Planning for Soils in Worcestershire

TECHNICAL RESEARCH PAPER

Soil

is the essential link between the components that make up our environment

Soil is a vital resource, its management is fundamental to sustainable development. It is a subject of great importance to planners.

December 2011

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This paper has been prepared in partnership with

Herefordshire & Worcestershire Earth Heritage Trust

Natural England

In partnership with Environment Agency

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1. Introduction

Purpose

With air and water, soil is one of the fundamental natural resources on which life depends. It gives us food, timber and many other essential crops. It supports our infrastructure and cultural heritage, shapes our landscape and supports a wide range of biodiversity. It filters and stores water and holds large amounts of carbon. Protecting these vital services for future generations is essential.

Soil is a finite resource that faces many challenges and threats, which include the impacts of climate change and pressure from development.

This paper has been developed to raise awareness of the importance of soils and to provide technical guidance to Local Planning Authorities with a view to policy preparation for the management and protection of Worcestershire's soil resource.

The paper aims to support the strategic consideration of soils by identifying emerging best practice and makes recommendations on how policy can best serve the sub regional interests and as a background paper to inform the development of the Waste Core Strategy, Minerals Core Strategy and Local Development Frameworks.

How has this paper been prepared?

This paper has been prepared in partnership with the Environment Agency, Natural England and the Herefordshire and Worcestershire Earth Heritage Trust through a desktop review and drawing together of the key policies, guidance, emerging best practice and available evidence as it relates to Worcestershire.

A consultation exercise has been undertaken with key stakeholders on the draft paper (see appendix 1).

Audience, Scope and Status

This is one of a series of natural resource technical research papers[1] prepared by Worcestershire County Council to assist in the preparation of Sustainable Community Strategies and in the preparation of Local Development Documents.

The intended audiences for this paper are planning officers, the development industry, the local strategic partnership members and anybody with an interest in how to plan for soils within Worcestershire.

Although the paper has benefited from scrutiny and consultation with stakeholders it is not a statutory document and holds the status of a research paper that provides evidence to inform the development of statutory documents such as Local Development Frameworks and Community Strategies.

In drawing together the available evidence and key policies, the paper intends to be a useful tool to policy makers, but does not diminish the need for the reader to be alert to both existing and emerging evidence and policy upon soil. To help the reader a suggested list of guidance and best practice is provided in appendix 2.

[1] Others either prepared or in preparation include Planning for Renewable Energy, Planning for Water, Planning for Climate Change and Planning for Green Infrastructure.

2. Background

"Soil is a fundamental and irreplaceable natural resource, providing the essential link between the components that make up our environment. The sustainable management of soils is a central pillar in sustainable development". The First Soil Action Plan for England: 2004 - 2006 (DEFRA, 2004b).

The Role & Function of soils

Different types of soils are formed from the complex variations and interactions of relief, climate, geology, vegetation and human activity. Soils are a requisite for human life as they grow our food and help keep our drinking water clean by breaking down and locking away substances that may be harmful to people and wildlife. Soils are a key factor in defining the landscape character of Worcestershire and they have a strong influence on land use within the County. As well as supporting our diverse landscapes, soils play a vital role in maintaining the balance of gases in the air we breathe as well as playing a key role in storing and releasing carbon and the potential impact this may have in tackling climate change.

Soils and the underlying geology also form the base upon which we plan and develop the communities in which we live. In practical terms soil should be viewed as a non-renewable resource as it can take more than 500 years to form 2cm of topsoil.

Worcestershire's soils and natural environment face increasing pressures from climate change, development, minerals extraction and waste management. Perceptions of land as purely a physical resource are changing with the increasing recognition of the wider functions of soils and their capacities to support ever-increasing demands placed upon them by industry and society and as such are becoming an important consideration in spatial planning. The capacity and condition of local soils should be considered as an essential component of spatial planning and should be central to the debate on achieving the sustainable communities of the future.

However the benefits that soils provide our communities have perhaps previously been taken for granted. As our understanding of soil increases, we are seeing signs that climate change, increased urbanisation coupled with contamination and poor management are causing problems for soils. Climate change is also likely to impact on soils by modifying other processes that enable the soil to perform its many functions such as the retention of water to prevent flooding. Soils are facing a number of other external pressures including the working of minerals, disposal of waste to landfill and the effect of inappropriate land uses and the impacts of intensive farming methods. Future predictions for hotter, drier summers and wetter warmer winters in Worcestershire may affect the ability of certain soils to retain rainfall, leading to increased levels of run off and erosion whilst exacerbating issues such as slope failure, landslides and compaction reducing the potential for the growing of certain crops.

Whilst there is an increasing body of technical information available on soils (see appendix 2), there is perhaps currently a low level of awareness and understanding of the issues for policy makers at sub-regional and local level. Often there is a stronger focus on issues surrounding air and water and less account of impacts of policies and actions

on soils. To achieve sustainable development, soil protection must be balanced with the other needs of society, the economy and other parts of the environment and planning should be central to preserving the diversity of soils and the services they provide.

Policy Context

National Planning policy including Minerals Policy statements support the protection and conservation of England's soils and require Planning Authorities to take account of soils in the preparation of LDF's and development plans. These planning policies are supported by international and national environmental policies and documents including:

- The Soils Action Plan for England (2004 - 2006)
- Soil Strategy for England (September 2009)
- The EU Water Framework Directive
- Site Waste Management Plans

Defra's First Soil Action Plan for England: 2004-2006 set out a series of aspirations and objectives for England's soils resource by encouraging better understanding of soil as a resource and highlighting it's value to society by promoting a wider agenda of soil protection and better management set around a vision that recognised the vital functions that soils perform for our society. The action plan was supported by an Environment Agency report on the State of Soils in England and Wales (see appendix 2), the report set out the Environment Agency's own soil strategy and provided the evidence to support both action plans.

The Soil Strategy for England seeks to build on and replace the Soil Action Plan 2004-2006 which was the first time the Government set out its objectives for protecting soils by ensuring that the work of Defra, Environment Agency, Natural England, Local Authorities and other bodies focuses on the issues affecting our soils and takes account of the EU Thematic Strategy for soil protection published in 2006. The strategy aims to provide a strategic framework that will enable government and agencies alike to work in a co-ordinated and effective way. The vision of the strategy seeks to protect England's soils in line with the principles of sustainable development and in the context of climate change. A key objective of the strategy will be to ensure that planning authorities and the construction industry take account of the need to protect soil resources and to ensure that soils within the built environment are able to fulfil as many as possible of their functions.

The 2011 White Paper, Natural Choice: Securing the Value of Nature sets out an ambition for more integrated approaches to the natural environment through supporting healthy, well functioning ecosystems and ecological networks. The new institutional framework will include establishing Local Natural Partnerships (LNPs) and Nature Improvement Areas (NIAs). It also promises a new Biodiversity Strategy for England and a reformed approach to planning within and across local areas.

The White Paper talks about soil in the context of ecosystem services supporting wider sustainable economic growth such as food production, carbon storage or flood management. Taking into account all economic and non economic benefits from those services, enables decision-makers to make appropriate decisions on how to use the environment. However, there is a lack of a broader understanding of this issue. This is why the White Paper *commits to undertake a significant research programme over the next four years to explore soil degradation, soil's ability to support vital ecosystem services such as flood mitigation, carbon storage and nutrient cycling* (HM Government, 2011, p.28). This paper aims to provide a Worcestershire context to the issues raised within these respective documents.

The White Paper is partially drawn on the Lawton Report Making Space for Nature, published by the Government in partnership with the Environment Agency, Forestry Commission and Natural England. The report concluded that England's collection of wildlife sites does not comprise a consistent and flexible ecological network and it will not be capable of coping with the challenge of climate change and other pressures. It argues that we need a step-change in the approach to conservation, from trying to hang on to what we have, to one of large-scale habitat restoration and recreation, supported by the re-establishment of ecological processes and ecosystem services.

In 2009 Defra published A Code of Practice for the Sustainable Use of Soils on Construction Sites, which has been prepared to assist the construction sector in better protecting the soil resources with which they work. Whilst the Code is not legislatively binding it aims to:

- Protect and enhance the soil resources on development sites and to achieve wider environmental benefits.
- To help developers meet legal obligations regarding waste control.
- To highlight the potential cost savings for businesses.

The Code also outlines current guidance and legislation concerning the use of soil in construction projects, before offering stage-by-stage guidance on the use, management and movement of soil on site.

Furthermore, an online training tool Toolbox Talks can be found on the Defra's websites. It illustrates the sustainable ways of handling soils on construction (DEFRA, 2010).

National Planning Policies

There is an extensive EU and domestic legislative framework in place to prevent the introduction of pollutants to soil through addressing industrial emissions and ensuring that recycling materials to land does not present unacceptable risks to human health and the wider environment (DEFRA, 2009a, pg. 19).

The UK has also entered into several international agreements aimed at addressing long range air pollution. As these agreements come up for review the UK will play an active part in negotiations to ensure they continue to address industrial emissions and further limit the potential for pollutants entering soil through atmospheric deposition (DEFRA, 2009a, pg. 19).

Planning Policy Statements (PPS) Mineral Policy Statements (MPS) and Minerals Policy Guidance (MPG) aim to protect soil functions in a range of ways by recognising the value of soils and encouraging land uses that can help to protect soils, whilst also recognising the benefits they can deliver such as helping to secure carbon sinks. Regional and local plans should consider the impact on soils of their spatial planning options through Sustainability Appraisals (SA's), Strategic Environmental Assessments (SEA'S) and the impacts of individual developments can be addressed via Environmental Impact Assessments (EIA's).

A summary of policies highlighting soil conservation are given below:

PPS 1 - Sustainable Development.

"Development plan policies should take account of environmental issues such as:"

"…The protection of the wider countryside and the impact of development on landscape quality; the conservation and enhancement of wildlife species and habitats and the promotion of biodiversity; the need to improve the built and natural environment in and around urban areas and rural settlements, including the provision of good quality open space; ***the conservation of soil quality***…"

PPS 7 - Sustainable Development in Rural Areas.

PPS 7 recognises that much of the land use activity within rural areas falls outside the scope of planning authorities but that planning does have a role in providing a frame work for sustainable development that's supports traditional uses of the countryside and that in the preparation of LDD's this should take account of the need to protect natural resources.

PPS 7 also introduces the concept of best and Most Versatile Agricultural Land (which is discussed further in chapter 4) which should be taken into account alongside other sustainability considerations such as the "protection of natural resources, including soil quality".

PPS 9 Biodiversity and Geological Conservation - A guide to good practice.

"**PPS 9** states that regional planning bodies should liaise with the British Geological Survey and where appropriate, local Regionally Important Geological/geomorphological Site (RIGS) groups on geodiversity issues. Where they have been produced, it would be good practice to use Local Geodiversity Action Plans (LGAPs) as a framework upon which to audit, conserve, manage and promote characteristic geological, geomorphological ***and soils resources*** within a particular region".

Environmental Impact Assessments are also required on major projects and Sustainability Appraisal, mandatory under the Planning and Compulsory Purchase Act 2004, has been introduced to promote sustainable development into the preparation of revisions of Development Plan Documents (DPD) and Supplementary Planning Documents (SPD) (DEFRA, 2009a, pg. 31).

The Regional Sustainable Development Framework for the West Midlands aims to help those who develop, review and implement strategies, policies and plans in the West Midlands to ensure their work contributes towards a sustainable future for the Region. The Framework sets out differing approaches depending on whether strategies, policies and plans are subject to statutory Sustainability Appraisal and is designed to support regional delivery of the UK Sustainable Development Strategy 'Securing the Future'.

A series of sustainable development objectives are designed to help the Region move towards a more sustainable future. Where a strategy or plan is subject to formal Sustainability Appraisal, the Framework is designed to support the appraisal process and to provide a reference for scoping the sustainability issues. Where a formal Sustainability Appraisal is not required, the Framework sets out a best practice approach to incorporating sustainable development objectives within the strategy, policy or plan development process. Objectives that are of relevance to the sustainable use of Natural Resources and soils are:

1.1 - Natural resources such as water and minerals efficiently, including by incorporating efficiency measures into new land use and developments, redevelopment and refurbishment.

3.3 - Minimise air, water, soil, light and noise pollution levels and create good quality air, water and soils.

PPS 10 - Planning for Sustainable Waste Management - Companion Guide.
Table 1 of the document includes soil as a possible topic for sustainability objectives for Local Development Documents.

MPS 1 - Planning and Minerals

MPS 1 advises to "ensure that proposals for mineral extraction and the storage and tipping of mineral wastes are designed, and appropriate monitoring procedures set up, to ensure that the operation and restoration of the site does not create land instability and help prevent pollution of soil, air, surface water and groundwater".

MPS 2 - Controlling and Mitigating the Environmental Effects of Minerals Extraction in England

The document recognises the potential conflict between the utilising of resources such as soil and environmental protection. This can be minimised by careful use and conservation of soil in a sustainable way.

Furthermore, it identifies that the Development Plan policies should take into account the impacts on soil resources. The Annexes 1 and 2 give detailed practical advice on soil stripping, handling and storage, protecting soil structure and prevention of nuisances, including the use of conditions to do so.

MPG 7 - Reclamation of mineral workings

The document states that the Mineral Planning Authorities should provide policy guidance to applicants including the need for restoration. The restoration condition "is a condition requiring that after operations for the winning and working of minerals have been completed, the site shall be restored by the use of any or all of the following, namely, subsoil, topsoil and soil making materials" (ODPM, 2006a).

It also advises the applicants to prepare a working plan which includes restoration proposals and is based upon findings from the site investigation. The plan will usually involve a number of key stages relating to soil, including:

- stripping of soils and soil-making materials and either their storage or their direct replacement on another part of the site
- restoration, including soil placement, relief of compaction and provision of surface features

3. Worcestershire's Soils

Soil is a fundamental and irreplaceable natural resource, providing the essential link between the components that make up our environment. Soils are hugely variable from region to region and even from field to field, and they perform a number of functions. Worcestershire is one of the most diverse counties in England and this is reflected in the variety of geology and soils present within the County.

The soils of Worcestershire are young in world terms, having only begun forming at the end of the last ice age (c.10,000 years ago). Despite this, a wide variety of soil types have been formed in this time, largely due to the variable geology of the county. The National Soils Map shows 296 soil associations 140 of which occur in the Midlands and Western England. Within each Soil Association are multiple Soil Series. A number of these have been first described in the county (see table 1).

Whilst these classifications are tremendously detailed, it is possible to identify the key properties of soils that influence the kind of vegetation and land uses they can support, which in turn has a substantial influence on the character of the landscape. These are - drainage (whether free draining or water retentive), depth, chemical balance and nutrient status.

As part of the county's Landscape Character Assessment (LCA), Worcestershire County Council's A New Look at the Landscapes of Worcestershire (2004) document, groups the county's soils according to these key characteristics and identifies at a basic level, how these influenced the developing landscape character of the county. This is explained in further detail in Appendix 3, with an accompanying map which shows the distribution of these simplified soil types.

Further details on soil types including maps and a list of recommended reading are contained within the appendices and further information can be found by contacting the Geological Records Centre.

Table 1

Pelosols	Brown Earths	Podsolic Soils
Haselor Series	Barton Series	Malvern Series
Evesham Series	Bishampton Series	
Worcester Series	Nupend Series	
	Rushwick Series	
	Mayalls Series	

Land quality varies from place to place throughout the county and Agricultural Land Classification (ALC) provides a method for assessing the quality of farmland to enable sustainable choices to be made about its future use within the planning system and underpins the principles of sustainable development. Defra and others provide advice to local planning authorities, developers and the public if development is proposed on agricultural land or other 'greenfield' sites that could grow crops using the ALC system.

The ALC system classifies land into five grades as outlined below **(see table 2)** with the 'best and most versatile land' defined as grades 1, 2 and 3a. The classification is based on the long-term physical limitations of land for agricultural use. Factors affecting the grade are climate, site and soil characteristics, and the important interactions between them. A map of Agricultural Land Classifications within Worcestershire/West Midlands is available in appendix 4.

Table 2 - Agricultural Land Classifications

Agricultural Land Classifications
Grade 1: (Excellent)
Grade 2: (Very Good)
Grade 3a: (good)
Grade 3b: (moderate)
Grade 4: (poor)
Grade 5: (very poor)

In a rural county such as Worcestershire the presence of high grade soils have policy implications for planners. PPS 7 requires LPA's to "identify any major areas of agricultural land that are planned for development" and to consider the inclusion of "policies in their LDD's to protect specific areas of best and most versatile agricultural land from speculative development". Whilst most land use activity is largely outside the scope of the planning system, planning authorities still have a role in facilitating development and land use while taking account of the need to protect natural resources. Issues relating to soils and agriculture are further covered in chapter 4.

The table below outlines the coverage of land available within the differing grades and compares the level of Grade 1 land available within Worcestershire to the rest of the neighbouring authorities.

Table 3 - Percentage Coverage of Graded Soils within Worcestershire and comparison to neighbouring authorities.

Grade	Hectares	%
Worcestershire		
Grade 1	4834	2.8
Grade 2	28,884	16.6
Grade 3	110,578	63.5
Grade 4	17,135	9.8
Grade 5	411	0.2
Non Agricultural	2,526	1.5
Urban	9,683	5.6
Warwickshire (Grade 1)	105	0.1
Shropshire (Grade 1)	10	0.0
Gloucestershire (Grade 1)	2,883	1.1
Herefordshire (Grade 1)	8961	4.0

4. Issues and actions to consider in planning for soils in Worcestershire (and the implications of not doing so).

Soils provide us with many essential benefits however we know that poor soil management can have severe consequences for the natural, built and historic environments. The following chapter summarises the pressures on our soils today and identifies the influences that planning authorities and other organisations should consider in policy and plan preparation.The multi functional role of soils is reflected in the many issues that are highlighted within this chapter for consideration.

Climate Change

UK soils contain 10 billion tonnes of carbon - more than in all the trees in the forests of Europe (excluding Russia). This is equivalent to more than 50 times the UK's current annual greenhouse gas emissions (DEFRA, 2009a, pg. 10).

Soil has an important role to play in climate change mitigation. UK soil stores about 10 billion tonnes of carbon in the form of organic matter. Significant losses of soil carbon would have a major effect on climate change. If all UK soil carbon was lost to the atmosphere this would be equivalent to 36.7 billion tonnes of CO2 or over 57 times the UK's greenhouse gas emissions in 2007. A 1% loss of soil carbon would be equivalent to the UK's annual fossil fuel emissions. Protecting this carbon store is therefore a priority. *The UK Low Carbon Transition Plan* highlights the importance of the UK's soil carbon store and taking steps to protect and enhance it (HM Government, 2009).

Climate change is already having a wide-ranging impact on Worcestershire. Future climate change scenarios predict a range of impacts upon the climate of the UK and Worcestershire including:

- Increased average maximum temperatures - up to 4.5c by the 2080's.
- More frequent very hot summers and less frequent very cold winters.
- Summer rainfall to decrease by up to 50% by the 2080's.
- Winter rainfall to increase by up to 23% by the 2080's.
- More frequent extreme weather events such as storms and floods.

Soil structure is affected by variation in temperatures, rainfall and also by changes in atmospheric carbon dioxide, these elements affecting soil ecology and organic matter, which in turn affect soil structure, water regimes and plant growth. In addition changes in rainfall intensity and duration and amount could alter soil erosion rates. These changes in climate will have significant implications for agriculture, forestry, the environment, civil engineering and the preservation of cultural heritage.

But soil will not only be affected by climate change but will also contribute to the causes of climate change. Soil is a source of greenhouse gases including carbon dioxide and methane changing climate will lead to the release of this huge carbon store. Carbon held within soil is broken down and released as part of natural processes however increasing air temperatures will accelerate this process. The production of methane can also be increased in waterlogged and flooded soils an area of particular concern to Worcestershire.

The Kyoto Protocol (1997) highlights that soil is a major carbon store that must be protected and increased where possible. UK soils store some 10 billion tonnes of carbon and changes in land use, such as the conversion of grassland to crops, release carbon dioxide by oxidising soil organic matter (Environment Agency, 2004). Such land use change accounts for about five per cent of UK greenhouse gas emissions. However this release of carbon could be countered by planting more woodland and energy crops.

Climate change could have profound effects on soils, both directly and by stimulating changes in land use. Agriculture will change with shifting rainfall patterns, temperature, sunshine hours and soil quality. The implications for soils are hard to predict and the effects are uncertain but change is likely to lead to:

- Acidification and the movement of nutrients and other contaminants to water will also change with rainfall and temperature.
- Erosion risks will increase if the trend of wetter winters and more intense rainfall continues; drier soils in the summer would accelerate runoff.
- More demand for irrigation is likely where soil water deficits increase.

The result of all these changes in soil properties are that the soil type may ultimately change, i.e. the soil may dry out due to warmer temperatures (e.g. peat soils), or conversely, the soil may become wetter due to regular flooding. This has direct implications on land use.

Carbon is the main building block of all vegetation and plant material, which accumulates in soils as partially or fully decomposed organic matter making all soils that contain organic matter natural stores of carbon. Although the degradation of fresh plant material can be a fast process, organic matter accumulates relatively slowly in soils.

Climate can influence the properties of soils but conversely soil also regulates climate via the uptake and release of greenhouse gases such as carbon dioxide, methane and nitrous oxide. This is a complex relationship with many feedback mechanisms but soil can act as a source and sink for carbon, depending on land use and climatic conditions. Land use changes such as those identified within this paper can trigger organic matter decomposition, primarily via land drainage and cultivation.

Peat is inherently susceptible to erosion, desiccation and decomposition, for which temperature and rainfall are important triggers. Increased rainfall intensity and periodicity may accelerate erosion rates in peat soils in the winter and the risk of wind erosion could be high during dry summers, not only in peat soils, but also other soils with poor vegetation cover. Worcestershire has a fragmented network of peat deposits but peat has been recorded at many sites within the county including within three SSSI's (Richards, T.D. at all, 2007). Given the sensitivity to changes in the climate including moisture and temperature conditions, once erosion or decomposition is triggered this can lead to a catastrophic loss of carbon. Climatic factors have an important role in peat formation and it is thus highly likely that a changing climate will have significant impacts on this resource.

The restoration and re-creation of peat lands can result in increased methane emissions initially as soils become anaerobic, whereas in the longer term they can become a sink for carbon as organic mater accumulates. PPS 1 Planning and Climate Change supplement to Planning Policy Statement 1 paragraph 13 states that in integrating climate change planning bodies should 'recognise the potential of, and encourage, those land uses and land management practices that help secure carbon sinks'. Such land use may include the restoration of wetland habitats, reducing deforestation, increasing carbon storage (e.g. through planting of woodlands) through changes in agricultural practices to increase the quantity of carbon stored in soil organic matter. In addition the promotion of renewable forms of energy may provide an opportunity for surplus agricultural land to be used for the production of bio-fuel crops. In Worcestershire this could be realised through projects such as the Severn and Avon Vales Wetland Partnership or via the Grow with Wyre project.

Economy

The recent environmental policy and research publications such as the Foresight Land Use Report (2010) and the Natural Environment White Paper (2011) indicate the link between the economy and various elements of the natural environment such as soil, water or wood. They refer to soil in terms of natural capital and its value for the economy.

The documents note that a greenspace and semi rural landscapes that support wildlife are as important as land which is economically active and that they can add value and versatility when they are looked at in terms of their multiple benefits. The functional potential of this "multifunctionality" of natural resources may be achieved through, for example, integration of energy issues into agriculture and forestry. Similarly, careful management of agricultural land through protecting healthy soils may naturally lead to improved economic benefits but it also has a role in Climate Change mitigation and adaptation, as discussed on page 9, through a careful combination of flood risk and agricultural land management.

Soil degradation as a result of erosion by wind and water and the loss of organic matter and compaction, can cost the economy approximately £200 million per year (HM Government, 2011, pg. 128). Therefore, in economic terms, it is cost effective to protect healthy soils and prevent their degradation. For that reason, the Government in the White Paper introduces a four-year research programme into the effects of soil degradation on vital ecosystem services such as flood mitigation and nutrient cycling.

The potential changes in the management of agricultural terrain to reduce soil erosion, requires an integrated approach amongst all the stakeholders such as regulators, land managers or the insurance industry (Foresight Land Use Futures Project, 2010, pg. 22).

In order to achieve added economic benefits, there is a need to integrate land use management and change, as well as the protection of soils with other strategies including those on Flood Risk Management or Infrastructure Planning.

Taking or not taking appropriate actions towards the integration of different workstreams can be beneficial or detrimental to the economy. The examples of the financial value of the different green infrastructure areas are presented in Table 4.

Table 4 - Economic value of Green Infrastructure

Agriculture	• The total external environmental damage costs from agriculture in the UK ranges from £1149m to £3050m per year (Environment Agency, 2002). • The Environment Agency study (2005) identified that careful resource management in agriculture may save approximately £700 million (Environment Agency, 2005).
Forestry	• Woodland creation provides highly cost-effective and achievable abatement of GHG emissions when compared with potential abatement options across other sectors (£100 and less per tonne of CO2). By the 2050s, it could be delivering, on an annual basis, emissions abatement equivalent to 10% of total GHG emissions at that time (Forestry Commission, 2009).
Recreation and tourism	• 2.5bn visits were made to English countryside, coast and open spaces last year with visitors spending over £17 billion in 2010/11(Natural England, 2011).
Climate Change (Adaptation and Mitigation)	In 2007 only, flooding in Worcestershire caused: • £3.5 million worth of damage to a 12 mile stretch of track between Bewdley and Bridgenorth. This is seen as a major tourist attraction so closure had a knock on impact on local businesses • collapse of the road at Cropthorne B4084 due to supporting soil being washed away by flood water. Repairs cost nearly £1million and took 6 moths to complete.
Flood Management	• It is estimated that by 2035, the number of existing properties exposed to 'significant' risk of flooding in England could rise from about 500,000 to over 800,000 in the absence of any increase in expenditure on flood protection (Foresight Land Use Futures Project, 2010).
Ecosystem Services (water, food, materials, flood defences and carbon sequestration)	• Careful ecosystem management could add an extra £30bn a year to the UK's economy (UK National Ecosystem Assessment, 2010). • Protected natural areas can deliver economic returns that are 100 times greater than the cost of their protection and maintenance (TEEB, 2011).

Soil and Nature Conservation

Soil Biodiversity

Soil is a living entity and soil biodiversity is known to be greater than above ground biodiversity (Stace H and Larwood G, 2006). There are a large number of micro-organisms in the soil, many of which may have not been identified and whose role on ecosystem is as yet unknown.

The diversity of soil types leads to a diversity of organisms that live in and around it. Organic matter provides the food source for millions of micro organisms that live in these various soil types and these micro organisms in turn make nutrients available for plants and animals.

Soils directly influence the type and locations of habitats and the species which thrive in these habitats. For example, red sandstones break down to give sandy, acidic, well-drained soils and these soils can in turn give rise to areas of scrub or Heathland such as those at Hartlebury Common. Lime-rich soils, with areas of calcareous grassland, have developed on the limestones underlying Bredon Hill and the top of the Broadway escarpment both of which fall within the Cotswold Hills AONB.

Conservation of soil, both for its intrinsic and practical values has historically been poor with respect to other aspects of nature conservation. However soil provides the vital resource for ensuring habitats and their species can be sustained, as well as being a habitat in itself. Additionally, soils can provide other environmental benefits such as buffering and treating pollution, regulating water flow through the ground (an important consideration with respect to flooding), as well as regulating water quality. Soils can also be used for carbon sequestration and proper management of peat and other soils will contribute to mitigating the effects of climate change.

Another risk to biodiversity is transferring invasive species through the movement of soils. Inappropriate movement and disposal of soil containing the invasive species can lead to long term consequences to native wildlife. For example, Himalayan balsam and water primrose often become so prolific that they displace native plants. Responsibility for dealing with weeds rests on individual landowners; therefore, the main way of tackling it is through raising awareness of these individuals.

Geodiversity

Soils form part of the geodiversity resource[2]. They also provide the most direct link between geodiversity and biodiversity, and are strongly influenced by both geology and wildlife. The underlying geology directly affects which soil types naturally form, which in turn affect the type of habitat that grows on the surface. Relief, (which is a result of the variation of bedrock types, its structure and its interaction with the atmosphere and cryosphere), will also have an effect on soil thickness and type. Conversely, the variation of flora in any given area affects the amount of organic matter and nutrients in a soil, thus also influencing soil type.

[2] "Geodiversity: the variety of rocks, minerals, fossils, landforms and soils, alongwith the natural processes that shape the landscape" Natural England definition.

Local Geological Sites (formerly known as RIGS), form part of the Local Sites Network. The network seeks to "ensure, in the public interest, the conservation, maintenance and enhancement of species, habitats, geological and geomorphological features of substantive nature conservation value." (DEFRA, 2006, p.4) that have been identified as being of regional importance and notified to the local planning authorities as sites in need of protection from future development. In Worcestershire there are currently more than 90 designated Local Geological Sites and include a number of rock types and landscape features. Worcestershire's geology and geomorphology is considered as being of such importance that an area around the Abberley and Malvern Hills have been declared a Geopark. The county also has other sites that have a higher level of protection status as Sites of Special Scientific Interest (SSSI's). These sites have been chosen for biological, geological or geomorphological reasons.

Some of the county's soils additionally display rare properties, and their conservation and identification should be considered a high priority with potential for designation as a Local Geological Site, examples of which are detailed in table 5.

Green Infrastructure

Urban Green spaces, such as parks and playing fields, are important areas that need to be valued for the many services they provide. In addition to their many social benefits, green spaces support biodiversity, absorb rainwater thereby improving drainage, control pollution, regulate urban temperatures, reduce noise pollution and can be used by local communities to grow food. These services all rely on good soil quality (DEFRA, 2009a).

The Built Environment and Construction

The term 'built environment' should not be restricted to urban areas only, but refers to a variety of areas where construction has occurred or where development is planned and can therefore apply to both urban and rural environments.

Soil provides a foundation for built development and can also be seen as a component of aesthetic landscaping. Buildings (e.g. homes, offices) and transport infrastructure (e.g. railways and roads) are all built on soil and all rely on the different properties of soil. Building on the wrong type of soil can be costly in economic terms; it can also cause environmental problems - such as soil contamination, flooding and water pollution.

Table 5

Podsolic soils	Crannymoor Series	Preservation of natural heath or coniferous woodland is essential for the survival of the Crannymoor series, the only example of a podsol in Worcestershire.
Surface-water gley soils	Oakley Series	The former Broadheath, now Oakley Series, has a bright mottling pattern derived from sub-tropical conditions before the onset of the last ice age.
Groundwater gley soils	Midelney Series	The rather unusual Midelney Series consists of alluvium overlying peat.
Peat Soils	Adventurers Series	The Adventurer's Series occurs in small, fragmented areas. It is relatively unusual in this part of the country.

Some of the most significant impacts on soil properties occur as a result of activities associated with construction. Soils within the built environment are made up of a complex mixture of natural, imported and man-made (anthrosoils) soils and are present in a variety of situations including gardens, allotments, parks, school playing fields and derelict or brownfield land. But soils in these environments can be under a number of pressures and these pressures are summarised in Table 6. Using land for buildings and transport generally damages soils irreversibly, giving rise to conflicting pressures which are at their most acute in and around towns. Many problems arise in the on site management of soils during construction projects including both housing and infrastructure. The poor management of soils can lead to soil nutrients being lost, habitats being disturbed, good quality top soils being wasted and culture heritage being forgotten.

The costs of erosion, compaction and organic matter decline are already over £100m a year, including from lost production, and could rise unless we are able to adapt management practices to our changing climate (DEFRA, 2009a, pg. 22).

Soil compacted during a construction project.

Table 6 - Summary of pressures on soils in the built environment.

Development - Using land for buildings and transport can damage soils irreversibly. At a minimum the soil is covered (sealed) and prevented from functioning. Defra is working to ensure that consideration is given to sustainable soil use and protection during planning and development.
Soil sealing - is defined as the covering of the soil surface with a layer of impervious material or changing the nature of the soil so that it behaves as an impermeable medium. Soil sealing prevents the soil from performing other functions such as food and fibre production or the ecological functions of soil.
Construction - The activities carried out during the construction of a new building or transport link affect soil quality. It is not uncommon to find soils in built environment gardens and green spaces containing building rubble or with compacted layers. The landscaping phase of new construction may also involve the importing of topsoil, with its own set of risks.
Importing topsoil (and subsoil) - The importing of soil (both topsoil and subsoil) is common practice in the built environment. This practice is associated with a number of risks that need to be assessed and managed. Many of these risks arise due to a poor understanding of the soil however some of these risks have been considered in relation to mineral site restoration and this knowledge could be transferred to the built environment. These risks include: • Importing unsuitable soils for planned use • Damage to soil structure • Mixing of topsoil and subsoil • Loss of soil function in the area exporting the soil • Potential to import contaminants • Potential to import plant and animal diseases that use soil as a host

During construction soils are subject to movement, storage, compaction and contamination. In order to minimise costs and promote sustainable development sites are often re-contoured to create building platforms using the substrates on site but the practice of compacting soils on a site for engineering processes can lead to an over-compaction of substrate for plant growth. The loss and damage to soils caused by development can be reduced by careful management of construction activities and by the reuse of soils in gardens and open spaces. The unauthorised disposal or inadequate containment of soil during construction can also cause problems.

In urban areas, soils are compacted by frequent use and sealed by hard surfaces, causing rain to run off rapidly and greatly increasing the risk of flooding. Sustainable drainage systems, such as porous road surfaces, swales and wetlands, can reduce flood risk by storing rainfall and allowing it to percolate through the soil. They can also improve water quality by allowing the soil to filter and break down pollutants. Common practice for construction sites is to have topsoil and subsoil removed, either fully or in part, at the commencement of the site development process. Occasionally a site will have soil stripped in stages by different contractors responsible for different elements of the overall construction project rather than as one process. The treatment and handling of the soil resource on site can therefore vary widely. In some circumstances the topsoil and subsoil will be stripped, and then stockpiled separately either for future use on site or, quite commonly, for exportation as a saleable asset or waste material, however it is not uncommon, particularly on small sites for the topsoil and subsoil to be stripped and handled as one unit.

The construction industry has a severe impact on transferring invasive species to areas previously unaffected. It is common that soil inadequately treated for invasive weeds is sold or transported somewhere else, where it quickly shows signs of contamination. This may have serious consequences with, for example, Japanese Knotweed being able to penetrate through 20cm of concrete. In order to tackle this issue, there is a need for the enforcement of weed control as well as environment and waste management legislation on developers and landowners.

Soil stored on a construction site.

Waste and Minerals

The construction industry is the largest single source of waste arisings in England, producing 90 million tonnes of inert waste annually (DEFRA, 2009c), some of it soil. Therefore the protection and re-use of soil is fundamental to initiatives to reduce such waste. The Environment Agency's guidance *The Definition of Waste: developing greenfield and brownfield sites (April 2006)* helps those involved with construction work to decide whether or not they are handling waste. The guidance outlines the regulatory requirements that must be complied with when handling wastes.

The Waste Strategy for England (DEFRA, 2007) seeks to avoid the disposal of soil to landfill through recycling incentives and the less onerous regulation of low-risk waste processes. Recycling initiatives within the Waste Strategy are also supported by the Finance Act 1996, which introduced the concept of Landfill Tax for "taxable disposals" of waste in landfill sites. There are two tax rates. The lower rate, for inactive materials (including soil), is currently £2.50 per tonne. This tax coupled with the cost of transport to landfill combine to create financial incentives to recycle soil.

The Site Waste Management Plans (SWMPs) would be encouraged for all new construction projects worth more than £300,000 (excluding VAT). Site Waste Management Plans will provide a structure for waste delivery and disposal at all stages during a construction project.

The SWMP will identify

- Who will be responsible for resource management?
- The types of waste that will be generated?
- How the waste will be managed - will it be reduced, reused or recycled?
- Which contractors will be used to ensure the waste is correctly recycled or disposed of responsibly and legally?
- How the quantity of waste generated from the project will be measured?

Construction and demolition wastes totaled an estimated 818,000 tonnes in Worcestershire in 2003 and SWMP's will help to manage and reduce the amount of waste that construction projects produce and that means less waste going to landfill (including soils). Other environmental benefits will include reducing the environmental impact of development, reducing incidents of fly tipping, reduced energy consumption and a greater take-up of recycled materials.

Some controlled wastes can be spread to land for agricultural or ecological benefits, as long as the wastes are not a pollution or health risk. There is currently a lack of collated data on the amount and quality of this waste being disposed of within the County. Food and construction and demolition wastes are a major source of such materials. Conditions applied through the waste regulations should prevent any long-term build-up in soils of contaminants, but this also depends on responsible management. This route for recovery of value from waste may become more important as industries seek alternatives to landfill. However, care is needed to avoid detriment to the soil and other environmental media the effective monitoring of inputs must be accounted for so that safe loading limits of nutrients and contaminants are not exceeded.

Soils overlie mineral resources and the extraction of these resources can severely disrupt the soil ecosystem through the movement and mixing of soils and vegetation that have developed over hundreds or thousands of years. Soils should however be seen as a valuable raw material, to be protected by the planning system and during the life and restoration of mineral extraction and other development sites. All mineral extraction sites have planning controls in place to control the use and handling of soil, largely due to the requirement for soils to be utilised for reinstating at some stage in the life of the extraction process. Retention of soils is often key in order to enable restoration to land uses such as agriculture, the cost associated with producing this to a high quality requires large volumes of good quality soils and purchase of large volumes of soil material is always extremely difficult so protection of the original soil asset removed prior to mineral extraction should always be a priority.

The stripping and storage of soils for reuse and restoration in mineral workings and landfill can lead to inevitable degradation although good practice can minimise the impacts of this damage and high quality restoration and aftercare e.g. restoring land to agricultural use or to woodland have been successful in the past. Extraction proposals for minerals workings have to include plans for storing and reusing the soil, and for restoring the site and technical advice notes provide guidance. Minerals Policy Statement 1: Planning and Minerals paragraph 17 (Environmental Protection) states that planning authorities should *"ensure that proposals for mineral extraction and the storage and tipping of mineral wastes are designed, and appropriate monitoring procedures set up, to ensure that the operation and restoration of the site does not create land instability and help prevent pollution of* **soil***, air, surface water and groundwater".*

Minerals Planning Guidance 7: Reclamation of Minerals Workings paragraph 7 defines reclamation as including both restoration and aftercare as defined in section 5 of the 1990 Act. However, it also includes events that take place before and during mineral extraction (e.g. correct stripping and protection of soils); and may also include operations after extraction such as filling and contouring or the creation of planned water areas.

A high level of restoration of minerals and waste sites is important to achieve sustainable development and to ensure the future use of land. In terms of Government policy it is not necessary for high quality land to be restored to agricultural use, but that the restoration and after-use following mineral or waste development should safeguard it's long-term agricultural potential and guidance is provided in the Defra publication *Guidance for the Successful Reclamation of Mineral and Waste Sites (2004a).*

Contaminated Land

Section 78A(2) of Part 2A of the Environmental Protection Act 1992 defines

"Contaminated land" as "any land which appears to the local authority in whose area the land is situated to be in such a condition, by reason of substances in, on or under the land, that (a) significant harm is being caused or there is a significant possibility of such harm being caused; or (b) pollution of controlled waters is being, or is likely to be, caused" (DEFRA, 2008b, pg.2).

Contaminated land is a risk to groundwater quality and a deterrent to redevelopment and is an issue that needs to be identified and treated. Contamination of land and pollution of waters arises principally from industrial practices which have led to deposition of substances such as oils and tars, heavy metals, organic compounds and soluble salts, and mining materials; and from the land filling of waste without adequate precautions against leaching or the escape of landfill gas. However contamination is not restricted to land with previous industrial uses, it can also occur on greenfield as well as previously developed land and it can arise from natural sources as well as from human activities.

The legal complexity and costs of dealing with contaminated land can cause developers to choose greenfield rather than brownfield sites. This creates a double impact on soils in the form of the contamination (real or perceived) and the loss of greenfield soils.

Land contamination describes a wide variety of site and soil conditions and may include areas with elevated levels of natural substances as well as sites contaminated as a result of former industrial uses. The development industry has in the past tended to play safe by excavating potentially or actually contaminated soil and disposing of it as waste to suitably licensed landfills a practice otherwise known as 'dig and dump' (English Partnerships, 2006). However the Waste Framework Directive now requires pre-treatment of contaminated soils that are to be land filled to reduce the level of contaminants or volume of soil before disposal can take place.

Soil contamination can take many forms but soils can be remediated and potentially hazardous materials can be disarmed by the use of plants and micro-organisms.

Bacteria can be injected into soils to break down organic chemicals such as oil whilst plants can absorb toxic metals into their stems and leaves, which can then be harvested and incinerated, and the metals recovered from ash for recycling.

The contaminated land sector in the UK and elsewhere is already looking at ways to improve sustainability, including how to rely less on "dig and dump" techniques that involve disposing of large amounts of contaminated soil in landfills. The Government recently acted to discourage "dig and dump" by announcing that the current Landfill Tax exemption on the disposal of contaminated soil (which had existed since landfill tax was introduced in 1996) will be phased out by 2012 (DEFRA, 2009a, pg. 16).

Part 2A of the Environmental Protection Act 1990, which came into force in 2000, requires Local Authorities to identify contaminated land in their areas, ensure it is remediated, and make the "polluter" pay

wherever possible. Part 2A is primarily intended to be used only where the "market" does not provide a solution. Part 2A also plays an important indirect role by encouraging market solutions (i.e. the presence of legislation which could force action often provides a strong incentive for polluters and landowners to take action voluntarily) (DEFRA, 2009a, pg. 39).

Throughout Worcestershire there are a number of sites that may have been contaminated by past activities or practices. These may present a threat to the environment and pose a risk to human health. Worcester City Councils Contaminated Land Inspection Strategy notes the impact of the city's industrial heritage, which has left a legacy of some derelict or under used land, largely associated with the railways. Similarly Wyre Forest District Council's Contaminated Land Strategy notes similar legacies including brass and iron foundries (Stourport on Severn), former Coalfields with former pits being identified in the west and north west of the District.

District and Borough councils hold information on contaminated land, which has primarily been submitted as part of development control planning applications on sites where previous contaminative uses are believed to have existed.

Some of these sites may be cleaned up during remediation processes as a result of government policies that have encouraged the re-use of brownfield land that has been used for industrial purposes in the past. It may cause a risk if the sites are left as they are.

In response to this the government introduced legislation Part 2A of the Environmental Protection Act 1990. The Government sees a central aim of the Part 2A regime as being to encourage voluntary remediation of land affected by contamination and voluntary remediation often takes place as land is redeveloped, or because land owners want to increase the utility and value of their land and the planning system can and should secure appropriate investigation and remediation of land. The legislation also requires local authorities to:

1. Cause the District / Borough to be inspected to identify contaminated land
2. Determine whether any particular site is contaminated land
3. To act as the enforcing authority for all contaminated land that is not designated as forming a "Special Site". In the case of Special Sites the Environment Agency will be the enforcing authority.

Planning Policy Statement 23: Planning and Pollution Control (PPS 23) explains the relationship between the two regimes. In brief, as a minimum, after carrying out a development and commencement of its use, the land should not be capable of being determined as contaminated land under Part 2A. The advice on Part 2A above may be useful to planners, but it needs to be read in conjunction with PPS 23.

Across Worcestershire there are differences in geography, geology, soils, industrial activity and prevalence of vulnerable 'receptors' such as protected wildlife and water resources. The manner in which contaminants have been deposited, or moved may have affected (or threatened) vulnerable receptors and can vary even between localities a few miles apart. Local Authorities should therefore consider the character of the individual District when developing priorities and objectives for inspecting land that may be contaminated.

Agriculture and Land Use

Soil is the basic medium for plant and crop growth and the distribution of soils within the County will define their agricultural or horticultural uses. Whilst agricultural land practices are largely beyond the influence of planning, inappropriate soil management can have significant off site impacts that can impact on wider spatial planning including:

- Increased water run off influencing flood events
- The loss of sediments affecting drainage channels
- Nutrients and pesticides affecting water quality.
- The production of food and fibre can compromise biodiversity and cultural heritage measures.

As the maps in appendix 4 identify Worcestershire has soils that are of high agricultural importance and Planning Policy Statement 7 supports the policy of Best and Most Versatile Agricultural Land. *(see box below)*

The loss of soil increases the need for soil conditioners and reduces the retention and filtering of water. The soil particles and their associated contaminants (that can include pesticides, nutrients, metals and pathogens) often end up in watercourses. In England and Wales erosion moves some 2.2 million tonnes of arable topsoil annually and 17 per cent of soils show signs of erosion. Contamination of soils can have significant effects for agricultural soil quality and, if remobilised, can also affect water quality. The main causes of structural damage and erosion can be as a result of intensive cultivation, particularly when soils are compacted by heavy machinery or left exposed to heavy rain (as with winter cereals and maize) or from heavy trampling of soil by sheep and cattle.

Farmland is one of the sources of water pollution by nitrogen and phosphorus, which are both plant nutrients. Most phosphorus lost to water is carried on eroded soil particles, while nitrate is lost mainly by subsurface leaching. Agricultural intensification combined with sewage inputs have led to widespread eutrophication of surface waters. Generally, manure and slurries from livestock increase soils organic matter content by increasing their water retention function and stability. However they may also contain pollutants such us heavy metals.

Planning Policy Statement 7, paragraph 28 - Best and Most Versatile Land

The presence of best and most versatile agricultural land (defined as land in grades 1, 2 and 3a of the Agricultural Land Classification), should be taken into account alongside other sustainability considerations (e.g. biodiversity; the quality and character of the landscape; its amenity value or heritage interest; accessibility to infrastructure, workforce and markets, maintaining viable communities: and the protection of natural resources, including soil quality) when determining planning applications.

Where significant development of agricultural land is unavoidable, local planning authorities should seek to use areas of poorer quality land (grades 3b, 4 and 5) in preference to that of higher quality, except where this would be inconsistent with other sustainability considerations.

Diffuse pollution cannot be attributed to precise points or incidents and is the effect of activity over a large area or length of time. Various activities may contribute to diffuse pollution including construction, agriculture and forestry. Pollutants deposited on land, roads and other surfaces can be washed into watercourses and may be influenced by climate, geology and in agriculture may include silt from soil erosion as well as nutrients from fertilisers, manures and also pesticides.

The Water Framework Directive requires countries in the EU to manage the water environment to consistently high standards and this includes:

- Conserving habitats and species that are directly dependent on water;
- Reducing and phasing out the release of pollutants that represent a threat to the aquatic environment;
- Progressively reduce the pollution of groundwater and prevent or limit the entry of pollutants.

The Environment Agency has prepared the Draft River Severn Basin Management Plan under this directive which has set a target of achieving 'good status' in all waters by 2015.

The River Basin District is divided into ten catchments and three of these catchments fall within Worcestershire including:

- Worcestershire Middle Severn Catchment - is predominantly rural but contains urban areas such as Kidderminster and Worcester. The area has many water dependant sites including SSSI's and SAC's. Proposed actions to tackle issues in the catchment include the provision of advice to farmers to reduce sediments and nutrients entering water courses.
- Teme Catchment - passes through Tenbury Wells before joining the River Severn south of Worcester and the whole of the River Teme is classed as a SSSI. Water quality in the lower reaches of the catchment is affected by diffuse pollution from sediments and nutrients and proposed actions to tackle these issues include the provision of advice under the Catchment Sensitive Farming Delivery Initiative.
- Warwickshire Avon Catchment - the catchment includes urban areas such as Evesham and Redditch and agriculture accounts for a large proportion of land use particularly in the Vale of Evesham. Water quality issues are in part due to agricultural run off leading to nutrient enrichment and initiatives include actions to reduce diffuse pollution and run-off.

The actions set out within the management plan seek to build upon actions required by other EU directives some of which are already underway and these are outlined below:

Nitrate Vulnerable Zones (NVZs) were introduced by member states of the European Union following the ratification of the EC Nitrate Directive in 1991. These NVZs are areas of land that drain to waters where nitrate concentrations exceed, or are likely to exceed, the 50 mg/l level dictated by the EC Surface Water Abstraction Directive (1975). The areas designated can therefore be both groundwater and surface water catchments. NVZs may also be designated where it is deemed that nitrate concentrations are such that they will/could trigger eutrophication in fresh, estuarine, coastal or marine waters. The directive requires farmers within Nitrate Vulnerable Zones to follow an Action Programme of measures aimed at controlling when, where, how, and in what amount, nitrogen can be applied to land.

The England Catchment Sensitive Farming Delivery Initiative (ECSFDI) is funded by Defra and aims to tackle the problem of diffuse water pollution from agriculture (DWPA). The Catchment Sensitive Farming Delivery Initiative has been rolled out across 40 priority catchments in England that have been identified by the Environment Agency and Natural England. These priority catchments have been identified by data gathered from the Water Framework Directive (WFD). Diffuse pollution is contamination that cannot be traced back to a single source - instead it arises from multiple sources as a consequence of the general pattern of land use in a particular area.

Priority catchment 28 identifies the River Teme and the land draining into it and its tributaries from the source West of Ludlow to the River Severn and includes tributaries such as the Leigh Brook and Rivers Rea.

Agencies including Environment Agency, Natural England and the Rural Payment Agency are engaged with the farming industry and work in partnership to ensure that farmers have the tools that they need to manage their soils effectively. Farmers are required to take action to protect and manage their soils under a variety of regulatory frameworks including existing programmes such as CAP, cross compliance, Environmental Stewardship. For example, anyone who receives support under one of the RDPE schemes need to meet the Good Agricultural and Environmental Conditions (GAEC) standards for soil management and protection including annual preparation of the Soil Protection Review. These conditions are designed to:

- Prevent loss of soil
- Prevent loss of organic matter in soils
- Prevent negative impacts on water quality and aquatic ecosystems
- Minimise carbon losses to the atmosphere (DEFRA, 2010a, pg. 4).

Additionally, Environment Agency encourages farmers to produce soil management plans as a good measure to reduce soil losses (Environment Agency, website).

A range of advice is available to farmers and landowners on soil management an example of which 'Think Soils' is outlined in the box below.

Think Soils

The Environment Agency has developed the 'think soils' manual as a practical guide to soil assessment. It aims to help farmers, land managers, government and non-government adviser to recognise the problems associated with soil erosion and run off from agricultural land.

The guide covers soils in England and Wales and considers how weather conditions, landscape, land use and soils can combine to increase the risk of erosion and run off and by also recognizing how the effects of climate change are increasing the importance of this issue.

Landscape character

Soils are one of the three physiographic elements that, in combination with the overlying cultural elements, define the character of the landscape. Altogether, we use six elements - geology, topography, soils, land use, tree cover and settlement pattern - to identify Landscape Description Units, the 'building blocks' of landscape, within which the character is relatively uniform. We then look for commonalities in the patterns of how and where landscape characteristics appear across the county in order to classify these units into Landscape Types. For each Landscape Type (there are 23 in Worcestershire, including the Urban Landscape Type) a set of key characteristics are identified which are most significant in contributing to its distinctive character.

Clearly, and as alluded to above, soils influence landscape character principally by determining the kind of vegetation and land use that can be supported. In one Landscape Type - the Limestone Estatelands of Cotswold outlier Bredon Hill - the thin calcareous limestone soils are a primary characteristic - i.e. are significant contributors to the character - in themselves. In others the land use or ground vegetation are key characteristics and so it follows that the soil type in those areas indirectly plays a more significant role in defining character. For example, the heavy, poorly-drained (gleyed) soils of the Settled Farmlands with Pastoral Land Use and the Village Claylands have been significant in defining the dominant (pastoral) land use of those Landscape Types. Similarly, the impoverished, free-draining sandy soils in the north of the county support a characteristic and, in places ecologically-important, heathy-acid ground vegetation in the Sandstone Estatelands, Wooded Forest and Forest Small Holdings and Dwellings Landscape Types in the north of the county. The shallow soils of the High Hills and Slopes supports acid grassland and, in turn, the characteristic rough grazing land use. The poor-draining soils of the Wet Pasture Meadows and the seasonally flooded Riverside Meadows have long defined their unsettled character and the range of wetland habitats they support, largely unaffected by agricultural intensification.

In these Landscape Types, it is important to maintain an awareness of how land management practices can influence or adversely affect soils which, in turn, may affect land use, and ultimately the locally distinctive character. Notably, a change (or increase) in land drainage regimes can impact negatively on the unimproved character and wetland vegetation of the Wet Pasture Meadows while the shallow, impoverished soils of the High Hills and Slopes or Sandstone Estatelands would be vulnerable to artificial enrichment and deepening if there was substantial addition of 'non-native' top soils. While these may not effect gross changes that are immediately evident, poor soil management can gradually erode the character of the landscape over time, leading to an increasing uniformity and loss of local distinctiveness. Consequently, it is important to maintain an awareness of the landscape character when undertaking any land management activities that may impact on soil type.

Archaeology and the Historic Environment

Soils provide a range of services for society including the protection of our archaeological and cultural heritage. Changes in climate and current patterns of soil management and soil degradation can have detrimental impacts on different aspects of the built environment, historic landscapes and archaeology.

Archaeological remains are in many cases highly fragile and vulnerable to damage and destruction. Appropriate management is therefore essential to ensure that they survive in good condition. In particular, care must be taken to ensure that archaeological remains are not needlessly or thoughtlessly destroyed. Archaeological and cultural heritage can however be destroyed by human activity such as construction, urban and rural development, expansion of infrastructure, modern agricultural techniques (in particular deep ploughing or drainage of wetlands), and by mineral extraction.

Managing archaeological sites on cultivated land presents a challenge as regular cultivation or deep ploughing can damage or destroy any hidden remains however large numbers of sites under cultivation still remain of great importance and would benefit from action to halt or minimise the impact of ploughing.

English Heritage has developed guidance for farmers on caring for archaeological sites when ploughing. The guidance identifies situations where the risk of damage is greater as a result of ploughing for arable farming and these include sites located on:

- Light soils vulnerable to soil thinning from water and wind erosion, especially when coupled with deep cultivation and/or autumn sowing
- Heavy soils requiring drainage, sub-soiling and deep cultivation
- Peat soils which are especially vulnerable to drying-out and shrinkage as a result of drainage and subsequent wind erosion
- The top or middle of slopes vulnerable to the down slope loss of topsoil
- Land where compaction leads to the thinning of soil depth and loss of topsoil through run-off (English Heritage, 2004)

Climate change has been discussed previously within this paper but any increase in flooding and soil erosion will put historic settlements and archaeological sites at risk and threaten the integrity and economic contribution of our heritage. Some of the direct impacts of climate change on the historic environment are identified below:

- Increased extremes of wetting and drying of soils will heighten the risk of ground subsidence and pose a threat to many historic buildings
- More frequent intense rainfall that causes increased erosion of soils on archaeological sites
- Changes in hydrology that put buried archaeological remains, including well-preserved wetland archaeology, at risk
- Significant short-term erosion and damage to historic structures such as bridges, as a result of severe flooding events and landslides

Wetlands, including peat deposits, are an important repository of information on past environmental change. Wetlands are, however, extremely vulnerable to climatic change and deteriorating peat lands are now recognised as an important source of greenhouse gas emissions, releasing as much carbon dioxide into the atmosphere annually in the UK as the entire terrestrial transport system (English Heritage, 2008). The active conservation of peat deposits can, therefore, not only protect their high archaeological potential and safeguard the evidence they contain about past climate changes, but also reduce damaging carbon emissions.

Soils and Flooding

Soil regulates water flow from rainfall to vegetation and groundwater, and influences river flows and flooding. Many flooding problems are made worse by ignoring the water retention function of soils. The compaction of soils can lead to changes in the soil structure; more specifically compaction reduces the size of pore spaces between the soil particles and compaction is most likely to occur and will be most acute in wet conditions.

Soil sealing, is defined as being the covering of soil with impermeable materials such as buildings, or changing of the properties of the soil's surface so that it becomes impermeable e.g. through compaction can also impact on the drainage function of soils. Soil quality and porosity can also be degraded through compaction by heavy pedestrian traffic, vehicles and machinery including agricultural equipment.

While most soils, if undamaged, can accept heavy rain, bare and structurally degraded soils as a result of intensive agricultural practices have less capacity to soak up rainfall. This leads to overland flow, water-driven soil erosion and flooding. Work is underway by the Environment Agency to improve understanding of these effects and to incorporate them into catchment flood management plans.

The compaction of soils inhibits water infiltration and this can give rise to increased overland water flow, increasing the risk of flooding and the export of sediment to surface water drainage systems. Sustainable urban and rural drainage practices are needed that work with the natural soil hydrology.

Sustainable drainage systems, such as porous road surfaces, swales, wetlands and green roofs, can reduce flood risk by storing rainfall and allowing it to percolate through the soil. They can also improve water quality by allowing the soil to filter and break down pollutants.

As part of the Soil Strategy Defra have committed to prevent surface water flooding from rainfall. Defra will also maintain its commitment to improving drainage in urban areas building on planning policy in Planning Policy Statement 25, and the measures set out in the Floods and Water Management Act 2010 to facilitate the use of sustainable drainage systems.

Ground Movement

Ground movements vary in intensity and extent and thus in their effects on surface land use. It should be noted that instability may arise whether or not there is any development on the surface and that development or the intensification of development may be the triggering factor that initiates instability problems.

The stability of the ground in so far as it affects land use is a material consideration that should be taken into account when deciding a planning application. PPG 14 (Development of Unstable Land) notes that the consideration of land instability at the planning stage can help to minimise the impacts of land instability on property, infrastructure and the public and that in the preparation of development plans local authorities should take into account the possibility of ground instability.

Landslides

Both natural and man-made slopes may be subject to landslides or soil creep. Landslides are mass movements of soil and/or rock under the influence of gravity. The movement may be slow or it may be very rapid; it may be continuous or subject to intermittent surges. Slopes will only move if the forces contributing to movement (eg gravity, water pressure, etc) exceed those resisting movement (eg strength of material, frictional resistance, etc). Increases in water content due to heavy rainfall or alteration of drainage may increase water pressures and thus decreases the resistance to ground movement. One of the main causes of slope instability in more recent years has been due to the disturbance of ancient landslide areas by various human activities such as mining, highway construction and topographic reprofiling as a consequence of industrial and urban development.

Landslides occur most frequently in areas with highly erodible soils, clayey sub-soil, steep slopes, intense and abundant precipitation and represent an increasing threat due to population growth and intensive land use. Landslides or subsidence can have many impacts including:

- In extreme circumstances the loss of human life and well-being
- Damage to property and infrastructure
- Indirect negative effects on economic activities, e.g. of blocked transport routes
- The costs of contamination from broken underground pipelines and tanks containing chemicals

However it should also be recognised that due to their instability landslide areas may often remain undeveloped or uncultivated and may thus represent a significant opportunity to retain and increase the ecological resources of the wider area.

Subsidence

Subsidence can be caused by the settlement of ground due to consolidation of near-surface materials or the shrinking and swelling of certain clays due to seasonal variations in moisture and this can lead to the appearance of holes in the ground, collapse of buildings or structures, or the fracturing of gas mains and other services.

PPG 14 Annex 2 Subsidence and Planning paragraph 2 states "development proposals in local plans or the proposed local development frameworks should also take account of the potential for subsidence from various causes since it can influence their feasibility and sustainability".

The potential for subsidence should also be foreseen as part of the preparation of development proposals whilst most potential subsidence problems can be minimised by careful site investigation and the use of appropriate ground treatment or the adoption of sufficiently robust foundation and/or superstructure designs and as such should reduce the risk of damage and additional costs. However in some circumstances such measures may not always be justifiable in terms of cost. In such cases, the costs of mitigation may be so high that avoidance of land liable to subsidence by certain types of development might be the basis for finding a more effective, economical and, therefore, sustainable use of land. For example, built development on some previously developed land may be so costly that agriculture, woodland or recreational/amenity uses may be more appropriate.

Models of future weather conditions predict wetter winters with an increase of more extreme or intense and sudden periods of rainfall. Alternatively lower soil moisture due to lower summer rainfall and higher temperatures is likely to increase the risk of subsidence. Clay soils are the most subsidence prone soils because they shrink and expand according to the amount of water retained. Main areas at risk from subsidence are in eastern Worcestershire, especially Evesham, where most soil is clay. Properties on gleyed soils may also be at risk from subsidence, as these soils are poorly drained, and include boulder clay, shales and lias clays (Cavan G, 2004).

Extreme rainfall events in the summer of 2007 affected a substantial part of the county and triggered landslips or subsidence that impacted on infrastructure throughout the county. Most notable of these was the B4084 at Cropthorne where a 15m section of road collapsed exposing utility pipes and resulting in significant costs for rebuilding and closure of the road. Landslides also caused substantial damage to the Severn Valley Railway in 45 locations between Bewdley and Bridgnorth in Shropshire and resulting in closure of the line for months and a £3 million repair bill while six homes were evacuated at Northwood Halt in Worcestershire due to fears over further landslides.

Image c/o BBC Shropshire

Planning and Climate Change the supplement to PPS 1 paragraph 23 states that in deciding which areas and sites are suitable for what type and density of development that planning authorities should take into account *'the known physical and environmental constraints on the development of land such as stability and should take a precautionary approach to increases in risk that could arise as a result of likely changes to the climate'.*

There are many slopes within the county that conceal failure zones that relate to former climatic conditions. Models of future weather patterns resulting from climate change include a prediction of increased and more extreme rainfall. This has already been brought to the fore with the floods of June and July 2007, in which a substantial part of Worcestershire was affected. These extreme rainfall events triggered off landslips on slopes around Bredon Hill, the Teme Valley and in Worcester city (Richards, T.D., at all, 2008). There are many similar areas of land slipped ground on slopes around the county that were not reactivated during this period. This does not mean that they are permanently stable. If predicted rainfall patterns occur, then more slopes will eventually become unstable and may cause the frequency of landslips to increase.

A map of areas prone to landslip and subsidence can be found in appendix 5. The Landslip map identifies those areas in the county that have been mapped by the British Geological Survey (based on field evidence) as being landslip zones (i.e. landslips have occurred in the past, or have been recorded as occurring). This means that if conditions are right they may fail again in the future.
The scale of this map is 1:50,000 and as such not all areas are shown. Further zones can be identified on 1:10,000 scale maps. Further information and mapping is available from the Geological Records Centre.

Not all the landslips are the result of soil or superficial material however, some landslips do result from shallow bedrock movement. But it does appear that the majority of recent landslips have been shallow "earth flows" i.e. soil and overlying superficial material slipping down as a large single mass.

The main areas of failure are the slopes of Bredon Hill and the Cotswold escarpment; the banks of the River Avon; around Ankerdine Hill and along the Teme Valley; and in patches along the Rhaetic escarpment.

Whilst not all of those areas identified as vulnerable to landslip will directly affect housing development the risk to infrastructure (roads, railways, electricity pylons etc) from a landslip is something that should be considered more strongly in terms of soils, land use and development. Casing points are the fact that the railway north of Shrub Hill was shut last year after a landslip just north of the tunnel.

However it should be noted the map does not include areas that were subject to failure during the floods of summer 2007. Further details on recorded landslips are available from the British Geological Society website:
http://www.bgs.ac.uk/science/landUseAndDevelopment/landslides.html

5. Menu of options and delivery mechanisms to protect Worcestershire's soils.

Table 7

LDDs should take account of the Government's objectives and measures for soil protection.
Where appropriate these plans should contain policies for the sustainable use of soils.
County based minerals and waste development documents should include positive policy statements about the sustainable use of soils, especially in cases where land is to be returned to agriculture or forestry after minerals extraction.
LDD's should address the issues of dealing with contaminated land particularly with reference to the remediation of soils on brownfield sites.
Considers the introduction of policies or SPD to minimize the impact of rural/farm development/diversification on soil resources.
Local Planning Authorities should develop an increased awareness of the issues surrounding soil management within their own geographical areas including the development of an evidence base to ensure the protection of soils. Such an evidence base may include: • More detailed awareness of areas/sites at risk of subsidence/landslip. • The impact of such events on existing and proposed critical infrastructure. • Identify the impact of soil capping on the Water cycle and the impact on flooding. • Model the future impact of climate change on soils and its contribution to factors identified above. • Identify areas of BMV that may be impacted upon by future development at a strategic and site specific level but take consideration of sustainable development locations. • Identify sites of archaeological and historic environment interest.
Local Planning Authorities should work with partner organisations including Defra, the Environment Agency and partners to monitor and ensure the application of licensed and exempt wastes does not impair the long term functioning of soils.
Increased level of partnership working with relevant stakeholders to steer the implementation of policies including statutory consultees, developers, utility companies, highways agency, AONB's, farming and wildlife groups.
Local Planning Authorities should develop contaminated land strategies and identify areas of contaminated land.
LDD's Planning Authorities should ensure the use of Site Waste Management Plans on all construction and demolition sites. To reduce the volume of soils disposed off site.
LDD's should require all construction and development sites to produce a soils management plan in line with the Draft Code of Practice for the Sustainable Use of Soils on Construction Sites.
Identify sites of geodiversity interest that may be impacted upon by future development and introduce policies for the inclusion or retention of geodiversity features within sites.

6. Further Work

Planning for soils is an emerging policy area for the spatial planning system. Accordingly it is proposed that this paper be reviewed and updated at regular intervals. A significant challenge will be to develop and refine data on soils to both a Worcestershire and a District level. This paper represents the first attempt within the County to bring together the latest guidance and approaches towards managing Worcestershire soils. In preparing the paper it is evident that much further work is required to fully embed the management of soils into policy making. To this end the paper will be reviewed as legislation and guidance becomes available and a programme of further work developed to address the ideas outlined within the paper.
Whilst the County Council has produced/drafted this guidance it will look to District Planning Authorities, stakeholders and partnerships to both lead and contribute toward areas of further work that may include:

The list below includes suggestions for areas of further work that will supplement this paper (suggestions will be welcomed within the consultation process).

1. Identification of areas suitable for soil restoration to deliver the optimum environmental benefit/gain i.e. biodiversity, water management, carbon sequestration. This may include exploring the best practice options for the restoration of minerals working sites in terms of protecting Worcestershire soils resource. This could include the identification of sites that could be returned to agricultural use or achieving an upgrade of ALC to mitigate for BMV lost elsewhere to development.
   Such work can be undertaken in synergy with the ongoing development of a Sub Regional Green Infrastructure Framework for Worcestershire and exploring strategic areas for green infrastructure investment and implementation.

2. Risk based assessment of infrastructure at risk of subsidence, landslip or erosion utilising UKCIP 09. Climatic modelling could assist in identifying future weather extremes for Worcestershire and the implications of extremes of climate on the underlying geology. This could help to reduce the future vulnerability of infrastructure and housing both existing and planned to such occurrences.

3. Identification of Worcestershire's high quality soils both BMV and those of a biological importance that may be at risk from future development as identified in District and Borough Development Plans. It is recognised that development pressures will need to be balanced with the need to protect Worcestershire's environmental resource. However this mapping may provide opportunity to protect or mitigate key resources for future food or fuel production.

4. Carry out a comprehensive audit of Worcestershire's soils drawing on similar work for Hampshire County Council.

5. Develop a county wide map of areas of contaminated land and monitor future remediation. Identification of contaminated land will need to be completed in partnership with District Authorities and the Environment Agency to develop a data base and to ensure future monitoring (potentially through annual monitoring reports). Worcestershire County Council is the waste and minerals planning authority is currently unable to identify or map all areas licensed for disposal of certain wastes (i.e. construction and demolition). This work would assist in identifying the volumes of disposed material and protect soil resources and prevent any potential contamination.

6. Explore the need for a county wide partnership to encourage closer interaction and raise the profile of soils and soil management in terms of both planning and the wider environmental agenda including climate change, ecosystem services, water quality, biodiversity, flooding, geology and heritage. This partnership could include involvement in developing further evidence for Worcestershire's soils but also encourage the uptake of the proposed planner's tool kit for soils.

7. Explore the role of Worcestershire County Council and partner organisations in managing Worcestershire's soils with particular regard to inclusion within appropriate policies and strategies but also with regard to managing their own estate and also in commissioning of works.

Addendum:

The end of 2010 saw introduction of the Localism Bill which is now awaiting formal consent. In July 2011, the National Planning Policy Framework was published for comments. This will be followed with the National Waste Management Plan.

The emerging policy will significantly change the planning system as well as the way that we plan for and protect soils. This paper has been developed prior to those changes and its implications will be taken into account when reviewing the Soils Research Paper in the future.

Appendices

Appendix 1 - Consultees

Advantage West Midlands
British Waterways
Bromsgrove District Council LPA
Cotswold AONB Conservation Board
Country Landowners Association
DEFRA
English Heritage
Environment Agency
Forestry Commission
Government Office West Midlands
Herefordshire & Worcestershire Earth Heritage Trust
Home Builders Federation
Malvern Hills AONB Partnership
Malvern Hills District Council LPA
National Farmers Union
Natural England
Redditch Borough Council LPA
Severn Trent Water
Sustainability West Midlands
West Midlands Centre for Construction Excellence
West Midlands Climate Change Impacts & Adaptation Partnership
Woodland Trust
Worcester City Council LPA
Worcestershire Local Strategic Partnership
Worcestershire Wildlife Trust
Wychavon District Council LPA
Wyre Forest District Council LPA

Appendix 2 - Relevant Policy & Further Advice on soils

Policy

British Geological Survey - *www.bgs.ac.uk*

DCLG (2006a) - Minerals Policy Statement 1: Planning and Minerals

DCLG (2006b) - Planning Policy Statement 10 - Planning for Sustainable Waste Management - Companion Guide

DCLG (2007) - Planning Policy Statement: Planning and Climate Change. Supplement to Planning Policy Statement 1. Good Practice.

HM Government (2011) - Natural Choice: securing the value of nature. *http://www.archive.defra.gov.uk/environment/natural/documents/newp-white-paper-110607.pdf*

ODPM (2004a) - Planning Policy Statement 23: Planning and Pollution Control

ODPM (2004b) - Planning Policy Statement 7: Sustainable Development in Rural Areas.

ODPM (2005a) - Planning Policy Statement 9: Biodiversity and Geological Conservation.

ODPM (2005b) - Minerals Policy Statement 2: Controlling and Mitigating the Environmental Effects of Mineral Extraction in England - Annex 2: Noise

ODPM (2006a) - Minerals Planning Guidance 7: Reclamation of mineral workings

ODPM (2006b) - Planning for Biodiversity and Geological Conservation. A Guide to West Midlands Regional Assembly - West Midlands Regional Spatial Strategy Phase Two Revision - Draft.

Further advice

Cavan, G. (2004) - Worcestershire Climate Change Impact Study

DEFRA (2004a) - Guidance for Successful Reclamation of Mineral & Waste Sites *http://webarchive.nationalarchives.gov.uk/20090306103114/http://www.defra.gov.uk/ farm/environment/land-use/reclamation/index.htm*

DEFRA (2004b) - The First Soil Action Plan for England: 2004 - 2006.

DEFRA (2005) - Soils in the Built Environment - A Strategy for the Construction Sector.

DEFRA (2006) - Local Sites Guidance on their Identification, Selection and Management *http://archive.defra.gov.uk/rural/documents/protected/localsites.pdf*

DEFRA (2007) - The Waste Strategy for England 2007

DEFRA (2008a) - Consultation on the Draft Soil Strategy for England - March 2008.

DEFRA (2008b) - Guidance on the Legal Definition of Contaminated Land. July 2008.

DEFRA (2009a) - Safeguarding Our Soils: A Strategy for England, September 2009,

DEFRA (2009b) - A Code of Good Agricultural Practice for farmers, growers and land managers *http://archive.defra.gov.uk/foodfarm/landmanage/cogap/documents/cogap090202.pdf*

DEFRA (2009c) - Construction Code of Practice for the Sustainable Use of Soils on *Construction Sites. http://www.defra.gov.uk/publications/files/pb13298-code-of-practice-090910.pdf*

DEFRA (2010a) - Soil Protection Review 2010 *http://rpa.defra.gov.uk/rpa/index.nsf/0/c39ae2bb7b8ab8158025768e005e57cd/$FILE/Soil%20Protection%20Review%202010.pdf*

DEFRA (2010b) - Toolbox Talks. *http://archive.defra.gov.uk/environment/quality/land/soil/built-environ/documents/toolbox-talks.pdf*

DEFRA (2011) - Making Space for Nature: A review of England's Wildlife Sites and Ecological Network. *http://archive.defra.gov.uk/environment/biodiversity/documents/201009space-for-nature.pdf*

English Heritage (2004) - Farming the Historic Landscape, Caring for Archaeological Sites on Arable Land.

English Heritage (2008) - Climate Change and the Historic Environment, London.

English Partnerships (2006) - The Brownfield Guide: A Practitioners Guide to Land Reuse in England.

Environment Agency (2002) - The Total External Environmental Costs and Benefits of Agriculture in the UK

Environment Agency (2004) - The State of Soils in England and Wales.

Environment Agency (2005) - Assessment of 'Win Win' Case Studies of Resource Management in Agriculture

Environment Agency (2007) - Soil: a Precious Resource. Our Strategy for Protecting, *Managing and Restoring Soil. http://publications.environment-agency.gov.uk/pdf/GEHO1007BNDB-e-e.pdf*

Environment Agency (2008a) - Draft River Basin Management Plan, Severn River Basin District.

Environment Agency (2008b) - 'think soils' Soil assessment to avoid erosion and run off.

Environment Agency (on-line) - Agriculture Web Pages *http://www.environment-agency.gov.uk/business/sectors/32755.aspx*

European Soil Portal, European Commission - Land Management & Natural Hazards Unit. *http://eusoils.jrc.ec.europa.eu/*

Flood & Water Management Act 2010 - *http://www.opsi.gov.uk/acts/acts2010/pdf/ukpga_20100029_en.pdf*

Foresight Land Use Futures Project (2010) - Executive Summary. The Government Office for Science, London. *http://www.bis.gov.uk/assets/bispartners/foresight/docs/land-use/luf_report/8614-bis-land_use_futures_exec_summ-web.pdf*

Forestry Commission (2009) - Combating Climate Change a Role for UK Forests. An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change.

Hampshire County Council - Soils web page *http://www.hants.gov.uk/environment/soils/*

HM Government (2009) - The UK Low Carbon Transition Plan - National Strategy for Climate & Energy. *http://www.climatechangeandyourhome.org.uk/live/content_pdfs/137.pdf*

Local Government Association (2005) - Greening Communities: Ideas Into Action. Soil. *http://www.lga.gov.uk/lga/core/page.do?pageId=18781*

MAFF (2000a) - Good Practice Guide for Handling Soils. *http://webarchive.nationalarchives.gov.uk/20090306103114/http://www.defra.gov.uk/ farm/environment/land-use/soilguid/index.htm*

MAFF (2000b) - Land use planning. Good practice guide for handling soils. *http://webarchive.nationalarchives.gov.uk/20090306103114/http://www.defra.gov.uk/farm/environment/land-use/soilguid/index.htm*

National Soil Resources Institute - *www.cranfield.ac.uk/sas/nsri/index.html*

National Soil Resources Institute (2005) - Soil Based Services in the Built Environment. A Report Prepared for DEFRA.

National Trust (1999) - A National Trust Soil Protection Strategy. Available at *http://www.nationaltrust.org.uk/main/w-soil_protection_strategy.pdf*

Natural England (2008) - Carbon Baseline Survey Project. *http://www.naturalengland.org.uk/research/climate-energy/docs/calmreportfinal.pdf*

Natural England (2009) - Agricultural Land Classification: protecting the best and most versatile agricultural land. *http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductI D=88ff926a-3177-4090-aecb-00e6c9030b29*

Natural England (2011) - Monitor of Engagement with the Natural Environment survey 2010-2011. *http://www.naturalengland.org.uk/ourwork/enjoying/research/monitor/default.aspx#results*

Richards, T.D. Conway, J.S. Maddox, I. & Hill, G. (2007) - A Baseline Assessment of the Superficial Deposits, Soils and River Systems of Worcestershire. Herefordshire and Worcestershire Earth Heritage Trust.

Royal Commission on Environmental Pollution (2001) - A Review of the Royal Commission on Environmental Pollutions Nineteenth Report: Sustainable Use of Soil. *http://www.rcep.org.uk/pdf/soil1rep.pdf*

Stace, H. & Larwood, G. (2006) - Natural Foundations: Geodiversity for people, places and nature. Peterborough: English Nature.

TEEB (2011) - The Economics of Ecosystems and Biodiversity in National and International Policy Making. Earthscan. For general information on TEEB, refer to: *www.teebweb.org*

The Royal Society (2001) - The Role of Land Carbon Sinks in Mitigating Global Climate Change. *http://royalsociety.org/displaypagedoc.asp?id=11504*

UK National Ecosystem Assessment (2010) - Understanding nature's value to society

Worcestershire County Council (2004) - A New Look at the Landscapes of Worcestershire

Appendix 3 - Worcestershire's Soils

Soil is formed by the weathering and breakdown of the underlying rock, the chemical and physical properties of that rock in turn, determining the type of vegetation and land uses that will succeed in a given area. With such a varied geology, it follows that the soils of Worcestershire will be similarly varied.

Shallow soils are associated with the tops of the highest ground - Malvern Hills and the Cotswold plateau, the former being poor and acidic, with the latter being free draining, calcareous soils with a distinctive orange colouring and a notable content of light stones.

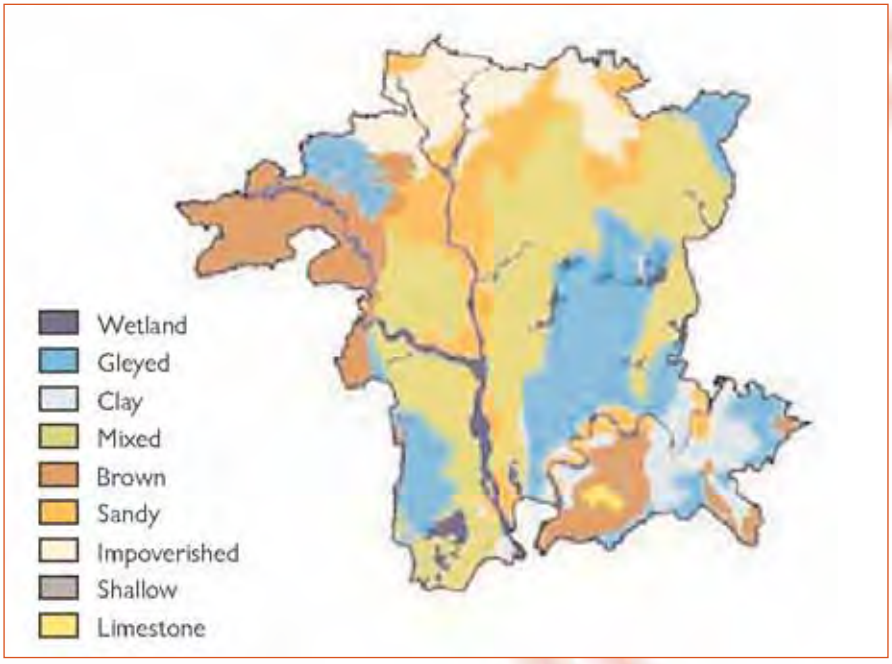
The soils in the north of the county are the most acid and impoverished, including those associated with the soft sandstone areas around Kinver, the sandy soils of the hard Palaeozoic rocks of Clent and those of the hard sandstone rocks of the Wyre Forest. Free draining sandy soils of better status lie to the south of these and also occur along the river terraces.

By way of contrast, large areas of gleyed soils occur, these poorly drained soils are associated with areas of drift such as boulder clay, shales and some of the areas of lias clays

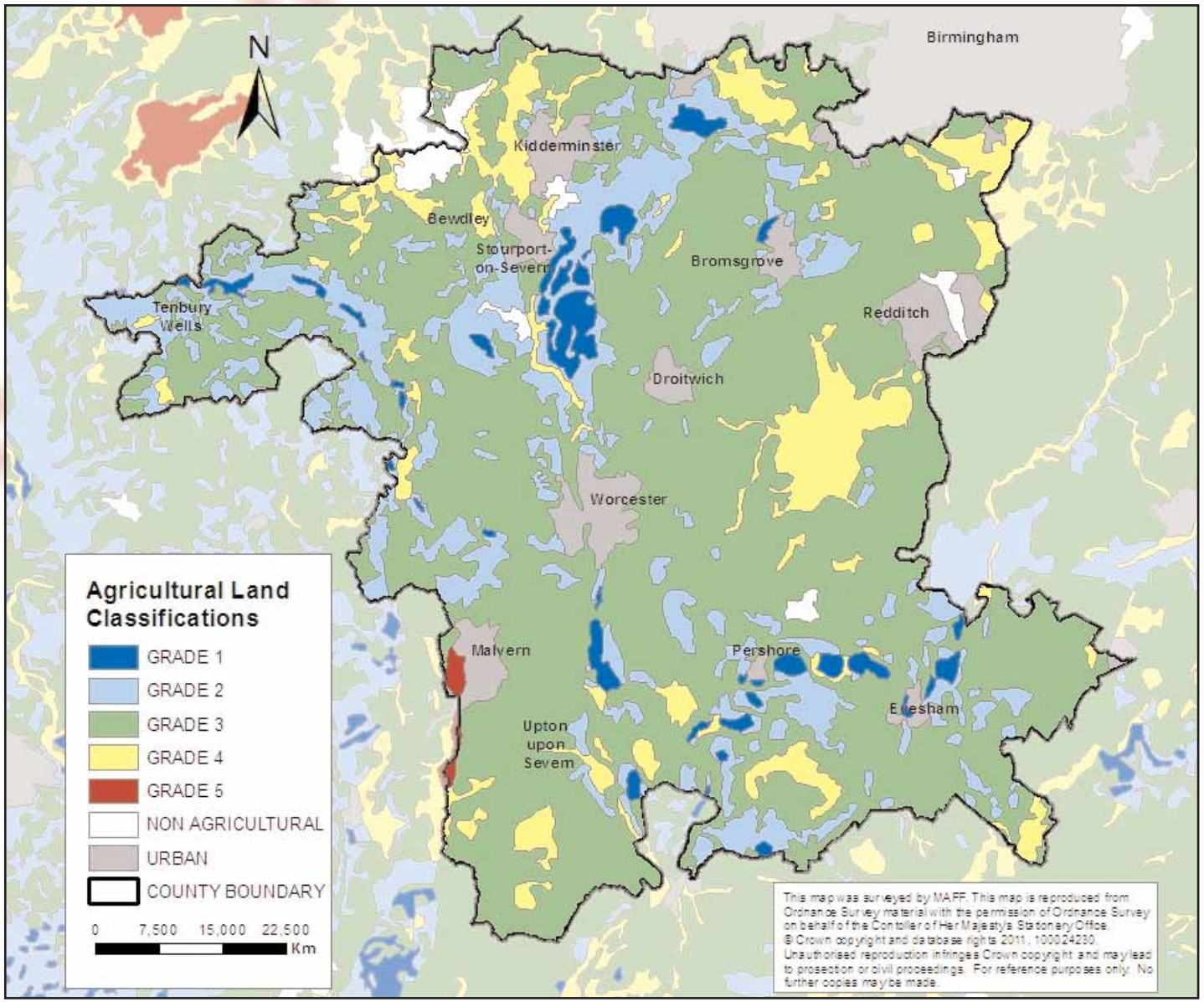
Wetland soils associated away from the river valleys, such as those found at Longdon and Feckenham are similarly poorly drained. Those in the river valleys themselves, derived from alluvium, are better drained but subject to seasonal flooding. The fertile base-rich clay soils, and brown soils, found in the vicinity of Pershore and Evesham, associated with the Lias Group of rocks, are better draining.

Free draining brown soils and mixed soils, associated with mudstones, mixed mudstones and sandstones, and fluvio-glacial deposits, account for much of central and western parts of the county.

Map of Worcestershire's Soils

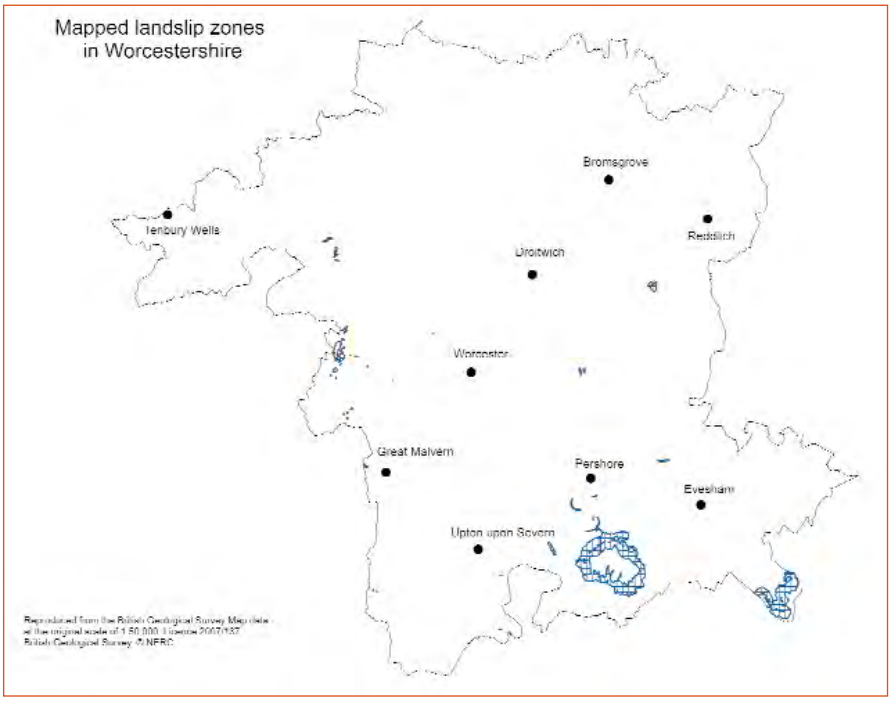


Appendix 4 - Map of Agricultural Land Classification



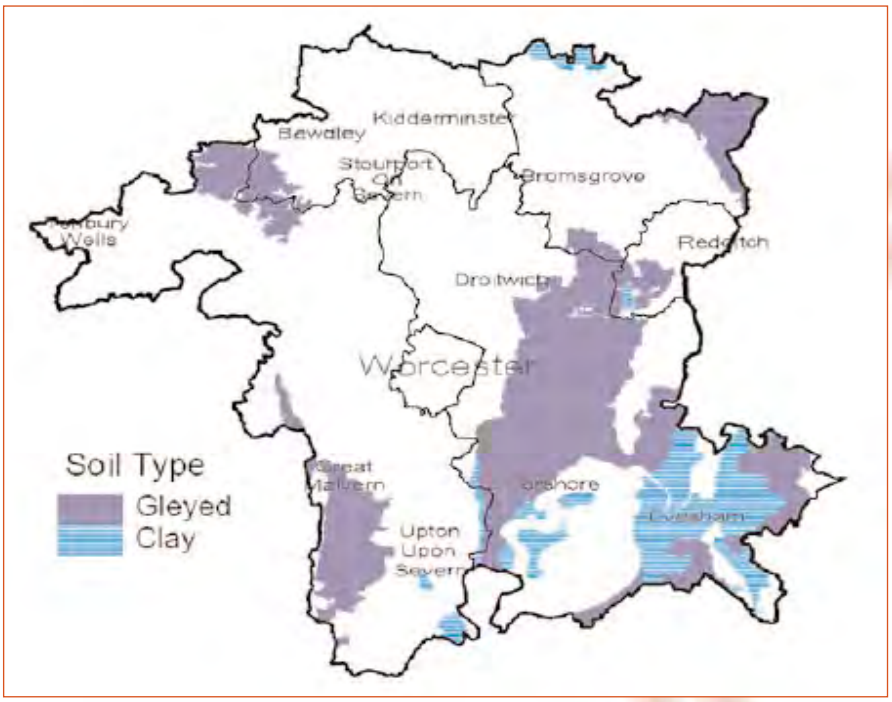
An explanation of agricultural land classifications grading and the percentage of coverage for the county are available on page 7.

Appendix 5 - Map of areas prone to subsidence and Landslip within Worcestershire



Source: Herefordshire and Worcestershire Earth Heritage Trust

Map of increased risk of subsidence in Worcestershire



Source: Worcestershire Climate Change Strategy

This document can be made available in other languages (including British Sign Language) and alternative formats (large print, audio tape, computer disk and Braille) on request from Strategic Planning on telephone number 01905 766097.

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