans, programmes, objectives, policies and legislation to be taken into consideration for the Soil Topic

International
• EU 6th Environmental Action Programme
• EU Environmental Liability Directive 2004/35/EC (2004)
• EU Soil Thematic Strategy (2006)
• EU Thematic Strategy on Soil Protection: Report of the Technical Working Group (2004)
• Groundwater Directive (80/68/EEC)
• Nitrates Directive (91/676/EC)
• Environmental Protection Act (1990)
• Sludge Directive 86/278/EEC
• EU Communication on Soil
• European Soil Charter (Council of Europe 2003)
• Water Framework Directive- future measures under RBMPs
• Proposed Assessment and Management of Floods Directive (COM(2006)15)
• Habitats Directive (92/43/EEC)
• Convention on Long Range Transboundary Air Pollution
• Landfill Directive

• Environmental Liability Directive • Air Quality Framework Directive • UNCCD National Action Programmes • National Emissions Ceiling Directive • Convention on Biological Diversity • EU Forestry Strategy/Action Plan • EU Common Agricultural Policy Reform 2003
National
• UK Soil Indicators Consortium (DEFRA) • The First Soil Action Plan for England (Defra, 2004) To be replaced shortly by the Second Soil Action Plan (provides useful generic context) • Welsh Soils Action Plan (under development) • Environment Agency Soil Strategy – under development • TAN 6 – Agricultural and Rural Development (June 2000) • Remediation of Contaminated Land (2001) • Code of Good Agricultural Practice for the Protection of Soil (1998). Currently being revised. New title likely to be 'The Environment Code', as it will combine the codes for Soil, Water and Air. • Identification and Development of a set of National Indicators for Soil Quality (2002) (R&D P5-053/PR/02) • Sludge Regulations 1989 • Nitrate Vulnerable Zones Regulations • Wise About Waste - The National Waste Strategy for Wales (WAG, 2002) • IPPC Regulations • Waste Incineration (England and Wales) Regulations 1994 • CoMAH Regulations • Countryside and Rights of Way Act (2000) (CRoW Act) • UK BAP and Priority Habitats in Wales (CCW, 2002) • Part 2A of the Environment Protection Act 1990 • Welsh Forestry Strategy – 'Woodland for Wales' (2001) • Sustainable Development Acton Plan 2004-2007 (WAG) • Soil Scoping Study (WAG, 2002)
Regional/Local
• Contaminated Land Strategies (e.g. Conway, 2006) • National Park and AONB Management Plans

Table 4: Example of review of other relevant plans, programmes, objectives etc

EU Soil Thematic Strategy (2006)	
The Soil Thematic Strategy is seeking to: • establish common principles for the protection and sustainable use of soils; • prevent threats to soils, and mitigate the affects of those threats; • preserve soil functions within the context of sustainable use; and • restore degraded and contaminated soils to approved levels of functionality. The Soil Thematic Strategy proposes the introduction of a Soil Framework Directive.	
Objectives and requirements	**Implications for the Plan or Programme**
The overall objective of the Strategy is protection and sustainable use of soil, based on the following guiding principles: (1) Preventing further soil degradation and preserving its functions: – when soil is used and its functions are exploited, action has to be taken on soil use and management patterns, and – when soil acts as a sink/receptor of the effects of human activities or environmental phenomena, action has to be taken at source. (2) Restoring degraded soils to a level of functionality consistent at least with current and intended use, thus also considering the cost implications of the restoration of soil.	The plan or programme should take into account the objectives of the Strategy and where appropriate take measures to protect and restore soils. **Affected issues:** soil, water and biodiversity

Informal consultation, with statutory consultees (referred to here as 'Consultation Bodies') and non-statutory consultees, is also a useful tool for identifying relevant plans, programmes, objectives etc (see Stage A5 for more information on consultation).

Draft Welsh Soils Action Plan

As one of the commitments from the Environment Strategy for Wales, the Welsh Assembly government is developing a Welsh Soils Action Plan. This identifies the priority threats to Welsh soils as:

- Climate Change
- Soil Sealing
- Contamination, including Acidification and Eutrophication
- Soil Erosion
- Degradation of Soil Structure
- Decline in Organic Matter
- Soil Loss to Extraction

The Action Plan is being released for public consultation in Autumn 2007.

A2: Collecting Baseline Information

Box 1 below describes some potential sources of baseline data for the Soil topic. Box 2 provides some key facts and figures about this topic. Once again, consultation bodies and non-statutory consultees may be good sources of data.

Box 1: Relevant and Appropriate Sources of Baseline Data – Soil

Soil Maps

- National Soils Resource Institute (NSRI) website: http://www3.landis.org.uk/soilscapes/ (shows Soilscape data in map format)
- Countryside Survey 2000 (Defra, Natural Environment Research Centre): http://www.cs2000.org.uk/ (land cover census for Great Britain and Northern Ireland, including habitat types, hedgerows, plant species and freshwater invertebrates)
- CCW – Register of Historic Landscapes: http://www.ccw.gov.uk/landscape--wildlife/protecting-our-landscape/assessing-the-landscape/historic-landscapes/historic-landscapes-register.aspx
- WAG maps: http://www.countryside.wales.gov.uk/fe_maps/maps_browse.asp?imgcat_id=1 (Agricultural Land Classification, National Soil Map or Wales)
- NB: If considering cross-border issues relating to England, the MAGIC Website available at URL: http://www.magic.gov.uk/website/magic/ has Soilscape maps and Agricultural Landscape Classification data

Soil Quality and Erosion

- Environment Agency – EA (2004) The State of Soils in England and Wales: http://www.environment-agency.gov.uk/commondata/acrobat/stateofsoils_1747056.pdf (soil erosion)
- Centre for Ecology and Hydrology - CEH (2002) Critical Appraisal of State and Pressures and Controls on the Sustainable Use of Soils in Wales: http://bangor.ceh.ac.uk/English/reports/SSSFinalreport.htm (soil quality - acid and nitrogen deposition)
- Geochemical Baseline Survey of the Environment (G-BASE): http://www.defra.gov.uk/environment/land/soil/research/monitoring/g-base.htm (geochemical mapping, including soil)
- Soil Survey of England and Wales - Soils and their use in Wales. Soil Survey Bulletin No. 11. Harpenden 1984
- Local Authority Contaminated Land Strategies
- Agricultural Land Classification (ALC) - Best and Most Versatile Land Classifications

Box 2: Wales Soil Facts and Figures

- Erosion moves some 2.2 million tonnes of arable topsoil annually and 17% of soils show signs of erosion (EA, 2004) in England and Wales.
- Loss of nitrate from agricultural soils is causing failure in drinking water standard in some groundwater sources and is contributing to some eutrophication in estuaries and the sea in England and Wales (EA, 2004).3% of Wales has been designated as Nitrate Vulnerable Zones (EA, 2004).
- The predominant land uses in Wales (2005) are grazing (72%), woodland (14%) and urban areas (10%) (NAW, 2006).
- It is estimated that 34% of soils in Wales are affected by acidic deposition, and in these areas about 50% of the first to third order streams (first order streams are the smallest streams – the scale goes up to twelfth order streams) may have been damaged (Ferrier, 2003).
- More than 40% of the total area of Sites of Special Scientific Interest (SSSIs) in Wales is potentially damaged by freshwater acidification (Ferrier, 2003).

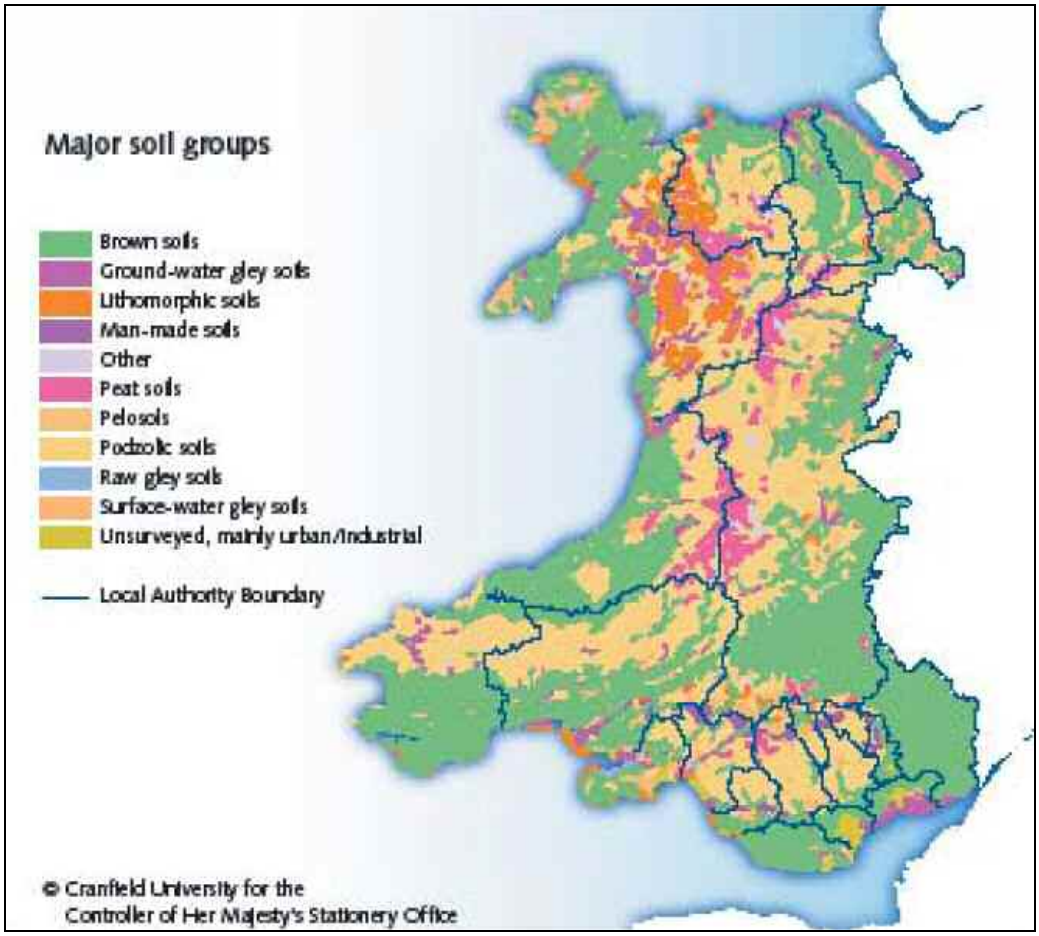

Figure 2: Soils in Wales (Source: NAW 2006)

A3: Identifying Environmental Issues and Opportunities

Environmental issues and opportunities are identified following the work undertaken in stages A1 and A2 and stage A3 often benefits from stakeholder workshops. Table 5 provides examples of various Soil issues in Wales and their trends, based on available baseline information.

Table 5: Examples of Soil Issues in Wales

Soil Issues affecting Wales	Description
Areas of contaminated land	The long industrial history in Wales has resulted in a substantial legacy of contaminated land.
Water Quality	Loss of nitrate from agricultural soils can cause failure of drinking water standards and contribute to eutrophication in estuaries and the sea (EA, 2004). Eutrophication can also be caused by excess phosphate entering water bodies, usually via soil erosion.
Contamination from air	Large areas of Wales are vulnerable to acidification and nitrogen deposition which is partly due to airborne sulphur and nitrogen compounds from industry and transport.
Soil Erosion	Soil erosion is an issue in Wales which can lead to soil particles and their associated contaminants ending up in water courses. This damages fish and their spawning sites, kills other aquatic life and reduces water quality. Soil erosion will also lead to increased need for soil conditioners.
	Soil erosion may also be caused in part through tourism and recreational activities, agricultural activities and during the construction process.
Minerals extraction & mining	Minerals extraction can have several implications for soil, including disrupting the soil ecosystem, soil loss and degradation, soil contamination and disrupting the water flow through the soil. Metal mining sites present significant sources of land contamination (EA, 2002).
Peatland	Wales possesses considerable quantities of peatland and organic soils which are large carbon stores (WAG, 2004) and these soils need to be protected. These should be protected as high priority.
Soil Compaction	Large numbers of grazing animals or vehicle traffic on wet land can cause soil compaction. This reduces the retention and filtering of rain water (EA, 2004) and has an effect on water quality. Woodland cover can sometimes provide a solution by reducing soil compaction and increasing water infiltration. Soils may be compacted during construction works, causing runoff and pollution.
Soil Sealing	Soil sealing under buildings and car parks is a major risk to soils in development schemes. This may destroy other essential soil functions such as regulating atmospheric gases, absorbing water to replenish ground water supplies and providing a habitat for soil organisms.
Loss of soils as 'waste'	Soils are sometimes stripped from a site prior to development; their important environmental functions are lost and they may not be put to best use elsewhere (e.g. In a landfill, top soils buried in an engineering project etc). Avoid the loss of soils in this way.

Table 6 below is a non-exhaustive list of potential Soil-related environmental issues that plan-makers may identify in the preparation of various plans and programmes.

Table 6: Potential Soil-Related Environmental Issues and Opportunities

Type of Plan or Programme	Potential Soil-Related Environmental Issues and Opportunities
Transport	• Development of transport infrastructure may lead to an increase in sealed surfaces (increasing flood risk) and soil contamination (either directly or indirectly through, for instance, increased air pollutants and run-off of contaminated water). • There may also be a loss of soil quantity as a result of development. • During the construction process there may be a loss of soil as waste, loss by water and wind erosion, compaction, mixing of top soil with sub-soil, and the introduction of noxious weeds in imported top soil.
Urban expansion / new development	• Development may lead to the contamination, compaction, sealing and/or loss of soils (during periods of construction and operation). • Where soils are lost to development, soil functions may be entirely eliminated. • Soil can remain in developments as an amenity role (gardens and parks) and may be important for controlling infiltration of rainwater in urban situations. • Increase in non-permeable surfaces through development may lead to increased flooding. • Land use and management (such as agriculture, crop rotation practices etc) may affect the acidification of soils, which may have chronic effects on some soil functions, especially interactions with the aquatic environment.

Agriculture / Forestry / Fisheries	• Large numbers of grazing animals or inappropriate use of heavy machinery can cause soil compaction. • Deep cultivation of soils can affect soil fertility. • Inappropriate manure and slurry application can contaminate soils. • Woodland cover can enhance soils by reducing soil compaction and increasing water infiltration. Woodland creation can also help reduce soil erosion. • Loss of nitrate, phosphate and sediment from agricultural soils (into water courses) can cause failure of drinking water standards and contribute to eutrophication in estuaries and the sea. • There may also be loss of soils as a result of water erosion from fields which have been inappropriately managed. • Impacts of climate change may have significant consequences for agriculture and forestry in Wales related to soils.
Minerals	• Minerals extraction can have several implications for soils, including disrupting the soil ecosystem, soil degradation, soil contamination and disrupting the water flow through the damage of soils during storage and restoration. • Mineral extraction can have a high local impact on soil functions and is geographically dispersed throughout Wales
Waste Management	• The development of waste management facilities may lead to the contamination and/or loss of soils, including landfill processes.
Energy / Industry	• Wind turbine foundations, wind farm access roads, underground electricity cables, maintenance tracks, sealing, compaction, erosion, contamination , loss of peat etc.
Telecommunications	• The laying of cables may disrupt soils.
Tourism	• Footpath restoration and maintenance may need to be undertaken due to erosion. • Increased pressure on open spaces for developments e.g. car parks.
Water and Flood Management	• The high quality of Welsh water makes it an important resource to be protected from eutrophication.

A4: Developing SEA Objectives

SEA Objectives are not a legal requirement but are a useful way of analysing the environmental affects of a plan or programme. Table 7 and Table 8 below describe some possible soil-related outcomes, objectives, sub-objectives and indicators. Those in Table 7 have been taken from the Wales Environment Strategy, with Table 8 providing a wider range which could be used in sector or area specific SEAs.

Table 7: Wales Environment Strategy Outcomes and Indicators: Soil

Environment Strategy Outcomes	Indicators
Soil is managed to safeguard its ability to support plants and animals, store carbon and provide other important ecosystem services	• Change in soil carbon. Further indicators to be selected when the UK Soil Indicator Consortium reports.

Table 8: Examples of SEA Objectives/Sub-Objectives and Indicators for Soil

Example Objectives (in bold) and Sub-Objectives (in italics)	Example Indicators
Quality	
Minimise contamination and safeguard soil quality and quantity and function	• Area of soil lost to impermeable surfaces • Change in soil carbon • Exceedance of nitrogen, ammonia and acid critical loads • Area of contaminated land remediated • Area of proposed new development on Greenfield sites • Number of grazing animals • Soil lost as waste
To avoid and reduce contamination of soils	• Exceedance of nitrogen, ammonia and acid critical loads • Area of contaminated land remediated

To protect and enhance soil quality (including non-chemical soil functions and process such as permeability) and quantity especially of carbon rich soils	• Change in soil carbon • Area of peat land affected by plan • Compaction avoided or remedied during construction • Percentage of construction activities with a soil management plan in place • Extent of erosion during construction activities (could be observed, or reported as incidents) • Extent of erosion during operational phase of development (could be observed, or reported as incidents)
To avoid increased diffuse pollution from agriculture and other economic activities	• Number of fertiliser and manure applications
Quantity	
To avoid loss of soils to non-permeable surfaces	• Area of soil lost to impermeable surfaces • Area of proposed new development on Greenfield sites • New homes built on previously developed land (although this is not always indicative of soil protection – e.g. Where two homes with impermeable paving are built where there was one with a grass garden. However, does imply that the development did not take place on prime agricultural, functioning soils • Loss of land to development (data on loss of soil to development is not compiled in Wales, although some authorities do compile data on loss of land to development)

Link to Welsh Assembly Government Sustainable Development (SD) Indicators

As part of its commitment to achieving sustainable development the Welsh Assembly Government has developed a series of indicators which will be used to measure progress towards that commitment[4].

Some of these indicators may not be suitable for many SEAs, particularly those for plans at a local level, as they are fairly 'broad-brush' and will not be able to either be measured at a local level, or respond to the policies and measures included within individual plans and programmes. Nevertheless they should be considered for inclusion wherever appropriate.

NB: a revised set of indicators is currently being developed and some of these are likely to be more appropriate for incorporation into SEAs.

Other indicators reported by the Welsh Assembly Government at a national level include those in the Environment Strategy (WAG, 2006) and those from the Key Environment Statistics Indicators.

WAG reports each year on its suite of sustainable development indicators, some of which include environmental indicators. It also reports separately on progress in implementing its Environment Strategy using a number of ES indicators, some of which overlap with its suite of SD Indicators. These reporting mechanisms provide useful data which can be used to inform SEA scoping and environmental reports. They also help to form a framework against which environmental indicators for the plan or programme can be developed.

A5: Consulting on the Scope of SEA

In addition to the three statutory Consultation Bodies (CCW, Cadw and EA) there are other organisations or bodies who could be consulted on the scope of the SEA, and on the Environmental Report. For the Soil topic, these may include:

- Regionally Important Geodiversity Sites (RIGS) organisations (Central Wales, Dyfed, NEWRIGS (North East Wales), Gwynedd and Ynys Mon);
- National Assembly for Wales Agricultural Department (NAWAD).

[4] Sustainable Development Indicators for Wales can be found at: http://new.wales.gov.uk/topics/statistics/headlines/sustain-2007/?lang=en

Stage B: Developing and Refining Alternatives and Assessing Effects

The Practical Guide provides guidance for undertaking SEA Stages B1 (Testing the plan or programme objectives against the SEA objectives), B2 (Developing strategic alternatives) and B3 (Predicting the effects of the draft plan or programme, including alternatives). This note provides no topic specific guidance for these stages.

B4: Evaluating the effects of the draft plan or programme, including alternatives

At Stage B4 the significance of the environmental effects forecast in Stage B3 is evaluated. Part of this concerns the interrelationship of the soil topic with other SEA topics and Table 9 below describes some of these interrelationships.

Table 9: Interrelationships with other SEA topics

SEA Topic	Interrelationship with Soil Topic
Air	The quality of the air affects soils, as the emissions of gases such as sulphur dioxide and nitrogen oxides contribute to the acidity of rainfall, and consequently affect soil and vegetation. Ammonia and many other air pollutants can also affect soils. Conversely, the management of soils can have an effect on air quality. Ground level ozone may be the cause of some soil problems.
Biodiversity	A large number of organisms are contained within soils, performing functions that are vital for healthy soils and for the habitats and uses that depend on them. Sustainable soil use should maintain and restore the functions of these soil organisms to support agriculture, environmental protection and nature conservation. NB: 100 species of soil invertebrates and fungi are included in the UK Action Plan to protect biodiversity (UKBAP). Areas of contaminated land can be high in biodiversity value which can cause issues with remediation.
Climate Change	Soil loss to impermeable surfaces during development operations can increase flood risk. The increase in extreme weather events linked to climate change will make this situation worse. Soils may act differently under the different temperatures and/or land uses associated with climate change. This may increase risks to or by soils. Soil loss from flash flooding may be an issue. Soils act as an important store for carbon.
Cultural Heritage	Archaeological remains may be destroyed by development and agriculture, and natural forces such as wind and water. Soil can protect this archaeological heritage and thinning of this soil cover. For instance, soil erosion can expose it to damage by cultivations. Where soil is contaminated, this may adversely affect archaeological remains (in some cases, remains can also contaminate the soil).
Landscape	Soil is one of the building blocks that define natural vegetation and the character of the landscape. This can be affected by loss of function due to changes in land use such as development, urbanisation and intensification of agriculture.
Material Assets	Certain soil types are not suitable for accommodating particular infrastructure, for example peat soils may be unsuited for the development of wind farms. Mine water outflows can cause soil contamination.
Water	Soil erosion and runoff can lead to pollution of watercourses. Contaminated land can adversely affect both surface and groundwater. The sealing of soil surfaces by development can lead to higher surface run-off and increased flooding.

Stage C: Preparing the Environmental Report

Refer to *The Practical Guide* for details relating to SEA Stage C.

Stage D: Consulting on the Draft Plan or Programme and the Environmental Report

Refer to *The Practical Guide* for details relating to SEA Stage D.

Stage E: Monitoring Implementation of the Plan or Programme

Whilst generic guidance on SEA Stage E is provided in *The Practical Guide*, some topic specific information of relevance to Stage A2 is provided below.

NB: many of the examples provided could be used not just when responding to adverse effects, but also to enhance the environmental outcomes of a plan from the outset.

E2: Responding to Adverse Effects

Plans can be used to deliver responses to adverse effects identified during SEA in a variety of ways. Specific examples of responses relevant to the Soil topic include:

- Ensure that strategic decisions take into account the need to reduce land-take and subsequent soil loss;
- Aim to minimise the contribution to soil acidification and nitrogen deposition;
- Ensure that strategic decisions (in particular those associated with farming, forestry and the countryside) take into account the need to avoid loss/contamination of soils in general, and carbon rich soils (such as peatland and organic soils) in particular;
- Ensure that appropriate site investigations and risk assessments are carried out on land suspected of being contaminated;
- Encourage regeneration and re-use of contaminated land, seeking the best practicable environmental option in relation to remediation and subsequent land use;
- Encourage appropriate land management and construction practices which minimise adverse effects on soils; and
- Encourage actions that seek to reduce SOx, NOx and ammonia emissions.

References and Further Reading

SEA and Generic References:

- ODPM, Scottish Executive, Welsh Assembly Government and Department of the Environment in Northern Ireland (2005) *A Practical Guide to the Strategic Environmental Assessment Directive*, TSO, UK.
- NAW (2006) *Local Development Plan Manual*, National Assembly for Wales, UK.
- DfT (2004) *Strategic Environmental Assessment for Local Transport* Plans, TAG Unit 2.11, TSO, UK. Available at URL: www.webtag.org.uk/webdocuments/2_Project_Manager/11_SEA/
- ODPM (2005) *Sustainability Appraisal of Regional Spatial Strategies and Local Development Documents*, TSO, UK (Sustainability Appraisal includes SEA).
- Welsh Statutory Instrument 2004 No. 1656 (W.170): *The Environmental Assessment of Plans and Programmes (Wales) Regulations 2004.*
- Environment Agency (2007) *Web-based Advice on SEA and Good Practice.* Available at URL: http://www.environment-agency.gov.uk/aboutus/512398/1504325/1504417/?version=1&lang=_e
- Environment Agency Wales, Welsh Assembly Government, Cadw, and CCW (2005) *Strategic Environmental Assessment: Consultation Bodies' Services and Standards for Responsible Authorities in Wales.* Available at URL: http://www.cadw.wales.gov.uk/upload/resourcepool/WalesS&Senglish6943.pdf
- Countryside Agency, English Heritage, English Nature and Environment Agency (2005) *Environmental Quality in Spatial Planning.* Available at URL: http://www.english-heritage.org.uk/upload/pdf/Envir_Quality.pdf#search=%22environmental%20quality%20in%20spatial%20planning%22

Topic Specific References and Further Reading:

- Avery, B.W. (1980). Soil Classification of England and Wales. Technical Monograph, 14. Soil Survey of England and Wales, Harpenden.
- CEH, NSRI, Institute of Grassland and Environment Research, Geoenvironmental Research Centre, and Cybefin Consultants (2002). *Critical Appraisal of State and Pressure and Controls on the Sustainable use of Soils in Wales*, WAG, UK. Available at URL: http://www.ceh.ac.uk/sections/bef/Wales_Soil_Scoping_Study.html
- Conway, J (Undated). *Soils in the Welsh Landscape*, Royal Agricultural College, Cirencester, UK. Available at URL: http://www.rac.ac.uk/?_id=1002
- Defra (2004). *The First Soil Action Plan for England: 2004-2006*, HMSO, UK. Available at URL: http://www.defra.gov.uk/ENVIRONMENT/land/soil/pdf/soilactionplan.pdf
- EAU (1988). *Survey of Contaminated Land in Wales*, Environmental Advisory Unit, Welsh Office.
- Environment Agency (2002). *Metal Mine Strategy for Wales*. Available at URL: http://www.environment-agency.gov.uk/regions/wales/426317/393155/?version=1&lang=_e
- Environment Agency (2004). *The State of Soils in England and Wales*, Environment Agency. Available at URL: http://www.environment-agency.gov.uk/commondata/acrobat/stateofsoils_1747056.pdf
- Ferrier (2003). *Recover: 2010 - Predicting recovery in acidified freshwaters by the 2010 and beyond*. Available at URL: http://www.macaulay.ac.uk/recover/index.html
- IPCC (2001). *Inter-governmental Panel on Climate Change: Climate Change 2001: The Scientific Basis.* Available at URL: http://www.grida.no/climate/ipcc_tar/
- NAW - National Assembly for Wales (2006). *Key Environment Statistics for Wales*, Statistical Directorate National Assembly for Wales, Cardiff. Available at URL: http://new.wales.gov.uk/topics/statistics (>Headlines, Releases and Bulletins > Environment)
- Rudeforth *et al*. (1984). *Soils and their use in Wales*, Soil Survey of England and Wales - Bulletin No. 11, Harpenden.
- Scottish Executive and Welsh Assembly Government (2007) *ECOSSE: Estimating Carbon in Organic Soils Sequestration and Emission*, Scottish Executive, UK.

- SNIFFER (2004). *Planning for Soils: Advice on how the planning system can help to protect and enhance soils*, Scotland and Northern Ireland Forum for Environmental Research. Available at URL: www.sniffer.org.uk/exe/download.asp?sniffer_news/Research%20report.pdf;
- Taylor J.A. and Tucker, R.B. (1968). *The peat deposits of Wales: an inventory and interpretation*. In proceedings of the 3rd International Peat Congress (ed. by C.Lafleur and J.Butler) pp163-173.
- WAG (2000). *Welsh Assembly Government: Minerals Planning Policy Wales.* Available at URL: http://new.wales.gov.uk/topics/planning (>Policy and guidance >Minerals Planning Policy)
- WAG (2004). *Minerals Planning Policy (Wales) - Minerals Technical Advice Note (Wales) 1: Aggregates*, WAG, UK. Available at URL: http://new.wales.gov.uk (>A-Z >M)
- Yeo, M. (1997). *Blanket Mire degradation in Wales.* In Tallis, J.H., Meade, R. and Hulme, P.D. (Eds) Blanket Mire Degradation: Causes, Consequences and Challenges. Macaulay Land Use Research Institute, Aberdeen.

Further Reading:

- Bradley, I., Clarke, M., Cooke, H., Harris, J., Harrison P. L., Mayr, T., Towers, W., Rodwell, J. and Gowing, (2006) *Guidance on Understanding and Managing Soils for Habitat Restoration Projects*, English Nature Research Reports Number 712, English Nature, UK.
- Burton, R. G. O. and Hodgson, J. M. (1987) *Lowland peat in England and Wales,* Soil Survey Special Survey No. 15. Harpenden.
- Defra (1998) *Code of Good Agricultural Practice for the Protection of Soil (The Soil Code*), Defra, UK.
- Defra (2003) *Water, Air and Soil Codes – Summary*. Available at URL: http://www.defra.gov.uk/farm/environment/cogap/pdf/summary.pdf
- Defra (2005) *Controlling Soil Erosion*, TSO, UK. Available at URL: http://www.defra.gov.uk/environment/land/soil/pdf/soilerosion-lowlandmanual.pdf
- Defra (2005) *Soil Sealing*, TSO, UK. Available at URL: http://www.defra.gov.uk/environment/land/soil/built-environ/soil-sealing.htm
- Environment Agency (2005) *A Better Place? State of the Environment 2005*, Environment Agency, Bristol
- Forestry Commission (1998) *Soil Conservation Guidelines*, Forestry Commission, UK. Available at URL: http://www.forestresearch.gov.uk/fr/infd-5wcfj7
- Hall, D.G.M., Reeve, M., Thomasson, A.J. & Wright, V.F. (1977). *Water retention, porosity and density of field soils,* Soil Survey Technical Monograph No. 9.
- Hodgson, J.M. (ed.) (1997). *Soil Survey Field Handbook*. Soil Survey Technical Monograph No.5. Silsoe, Bedfordshire.
- Howard, P.J.A., Loveland, P.J., Bradley, R.I., Dry, F.T., Howard, D.M., and Howard, D.C. (1995) *The carbon content of soil and its geographic distribution in Great Britain*. Soil Use and Management 11 9-15.
- Ingram, J (2003) *National Trust Soils - Management and conservation in agricultural landscapes*, Information Note No. EP1, June 2003, National Trust, UK. Available at URL: http://www.nationaltrust.org.uk/main/w-national_trust_soils.pdf
- Jarman, R (1999). *A National Trust Soil Protection Strategy, National Trust, UK*. Available at URL: http://www.nationaltrust.org.uk/main/w-soil01.pdf
- Mason, W.L. (1999) *Cultivation of soils for forestry - Bulletin 119*, Forestry Commission, UK. Available at URL: http://www.forestresearch.gov.uk/website/publications.nsf/WebpubsbyISBN/085538400X
- McGrath, S.P. and Loveland, P.J. (1992) *The Soil Geochemical Atlas of England and Wales*. Blackie Academic and Professional, Glasgow.
- Milne, R. and Brown, T.A. (1997) *Carbon in the vegetation and soils on Great Britain*. Journal of Environmental Management, 49, 413-433.
- Patterson, G., and Anderson, R (2000) *Forests and Peatland Habitats - Guideline Note 1*, Forestry Commission, UK. Available at URL: http://www.forestresearch.gov.uk/PDF/fcgn1.pdf/$FILE/fcgn1.pdf
- RCEP (1996) *19th Report: Sustainable Use of Soil*, Royal Commission on Environmental Pollution, UK. Available at URL: http://www.rcep.org.uk/pdf/soil1rep.pdf

- RCEP (2002) *Environmental Planning: Summary of the Royal Commission on Environmental Pollution Report*, RCEP, London.
- Stace, H. and Larwood, J.G. (2006) *Natural foundations: geodiversity for people, places and nature*. Peterborough, English Nature, UK.
- UK Soils Indicator Consortium. Available at URL: http://www.defra.gov.uk/environment/land/soil/research/indicators/consortium/index.htm