The East Midlands in 2010: The East Midlands Environment and Natural Resources

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7. The East Midlands Environment and Natural Resources

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7.1 Introduction

Economic growth affects, and is affected by, the state of the environment. The environment acts as a source of raw materials for economic activity and provides a network of ecosystem services, including the capture and storage of many by-products of economic activity (waste, emissions, etc). It also provides a source of recreation and well-being for its inhabitants. However, the environment poses hazards of its own, and can constrain economic growth in some areas, e.g. on floodplains or along the coast.

Parts of the East Midlands have a significantly degraded environment, which need careful rehabilitation and management to bring them up to the national standard in terms of biodiversity and landscape. Some of the region's already scarce natural assets are under growing stress, particularly from intensive agriculture and large scale mineral and aggregate extraction, whilst the implications of climate change will have significant consequences for the region, especially in coastal areas.

However, the region's environment also provides a range of assets for economic development, social cohesion and individual wellbeing. The Wash, much of which is in Lincolnshire, is the largest Site of Special Scientific Interest (SSSI) in England and the Peak District is one of the most visited National Parks, whilst the region has a range of heritage assets that generate tourism. The East Midlands has a rich geology which makes it the most important region in England for minerals and the production and export of aggregates.

There are parallels that need to be drawn between environmental challenges and the incentives and opportunities for enterprise, innovation and the development of new sectors, for example to take advantage of 'clean' fuel and to develop renewable energy sources.

This chapter provides context on some of these themes. Whilst the focus is on the East Midlands, these complex relationships exist at the global, national, regional and local level, and are rarely spatially and temporally specific. This chapter seeks to interpret these relationships, focusing on the way the environment is both affected by, and affects, economic growth.

The following section provides some broad context on the global relationships between economic growth and environmental impacts. It summarises some of the findings of the Stern Review on the likely future impacts of population and economic growth on emissions, water supply and food and energy security. It then introduces recent policy developments, including the outcomes of the international Copenhagen Summit on climate change in December 2009. This section then goes on to look at climate change in more

detail. It summarises some of the observed global and national climate trends and discusses the latest national climate change forecasts. These predict increasing temperatures across the UK but little changes in annual rainfall, although there will be increased seasonal variation. However, significant rises in sea levels are projected along with increased chances of coastal flooding. Progress is then assessed towards global and UK targets to reduce greenhouse gas emissions. In the East Midlands, although there has been a significant long-term reduction in emissions since 1990, there has been an increase since 1999. Analysis by sector reveals that the fuel and power production sector is responsible for the vast majority of emissions. In terms of end-user, the East Midlands has the third highest total CO_2 emissions per head of population, with an above average level attributable to road transport, and this has decreased less over the last three years than elsewhere in the UK. This can be linked to the East Midlands' relatively dispersed spatial pattern of development, with no single dominant centre and significant inter and intra-regional flows of commuters and goods.

The third section assesses other types of air pollution monitored by the Environment Agency. This demonstrates that pollution from particulates and sulphur oxides has fallen significantly in the region in recent years, due to technological improvements. However, nitrogen oxide emissions have been harder to control, and there has been little overall reduction in the region.

Section four provides an overview of the region's geology and mineral resources. The region has a rich geological character, and in terms of hazards, is relatively geologically benign. The East Midlands is an important producer of a wide range of minerals, and is the UK's major producer of gypsum and only producer of fluorspar. Overall, the region is the largest aggregate producer and exporter in the UK, and is responsible for a quarter of all primary aggregates supplied nationally.

Section five analyses regional energy production and consumption. The East Midlands is a key energy producer, accounting for a significant share of UK capacity, but most energy is produced through fossil fuels. The East Midlands also consumes the third largest amount of energy per capita, and again road transport accounts for a significant share of this. The region continues to have significant coal reserves, and its coal mining history provides a number of opportunities for clean coal energy extraction, such as through methane from abandoned mines. The East Midlands currently has a relatively low capacity for generating renewable energy overall, at around half the capacity of the leading region. However, there have been significant developments, notably in biomass capacity driven in part by the presence of large coal and biomass co-firing power stations in the region.

Section six discusses waste production and management. The East Midlands is responsible for just over 10% of waste arisings in England, with larger shares attributable to industry and commerce and construction and demolition than the national average. In terms of waste generated per unit of economic output, the East Midlands is less resource efficient than the national average. Moreover, an above average proportion of all waste (municipal, industrial and

construction) goes to landfill in the East Midlands. However, in the case of municipal and household waste, the East Midlands achieved has the highest rates of recycling and composting in England and has achieved the most significant increase in this over time.

Section seven looks at water resources, their condition and flood risk. Lincolnshire is one of the driest parts of the country, which contributes to water resource pressure in the region. Water abstractions from the Midlands region were amongst the highest in England. Water quality has improved significantly in the region in terms of both biological and chemical quality, with the highest percentage increase of any region in both between 1990 and 2007. The water industry and waste management sectors accounted for the largest proportion of water pollution incidents in the region. The East Midlands contains some of the most extensive flood-prone coastline in England, and is also prone to flooding from rivers and groundwater.

Section eight describes the region's biodiversity, landscapes and heritage. The East Midlands currently has the highest proportion of Sites of Special Scientific Interest (SSSIs) assessed as being in 'favourable' or 'recovering' condition of any English region, and has exceeded the Government's PSA target in this respect. On indicators of biodiversity outside designated sites, the East Midlands performs less well. Populations of farmland bird species have declined and the region has the lowest proportion of land designated as Areas of Outstanding Natural Beauty of the nine English regions. The East Midlands also has a very low proportion of its land area covered by forests or woodland, with only London having a lower proportion. Additionally, a relatively low proportion of this woodland is accessible to the public compared to regions in the North of England. More positively, of the large number of heritage sites in the region, there is a relatively low proportion of historic monuments in the region that are assessed as being at risk. Conversely, the East Midlands has an above average proportion of listed buildings at risk, and this proportion has not fallen as much as in other regions in recent years.

Finally, this chapter addresses land use in the region, especially with respect to agriculture. The East Midlands accounts for a significant proportion of total national agricultural land, with the second largest share of arable land in England. Soil is generally of good quality and lead levels in soils and streams are generally low.

7.2 Climate change

7.2.1 Evidence for climate change

It is now without doubt that average global atmospheric and sea surface temperatures are rising. Ten of the warmest summers on record (going back to1860) have occurred in the last decade, with 2005 being the second warmest year on record. Arctic sea ice is declining significantly faster than

predicted by the general circulation models[1] (known as Global Climate Models, or GCMs) in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC AR4).[2] Since 1900 mean global temperatures have risen by nearly 0.8°C, much of it over the past 50 years. The IPCC concluded in 2007 that: "it is very likely that anthropogenic greenhouse gas increases caused most of the observed increase in global average temperatures since the mid-20th century." Other indicators include:

- Overall, land-based ice caps on the world's mountain ranges are receding, with an average reduction in thickness of 8m over the last 30 years;
- Recent analyses show that sea levels, which have been rising at ~3.4 mm/year during the 20th century, are projected to rise up to ~1.4 metres above 1990 levels by 2100;[3] and
- Rising sea temperatures have a direct influence on the energy dissipated through tropical storms and hurricanes. In the last 50 years energy dissipated through such weather systems has increased by 50%. The 2005 North Atlantic hurricane season caused significant damage.[4]

In July 2005, the Government asked Sir Nicholas Stern to lead a review into the economics of climate change. Specifically, the review team was asked to examine: the implications of economic growth on energy demand and emissions; the economic, social and environmental consequences of climate change; the costs and benefits of actions to reduce greenhouse gas emissions; and the impact and effectiveness of national and international initiatives to reduce emissions. The review team reported its findings in autumn 2006 and key points were as follows:

- By 2050, global energy demand could double as populations rise and developing countries expand their economies;
- The current stock of greenhouse gases in the atmosphere is estimated to be equivalent to around 430 parts per million (ppm) of CO_2 compared to only 280 ppm before the Industrial Revolution. Even if emissions did not increase beyond the current rate, the stock of greenhouse gases would reach double pre-industrial levels by 2050, at around 550 ppm of CO_2 equivalent. At this level there would be at least a 75% probability that average global temperatures would increase by 2°C;
- Global warming will have several impacts, many of which will be related to impacts on water. Melting glaciers will initially increase flood risk and then rapidly reduce water supplies, potentially threatening a sixth of the world's population. Since 1950, global water use has more than tripled;
- Ecosystems will be particularly vulnerable to climate change, with around 15-40% of species potentially facing extinction in the eventuality of a warming of 2°C;

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[1] Stroeve, J., 'Arctic sea ice decline: Faster than forecast', in 'Geophysical Research Letters', DOI 10.1029/2007GL029703, 2007.
[2] Intergovernmental Panel on Climate Change, Fourth Assessment Report, 2007.
[3] Rahmstorf, S., 'A semi-empirical approach to projecting future sea level rise', in 'Science', 315:368-370, 2007.
[4] NOAA magazine, 'Noteworthy records of the 2005 Atlantic Hurricane Season', 2005, at: http://www.noaanews.noaa.gov/stories2005/s2540b.htm

- However, power production remains the principal source of global emissions. The Stern Review estimated that the power sector around the world will have to become at least 60%, if not 75%, decarbonised by 2050 to stabilise emissions at or below 550 ppm of CO_2 equivalent;
- The expected cost of this stabilisation is estimated to be around 1% of Gross Domestic Product (GDP) in the UK;
- The cost of making new buildings and infrastructure resilient to the impacts of climate change is estimated to be around $15-150 billion for OECD countries per year (between 0.05 and 0.5% of national GDP); and
- However, there are also economic opportunities in tackling climate change. Markets for low carbon energy products are estimated to be worth at least $500 billion per year by 2050. Energy diversification and efficiency of supplies could also assist in stabilising market fluctuations.[5]

Recent UK statistics on the impacts of climate change show that:

- After a period of relative stability through the first half of the 20th century, the Central England Temperature (CET) has increased by about 1°C since the 1970s;
- The three warmest years on record have all occurred since 1998 and 19 of the warmest 20 since 1980;
- Sea levels around the UK have risen by about 1mm per year in the 20th century. The rate of rise since the 1990 has been higher than this; and
- Although annual precipitation has not changed hugely since records began in the 18th century, seasonal variations have increased significantly. All regions in the UK have experienced increases in winter rainfall over the past 45 years whilst most regions (except for the North East) have experienced decreases in summer precipitation. Severe windstorms have also become more frequent over the last three decades.[6]

The economic impacts of climate change have been felt around the world, demonstrating that in a global economy, local extreme weather and climate change has implications for us all.[7] For instance, in 2005 energy prices in the UK rose as a result of refinery and oil production interruption by hurricanes in the Gulf of Mexico.

To combat climate change, the United Nations Framework Convention on Climate Change (UNFCCC, 1992) agreed that each participating developed country would reduce its greenhouse gas emissions to 1990 levels by 2000. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (Intergovernmental Panel on Climate Change, 1997) made these reductions legally binding and reduced emission targets further.

In December 2009, the United Nations held a conference on climate change at Copenhagen, known as the Copenhagen Summit, which aimed to update

[5] HM Treasury, 'The Stern Review: The Economics of Climate Change', 2006.
[6] Jenkins, GJ, Murphy, JM, Sexton, DS, Lowe, JA, Jones, P, and Kilsby, CG, 'UK Climate Projections: Briefing Report', Met Office Hadley Centre, Exeter, UK, June 2009.
[7] The Stern Review, 'The Economics of Climate Change', 2006.

and strengthen the Kyoto targets for 2012. Negotiations between Annex I[8] and developing nations proved difficult, and the Copenhagen Accord was not legally binding. Delegates did endorse the scientific advice, recognising that "deep cuts in global emissions are required according to science" and agreed to cooperate in stopping the rise of global and national greenhouse gas emissions. Annex I countries agreed to submit "economy-wide emissions targets for 2020" by 31st January 2010. Non-Annex I countries would "implement mitigation actions" to slow growth in their carbon emissions, and would be provided with incentives to continue to develop on a low emission pathway. The Accord included a "goal" for the world to raise $100 billion per year by 2020 to help developing countries cut carbon emissions and established a Copenhagen Green Climate Fund "to support projects, programmes, policies and other activities in developing countries related to mitigation". Although it potentially mobilised significant funding for both adaptation and mitigation, the Copenhagen Accord included no agreement on how much individual countries should either contribute to or benefit from any funds.

However, despite the Copenhagen Conference's limited progress towards international legally binding targets, significant recent progress has been made in the UK through a programme of legislation between 2008 and 2010. The UK Climate Change Act of 2008 included the following key provisions:[9]

- Legally binding targets: Greenhouse gas emission reductions of at least 80% by 2050, and reductions in CO_2 emissions of at least 26% by 2020, against a 1990 baseline; and
- A carbon budgeting system which caps emissions over five year periods, with three budgets set at a time, to set out our trajectory to 2050. The first three carbon budgets will run from 2008-2012, 2013-2017 and 2018-2022, and must be set by 1st June 2009.

In July 2009, the UK Government published its Low Carbon Transition Plan, which outlines how the UK will cut emissions by 34% on 1990 levels by 2020. The plan sets objectives for households, industry and power generation. It aims for the creation of an additional 1.2 million 'green' jobs by 2020, a large increase in pay-as-you-save home energy schemes, and support for households to produce their own clean energy (e.g. solar panels etc.). In terms of power generation, 40% should be from renewable sources, nuclear and clean coal by 2020, whilst gas imports will need to be halved. Finally, with road transport increasing its share of greenhouse gas emissions in many parts of the UK, the plan set an objective for the average car to emit 40% less

[8] In the UNFCC, developed countries were known as 'Annex I countries' ("industrialised countries and economies in transition"). A sub-group of these, 'Annex II countries', describes those developed countries who are members of the OECD and had agreed to financial contributions assisting developing countries ('non Annex I countries') to meet climate change objectives. Annex II countries include the UK and other EU member states and the USA.

[9] The Climate Change Act can be found here: http://www.decc.gov.uk/en/content/cms/legislation/en/content/cms/legislation/cc_act_08/cc_act_08.aspx

carbon by 2020. In summary, the Transition Plan aims to improve energy security objectives as well as achieving financial benefits for both industrial and domestic users, both of which will contribute towards the 'moral challenge' of tackling climate change.[10]

Following the publication of the Low Carbon Transition Plan, two pieces of further legislation have recently been passed. In November 2009, the Green Energy (Definition and Promotion) Act was passed, to promote the "development, installation and usage" of green energy.[11] It aims to facilitate the development of green energy through planning and fiscal incentives such as:

- Changing permitted development rights in planning law to facilitate the installation of domestic scale wind turbines or air source heat pumps; and

- Ensuring that any increase in the value of a domestic property caused by the installation of energy efficiency measures or micro-generation systems will not result in higher council tax or, similarly, in higher rates bills for non-domestic properties.

A second piece of legislation, the Energy Act, received Royal Assent in early April 2010. This implements some of the key measures of the Low Carbon Transition Plan, and includes the following elements:

- A carbon capture and storage (CCS) incentive, which will deliver a financial support mechanism that will bring forward demonstration projects;

- A mandatory social price support programme, aiming to reduce the energy bills of the most vulnerable households and giving suppliers greater guidance on the types of households eligible for future support; and

- Clarification of Ofgem's[12] remit and tackling market power exploitation, in order to incentivise the regulator to act to reduce emissions and improve energy security as matters of consumer interest.

[10] The Department for Energy and Climate Change, 'The UK Low Carbon Transition Plan', July 2009.

[11] This legislation defines green energy as "the generation of electricity or heat from renewable or low carbon sources by the use of any equipment", which does not exceed a capacity of 5 megawatts of heat or electricity.

[12] The Office of Gas and Electricity Markets (Ofgem), working for the Gas and Electricity Markets Authority (GEMA), is the government regulator for the electricity and downstream natural gas markets in Great Britain. It was formed by the merger of the Office of Electricity Regulation (OFFER) and Office of Gas Supply (Ofgas) in 1999. Its primary duty is to "promote choice and value for all gas and electricity customers". Its main powers derive from the Gas Act 1986, the Electricity Act 1989, the Competition Act 1998, the Utilities Act 2000, the Enterprise Act 2002 and the Energy Act 2004.

7.2.2 European and UK progress towards greenhouse gas emissions targets

Under the Kyoto Protocol, the EU has agreed to an 8% reduction in its greenhouse gas emissions by 2008-2012, compared to the Kyoto base year. The reductions for each of the EU15 countries have been agreed under the so called EU Burden Sharing Agreement, which allows some countries to increase emissions, provided these are offset by reductions in other Member States.

Chart 1 illustrates trends in greenhouse gas emissions across the EU15 as a whole and for several Member States, including the UK, against the emissions measures set by the Kyoto Protocol.[13] This shows that average EU emissions have remained fairly stable, but there have been substantial variations in performance between Member States:

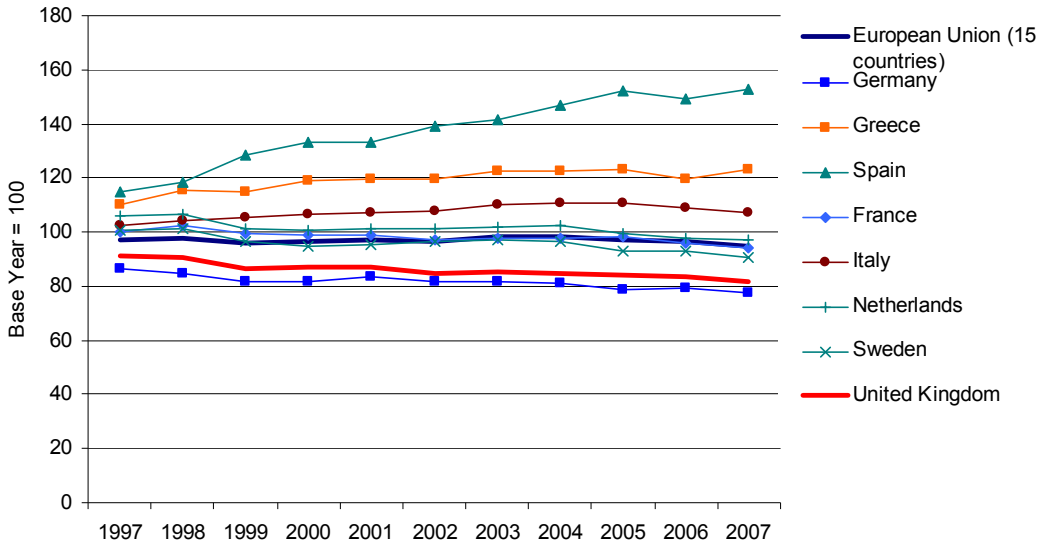
- Germany had the lowest emissions relative to 1990 throughout the period, with emissions falling to 77.6% of the 1990 level by 2007;

- The UK also has relatively low and falling emissions compared to other countries in Europe. In 2007, greenhouse gas emissions in the UK were 82% of the Kyoto baseline year. This shows that the UK, along with Germany, has a good chance of meeting the Kyoto targets by 2012, although subsequent milestones may be more challenging; and

- Emissions of greenhouse gases were highest in Spain, where they significantly exceed the 1990 baseline. They have continued to increase over time, to 152.6% of the baseline in 2007. In fact, all southern European countries experienced a similar increase in emissions.

[13] Emissions of the six greenhouse gases covered by the Kyoto Protocol are weighted by their global warming potentials (GWPs) and aggregated to give total emissions in CO_2 equivalents. The total emissions are presented as indices, with the base year = 100. In general, the base year is 1990 for the non-fluorinated gases (CO_2, CH_4 and N_2O), and 1995 for the fluorinated gases (HFC, PFC and SF_6).

Chart 1: Index of total greenhouse gas emissions from a selection of EU countries, and the EU as a whole (base year = 100)



Source: Eurostat, Greenhouse gas emissions – Index of greenhouse gas emissions and targets – In CO_2 equivalents (actual base year = 100), 1996-2006. Last updated July 2009, downloaded 16th March 2010.

7.2.3 Greenhouse gas emissions in the East Midlands

The UK Climate Change Act and subsequent legislation will have potentially profound impacts on the economic development of the East Midlands.

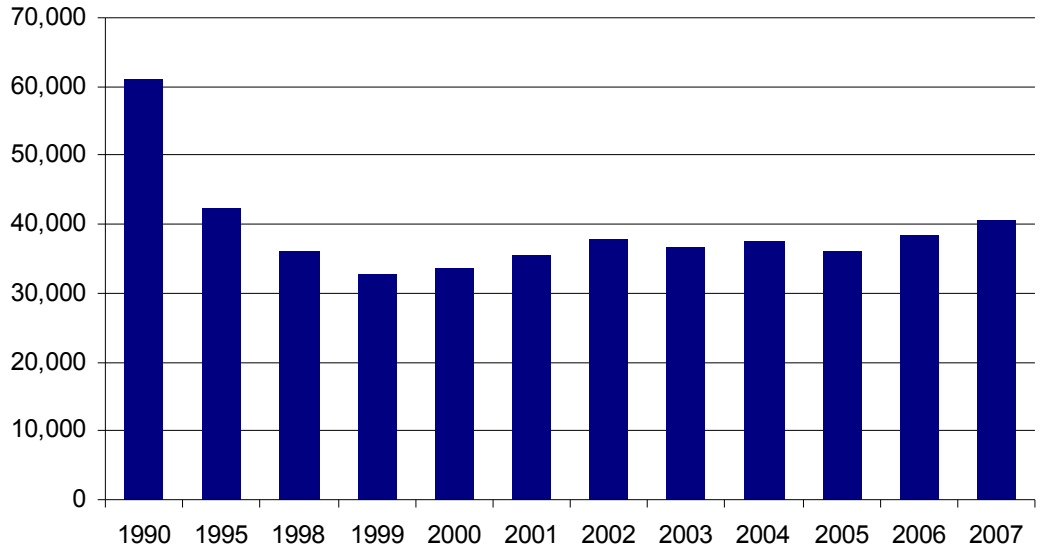
CO_2 is the main greenhouse gas emitted in the East Midlands, with smaller contributions from methane and nitrous oxide. An analysis of total 'Global Warming Potential' (GWP) emissions in the East Midlands from all Environment Agency regulated processes[14] from 1990-2007 is shown in Chart 2. This shows that, after the initial significant fall in emissions from 1990 to 1999, there has been a steady rising trend in total GWP emissions from regulated processes reaching levels similar to those in 1995:

- In 1990 total GWP emissions totalled more than 60,000 kilotonnes[15] of CO_2 equivalent. During the 1990s this fell to around 33,000 kilotonnes of CO_2 equivalent; and

- Between 1999 and 2007 there was an upward trend, from 32,800 kilotonnes of CO_2 equivalent in 1999 to 40,700 in 2007.

[14] The Environment Agency regulates about 1,600 of the most potentially polluting industrial processes including large combustion plants, metals, minerals, chemicals and incineration. These activities are then aggregated to broad industrial group for reporting purposes.
[15] A kilotonne is equivalent to a thousand tonnes, or a million kg.

Chart 2: Total emissions from Environment Agency regulated processes in the East Midlands, 1990-2007 (million kg CO_2 equivalent)

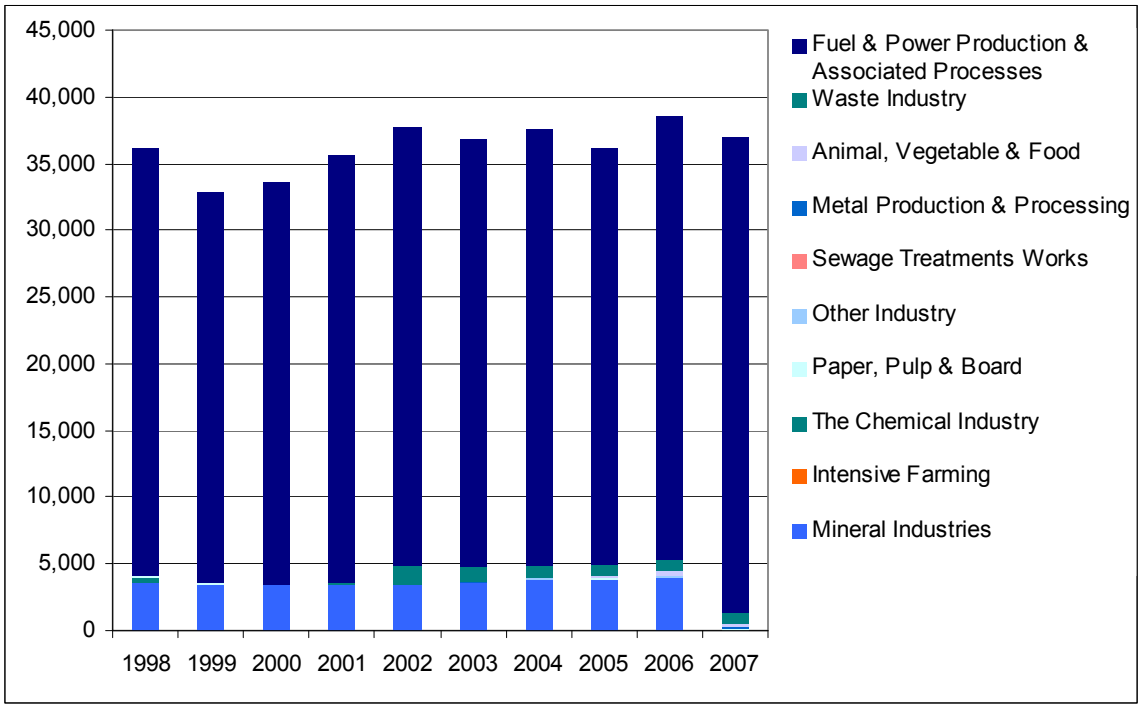


Source: Environment Agency, 2009.

Chart 3 shows these emissions with a breakdown by broad sector between 1998 and 2007. The key points to note are:

- Fuel & Power Production accounts for the vast majority of emissions from regulated processes. In 2007, 35,500 kilotonnes of CO_2 equivalent was attributed to activities in this sector, which was 87.2% of total emissions that year;
- Fluctuations in total emissions year-on-year are thus largely driven by changes in emissions from activities associated with Fuel & Power Production; and
- The next largest sector is the Mineral Industry, which accounted for 9.4% of total emissions in 2007. This is followed by the Waste Industry, which accounted for 2.2% of the 2007 total. However, the chart shows that emissions from Waste have increased significantly since 2001 (when activities associated with Waste only accounted for 0.2% of total emissions in the East Midlands). This is largely a function of additional reporting requirements imposed on the industry from 2002 onwards.

Chart 3: Emissions from Environment Agency regulated processes by broad sector, 1998-2007 (million kg CO_2 equivalent)



Source: Environment Agency, 2009.

Map 1 illustrates the point sources of emissions from regulated sources and the relative volume of these emissions (in kilotonnes of CO_2 equivalent per year). This shows that emissions from sites associated with the Fuel & Power Production and Associated Processes sector are mainly from the Trent Valley power stations.[16]

Indeed the East Midlands has some of the largest point sources of CO_2 emissions in the UK, such as Ratcliffe Power Station, south of Nottingham, which has a capacity of 2,000 Megawatts and generates between 8,000 and 10,000 kilotonnes of CO_2 equivalent per year. Other than Ratcliffe, the other two major point sources of emissions shown in Map 1 are the West Burton and Cottam power stations, both in north Nottinghamshire, near Retford, with generating capacities of 1,932 and 1,970 Megawatts respectively.

However, it should be noted that this production serves demand from consumers and industrial users from the East Midlands and beyond. As well as point sources, there are a number of 'mobile' sources of CO_2 emissions, mainly from transport routes running through the region, such as the M1. Emissions attributed to these 'end users' will be explored later in section 2.4.

[16] Emissions from power stations result from both the burning of fossil fuels and from flue gas desulphurisation (FGD) equipment, which reduces sulphur emissions, but increases CO_2 emissions.

Map 1: Major point sources of carbon dioxide emissions in the East Midlands, 2007

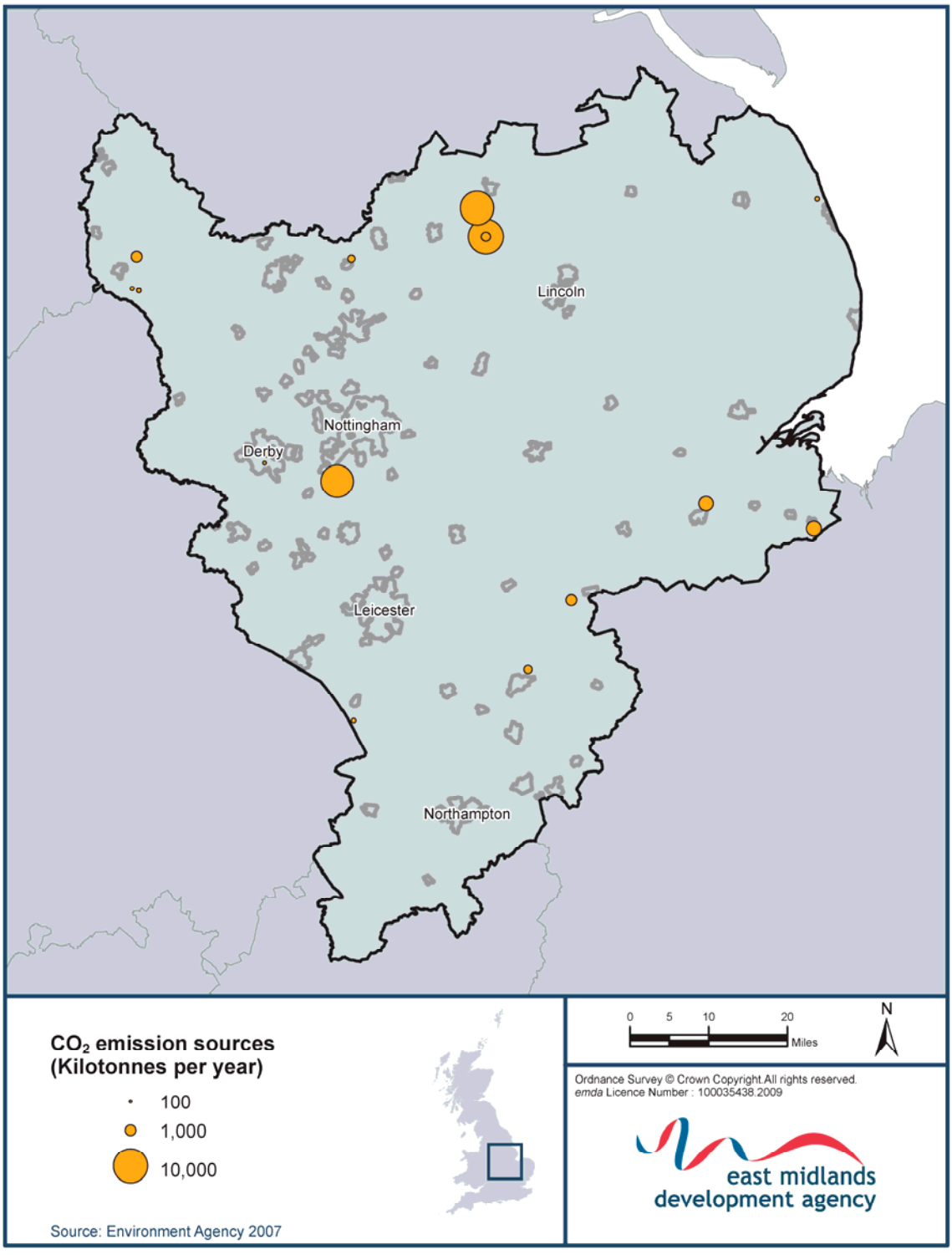


Chart 3 and Map 1 also illustrate that activities associated with mineral industries account for significant emissions of CO_2 equivalent. The main downstream mineral processes with greenhouse gas emission implications are:

- Aggregate processing: This accounts for the bulk of mineral production in the region, and has significant energy requirements, although gaseous emissions are largely of steam;

- Lime production: Where limestone is heated to produce lime, carbon dioxide is emitted into the atmosphere. The East Midlands is by far the largest producer of lime. Total UK tonnage of limestone, dolomite and chalk for conversion to lime was 2.9 million tonnes in 2004 (producing c. 1.3 million tonnes of CO_2 equivalent), of which a substantial proportion (at least two thirds) was carried out in the East Midlands at three Derbyshire sites;[17] and

- Cement production: In 2006, 3.5 million tonnes of limestone were used for cement making in the East Midlands, producing a similar amount of carbon dioxide to the lime industry.

Future projections for emissions of CO_2 equivalent in the UK in 2020 range between 144.6 million tonnes and 147.3 million tonnes.[18] The UK Government target is for emissions to be reduced by at least 60% by 2050. Increasing global transport flows, along with rapid population and economic growth in developing countries, will mean that emissions from industry will have to be reduced by more than 60% if the global targets are to be reached. CO_2 emissions in the UK were projected to have fallen by as much as 21% by 2010, although the Government has now conceded that it is unlikely to meet this target, and is aiming for a 15-18% cut in emissions from 1990 levels (though CO_2 emissions have in fact increased over the past three years), with cuts of 34% on 1990 levels by 2020 recently announced in the Low Carbon Transition Plan. It is not clear how much the East Midlands will contribute to any such reduction.[19]

7.2.4 CO_2 emissions by end user

The discussion so far has focused on emissions associated with the activities of source producers regulated by the Environment Agency. As well as improving the safety, efficiency and regulation of such processes, policy aimed at climate change mitigation also needs to change the consumption of the outputs associated with these processes. This section therefore looks at emissions attributed to the end user of the product or process – i.e. the consumer.

[17] United Kingdom Minerals Yearbook 2004, Keyworth, British Geological Survey, available for download from http://www.bgs.ac.uk/mineralsuk/free_downloads/downloads.html
[18] HMSO, Climate Change: The UK Programme 2006, March 2006.
[19] East Midlands Regional Assembly, England's East Midlands Integrated Regional Strategy – Our Sustainable Development Framework, 2005.

The main difference between source and end user emissions comes from the treatment of emissions from combustion of fossil fuels, the largest source of CO_2 in most countries. To derive emissions by end user, emissions from power stations and other fuel processing industries have been re-allocated to end users on an approximate basis according to their use of the fuel. Regional allocation excludes emissions from domestic aviation and shipping and the offshore oil and gas industry, which cannot readily be attributed to regions. Emissions by end user are subject to more uncertainty than emissions by source and should only be used to give a broad indication of emissions by sector.

Emissions attributed to end users are grouped into three categories:

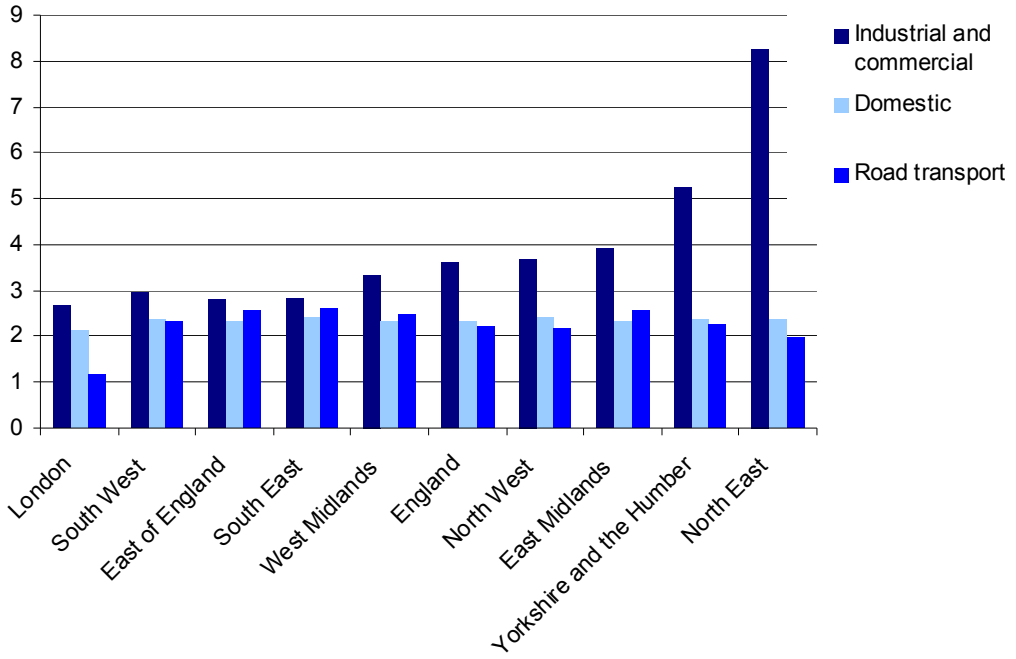
- Industrial and commercial;
- Domestic; and
- Road transport.

In the UK as a whole the total volume of CO_2 emissions attributed to end users has fallen, by 1.8% between 2005 and 2007. Over the longer term, falling emissions from the industrial and commercial sector, due to cleaner processes and continued changes in the industrial structure, have been the principal drivers of the total decline in emissions attributed to UK end users. Falls in emissions from domestic users have made a more significant impact in recent years. Between 2005 and 2007, emissions from industrial and commercial end users in the UK fell by 2.1% whilst domestic emissions fell by 2.6%. However, emissions from road transport have not fallen at a comparable rate, decreasing by only 0.6% between 2005 and 2007.[20]

Chart 4 illustrates CO_2 emissions per resident for 2007 by English region. This shows that the East Midlands had the third largest emissions per head of the nine regions, at 8.8 tonnes of CO_2 equivalent per capita (a total of 39,000 kilotonnes of CO_2, 9.3% of total emissions attributed to end users in England). This exceeds the average for England, of 8.1 tonnes per capita. The North East had the highest emissions, at 12.6 tonnes per capita in 2007.

[20] Detailed data from Department of Energy and Climate Change (DECC) and AEA Technology, 'Local and Regional CO_2 Emissions Estimates for 2005-2007', November 2009. This is derived from Local Authority data and from the National Atmospheric Emissions Inventory (NAEI), which is maintained by AEA. This data is the primary sources for the summary 'Regional Sustainable Development Indictors' published by Defra.

Chart 4: CO_2 emissions by end user by region (tonnes per capita), 2007



Source: Defra, 'Regional Sustainable Development Indicators 2009': Sustainable Consumption and Production Datasets – Carbon dioxide emissions by end user, 2007. Downloaded 17th March, 2010.

Looking at the categories of end user, the North East exceeds the other English regions because of the large volume of emissions attributable to industrial and commercial users, at 8.2 tonnes per capita in 2007, compared to 3.9 in the East Midlands.

In the East Midlands, the division of emissions between the three end user categories are as follows:

- Industrial and commercial users accounted for 44.5% of end user emissions (closely in line with the national average) in 2007;

- Domestic users accounted for 26.5% of all end user emissions, which was below the share in the England overall, at 28.7%; and

- Road transport accounted for a larger share of end user emissions in the region, at 11,200 kilotonnes, or 29% of total emissions. This is two percentage points higher than the national share.

In per capita terms, road transport end user emissions in the East Midlands also exceeded the national average, at 2.5 compared to 2.2 tonnes in 2007. Road transport emissions in the East Midlands also decreased at a slower rate than the national average between 2005 and 2007, by only -0.2% compared to -0.6%. This can be linked to the East Midlands' relatively dispersed spatial pattern of development, with no single dominant centre and significant inter and intra-regional flows of commuters and goods.

7.2.5 Impact of climate change

In June 2009, the UK Climate Projections 2009 (UKCP09) were published on behalf of the Department for Environment and Rural Affairs (Defra) and the Department for Energy and Climate Change (DECC).

UKCP09 differs from previous projections in that they are 'probabilistic', i.e. they take into account the uncertainty of projecting climate change due to natural variability and our incomplete understanding of the phenomena, by reporting a range of possible outcomes for each scenario. UKCIP09 is reported in 30 year intervals (up to the 2020s, the 2050s, and the 2080s) for three scenarios of emissions (low, medium, and high) based on work published by the IPCC. As trend based projections, they do not account for any possible future policy interventions to reduce or mitigate the effect of emissions.

For the UK as a whole, the medium emissions scenario from UKCP09 suggests that:

- All areas of the UK will get warmer, more so in the summer than in the winter. According to the 'medium emissions'[21] scenario, there will be a 50% probability (known as the 'central estimate of change') that in the 2080s mean temperatures across the UK will have increased by between 1.8 and 3.1°C in the winter and 2.5 and 4.2°C in the summer. The greatest increases will be in southern England whilst the smallest increases will be in northern Scotland;

- Under the medium emissions scenario for the 2080s, winter precipitation could increase by as much as 33% in some parts of the UK whilst summer precipitation could decrease by -40% in other areas; and

- Sea levels around the UK could rise by between 12 and 76cm between 1990 and 2095 under the medium emissions scenario.

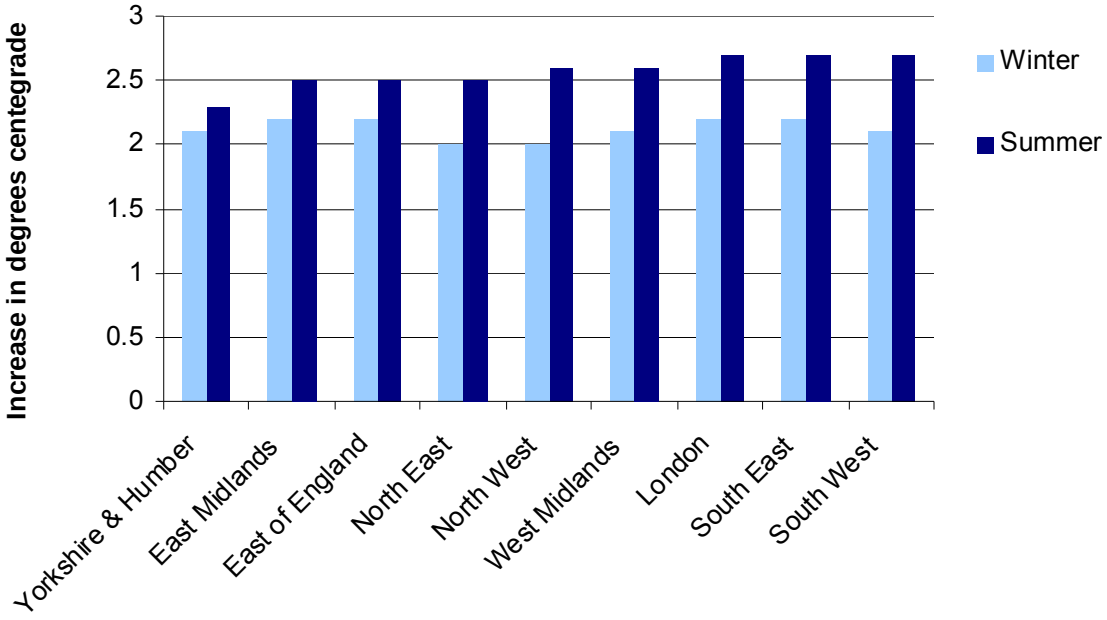
7.2.6 Climate Change in the East Midlands

The UKCP09 model provides climate forecasts for the English regions. Chart 5 shows temperature changes for the medium-term (the 2050s) for each of the English regions under the medium emissions scenario. This shows that summer temperatures in the East Midlands are expected to increase by the second smallest amount compared to the English regions, by an additional

[21] The scenarios used in UKCP09 are based on three storylines used in the IPCC 'Special Report on Emissions Scenarios' (SRES). These varied climate change emissions according to three possible pathways in which the world could develop. The high, medium and low emissions scenarios are all non-interventionist – i.e. they assume no political action. Differences are purely based on different assumptions about future socioeconomic change, such as population growth, energy intensity and land use. The medium emissions scenario assumes the same high level of economic and population growth as the high emissions scenario, but assumes a higher use of non-fossil energy sources.

2.5°C, compared to 2.3°C in Yorkshire and the Humber and 2.7°C in the South West. Winter temperatures are projected to increase by 2.2°C in the East Midlands, which is one of the larger changes of the English regions.

Chart 5: Temperature change by the 2050s by English region, medium emissions scenario, at the 50% probability (°C)



Source: UKCP09.

In the shorter term, under the medium emissions scenario, winter temperatures in the East Midlands could increase by between 0.5°C and 2.2°C by the 2020s. In the summer, temperatures could increase by between 0.4°C and 2.5°C. By the 2020s, there is a 50% probability that precipitation in the East Midlands will increase by 5% in the winter and decrease by -6% in the summer.

The social, economic and environmental effects brought about by climate change in the East Midlands could include:

- Greater damage to buildings through subsidence, and consequent economic impact due to increases in insurance claims;

- More flooding on the Lincolnshire coast and around rivers. Much of the East Midlands is low lying and vulnerable to flooding, while coastal areas will also be exposed to increased coastal erosion and landslip risk due to rising sea levels, more intense storm activity and increased incidence of wet/dry extremes. For example, a sea level rise could lead to erosion on the East Coast with the likely loss of coastal habitats;

- Higher temperatures, leading to deterioration in working conditions and potential disruption to transport;

- Less water available for domestic, industrial and agricultural purposes; and

- A mixture of effects on crop production – some beneficial (such as reduced frost damage and accelerated growth encouraged by warmer temperatures), others detrimental (such as spread of crop diseases, pests and increased water stress reducing crop yields). Periods of dry or very wet weather coupled with poor germination could lead to significant soil erosion due to wind, especially in spring.

There could be changes in the sorts of plant and animal species found in the region. Species that are temperature or water sensitive are likely to suffer stress and this could lead to local extinctions, while species preferring warmer conditions could become more prevalent.

Key Points: Climate Change

- Even if current green house gas emissions are stabilised there is a high probability that global temperatures will increase by 2°C by 2050. This level of warming will increase flood risk and threaten biodiversity. However, tackling climate change with low-carbon products could be worth at least $500 billion per year by 2050.
- In recent years the UK has had low emissions of greenhouse gases compared to other European countries.
- Over the long-term, emissions in the East Midlands have fallen, from 61,100 kilotonnes of CO_2 equivalent in 1990 to 40.7 billion kg in 2007.
- Fuel and power production accounts for the largest share of emissions in the East Midlands. The East Midlands also has some of the largest point sources of emissions in the UK, principally from power stations such as Ratcliffe.
- The East Midlands has the third largest CO_2 emissions per head attributed to end users of the English regions and had a significantly higher than average proportion of emissions attributed to road transport.
- In the future, all regions in the UK are projected to get warmer. By the 2050s, the East Midlands could see a 2.5°C increase in summer temperatures and a 2.2°C increase in winter temperatures.
- This could threaten water availability for domestic, industrial and agricultural uses and damage crops.

7.3 Air Pollution

Historically in developed industrialised countries, the major component of air pollution has been high levels of smoke and sulphur dioxide arising from the combustion of sulphur-containing fossil fuels such as coal for domestic and industrial purposes. Now however, with significant changes in industrial structure and improved environmental processes, the major threat to air quality in developed countries is now posed by traffic emissions. Petrol and

diesel engine motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), nitrogen oxide (NOx), volatile organic compounds (VOCs) and particulates (PM10s). In addition, photochemical reactions resulting from the action of sunlight on nitrogen dioxide (NO_2) and VOCs from vehicles leads to the formation of ozone, a secondary long range pollutant, which affects areas often far from the original emission site. Acid rain is another long range pollutant influenced by vehicle NOx emissions.

In all except worst case situations, industrial and domestic pollutant sources, together with their impact on air quality, tend to be steady state or improving over time. However, despite improvements in engine technology and fuel additives, worldwide traffic pollution problems are worsening (due to increased volume and density).

The East Midlands has experienced the third highest rate of road traffic growth of all English regions between 1998 and 2008, with the level of road traffic on motorways and A-roads increasing by almost 11% compared to just over 8% in England overall. The East Midlands is one of the most car-dependent regions, and had the highest proportion of workers citing travel by car and the lowest proportion using of public transport as a means of getting to work out of the nine regions.[22]

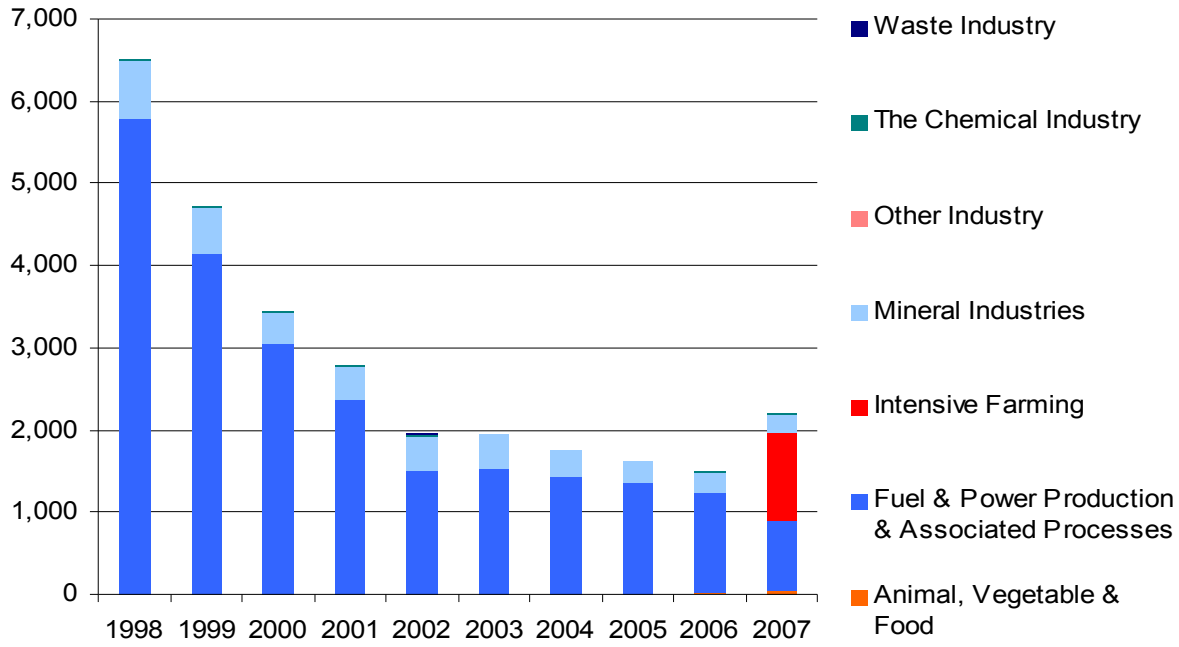
7.3.1 Air quality strategy substances in the East Midlands

In the UK, a number of substances are monitored as part of the Government's Air Quality Strategy (AQS Substances). Among these are benzene, carbon monoxide, lead, sulphur, nitrogen oxides and particulate matter.

Air quality in the East Midlands is generally better than the national average, although less good along the main road routes. Chart 6 shows data on emissions of particulates (PM10s) by Environment Agency regulated processes sourced in the East Midlands. This shows significant decreases in PM10s over the period 1998 to 2007, from 6,508 to 2,190 tonnes. Until 2007, fuel and power production and associated processes accounted for the majority of emissions. In 2007 the trend in total PM10 emissions increased because of the inclusion of intensive farming, accounting for 1,073 tonnes (49% of the 2007 total), which had not previously been required to report releases to the Pollution Inventory.

[22] See Chapter 8: Transport and Infrastructure.

Chart 6: Releases of particulates (PM10s) by Environment Agency regulated processes in the East Midlands by sector, 1998-2007 (tonnes)

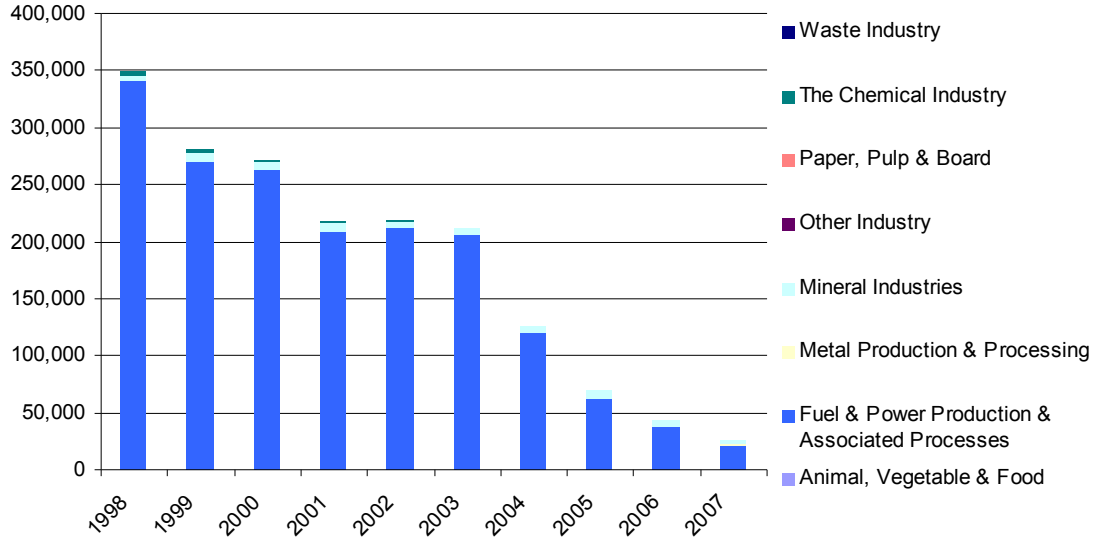


Source: Environment Agency, 2009.

Chart 7 shows emissions of sulphur oxide. As in the case of PM10s, the chart shows that emissions have decreased significantly over time and also that fuel and power production and associated processes have consistently accounted for the vast majority of emissions, accounting for 84.7% in 2007. In 1998, regulated processes in the East Midlands emitted 348,661 tonnes of sulphur oxide. By 2007, this had decreased very significantly, to 25,757 tonnes. This demonstrates the impact of flue gas desulphurisation (FGD) techniques, which use limestone to remove around 90% of sulphur from the exhaust flue gases of fossil fuel power plants. FGD generates gypsum as a by-product, which is then sold for use in plasterboard. Although large proportions of the region's limestone output is sourced from areas around the Peak District National Park, Government guidance and local planning frameworks make it very clear that limestone cannot be extracted from national parks for use in FGD processes, avoiding the trade off between emissions reduction and damage to protected areas.[23]

[23] Extraction of limestone for flue gas desulphurisation is no longer permitted according to the Structure Plan for the Peak District National Park.

Chart 7: Releases of sulphur oxides by Environment Agency regulated processes in the East Midlands by sector, 1998-2007 (tonnes)

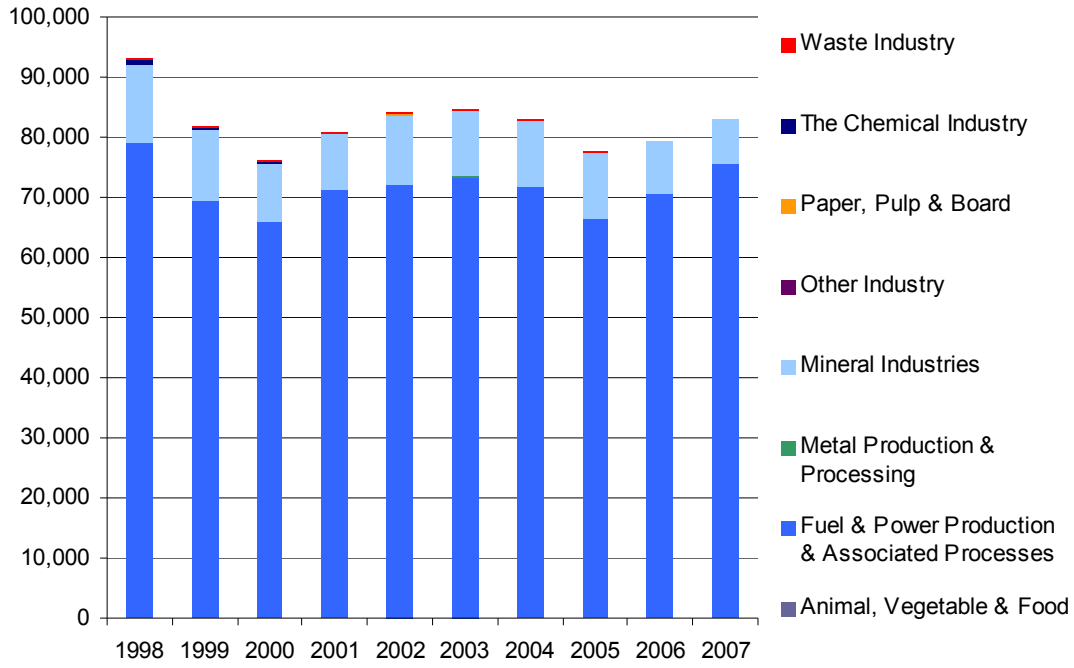


Source: Environment Agency submission, 2009.

Charts 6 and 7 show the strong positive impact of new technologies on environmental emissions. Both PM10 and sulphur oxide emissions have been considerably reduced by the application of cleaner technologies and fuels in the power industry – again the dominant source of releases in the sectors regulated by the Environment Agency. However, Chart 8 shows releases of nitrogen oxide, which have remained far more stable over time. In 1998, regulated processes in the region were estimated to have emitted 93,240 tonnes of nitrogen oxide. In 2007, this was estimated to have been reduced to 82,812 tonnes. As in the case of other emissions, fuel and power and associated processes has consistently accounted for the largest share (91.3% in 2007).

The relative stability of nitrogen oxide emissions over time is because it is much harder to control with technological fixes, so emissions have not dropped significantly since 1998.

Chart 8: Releases of nitrogen oxides by Environment Agency regulated processes in the East Midlands by sector, 1998-2007 (kg)



Source: Environment Agency, 2009.

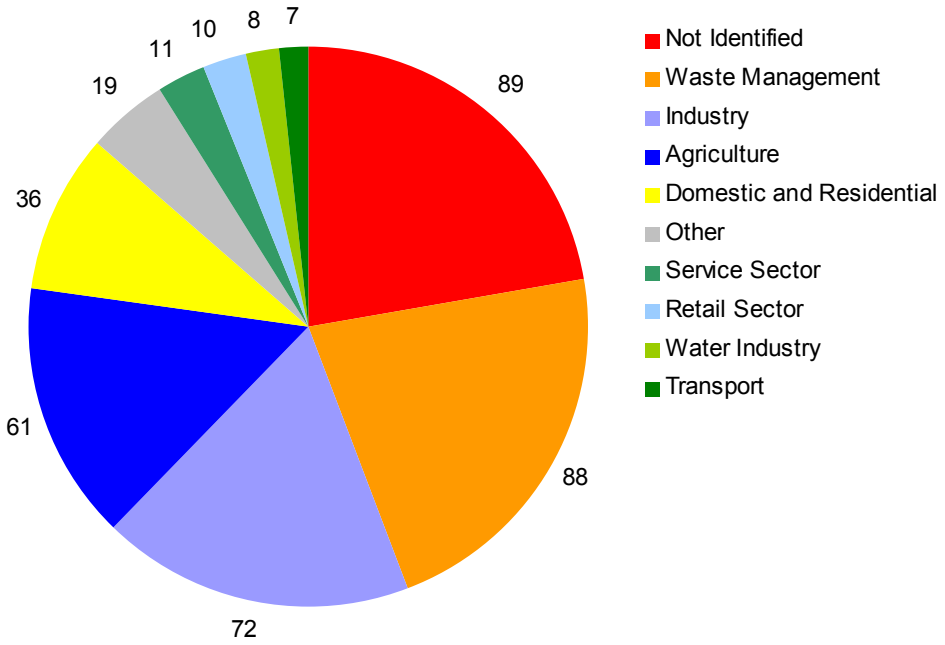
7.3.2 Air pollution incidents

The Environment Agency records all complaints and reported incidents of pollution. Each individual incident is then logged and categorised according to its severity. The category describes the impact of each incident on our water, land and air. The impact of an incident on each medium is considered and reported separately.

Category 1 incidents are the most serious, and result in persistent and extensive effects on air, water or soil quality along with major damage to ecosystems, properties, agriculture and associated commerce. If no impact has occurred for a particular media, the incident is reported as a Category 4. In 2007, there were 151 pollution incidents nationally that had a serious impact on air quality. This is a 6.2% decrease on 2006. The waste industry caused two thirds of all serious (Category 1 and 2) pollution incidents that affected air quality in 2007. Most of these incidents related to landfill sites and composting facilities. Generally the number of air pollution incidents has decreased since 2002.

Chart 9 shows data provided by the Environment Agency for incidents reported in the East Midlands in 2008.

Chart 9: Pollution incidents with impact to air in the East Midlands, 2008



Source: Environment Agency, March 2009.

In 2008, a total of 401 incidents (of all categories) were reported on premises in the East Midlands. Of these, 22% (88 incidents) were associated with waste management. This share is down from 2003, when 32% of all incidents were associated with waste management sites. The broad 'industry' sector was also associated with a significant number of incidents in 2008, at 20% of the total (similar to 2003, where industry accounted for 18% of all incidents in the region).

Key Points: Air pollution

- Air quality in the East Midlands is generally better than the national average, although less good along the main road routes.
- Airborne substances monitored under the Government's Air Quality Strategy have been decreasing in the East Midlands, with the exception of nitrogen oxides.
- Particulate emissions from regulated processes have decreased from 6,508 to 2,190 tonnes between 1998 and 2007 whilst sulphur oxide emissions have decreased from 348,661 to 25,757 tonnes over the same period.
- However, emissions of nitrogen oxides have remained relatively stable and above 80,000 tonnes throughout the period.
- This is because technological improvements have enabled industries like fuel and power production to significantly reduce emissions. Nitrogen oxide emissions have so far proved harder to control through technological fixes.
- Incidents reported to the Environment Agency with a serious impact on air quality fell between 2007 and 2006. Waste management accounted for the largest share of these incidents in both years.

7.4 Geology and natural resources

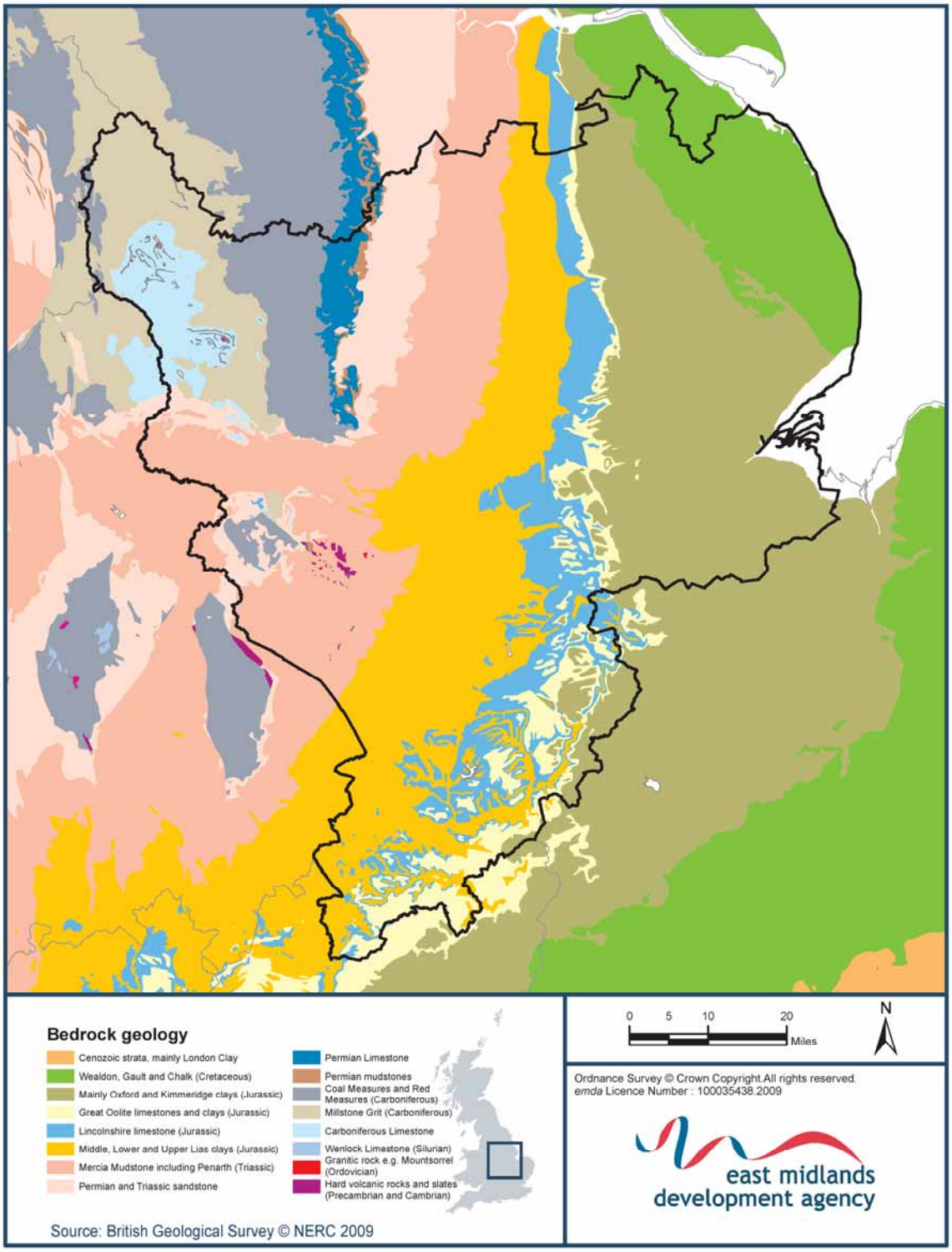
7.4.1 Geology

The geology of the region has exerted an important impact upon industrial development, energy resources, minerals economy and rural land use, and will continue to do so. It can also outline areas with potentially adverse ground conditions ('geohazards'), caused by certain physical properties of the substrate. Allied to these factors is the possibility of minor earthquake damage, and changes to the land surface or subsurface brought about by human activities such as mining, quarrying and landfill.

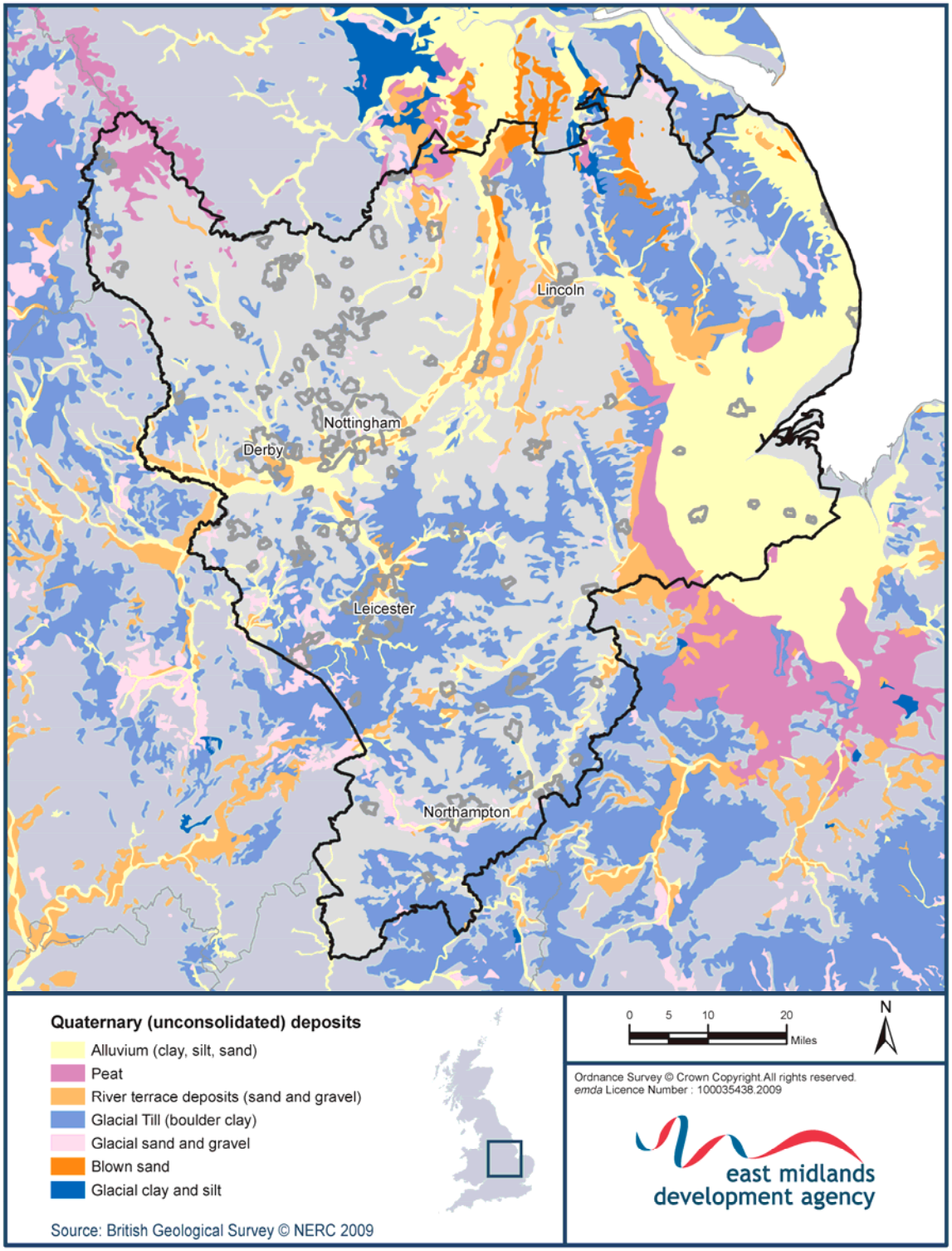
The geology of the East Midlands region[24] is arguably without parallel elsewhere in the south and midlands in terms of the diversity of the rocks and periods of time that are represented. In its simplest terms, the geology of a region can be broken down into two principal geological components – the solid substrate, or bedrock, and the overlying and generally much thinner superficial deposits.

[24] Hains, B. A. and Horton, A., 1969, 'British Regional Geology. Central England' (3rd Edition). (Keyworth: British Geological Survey).

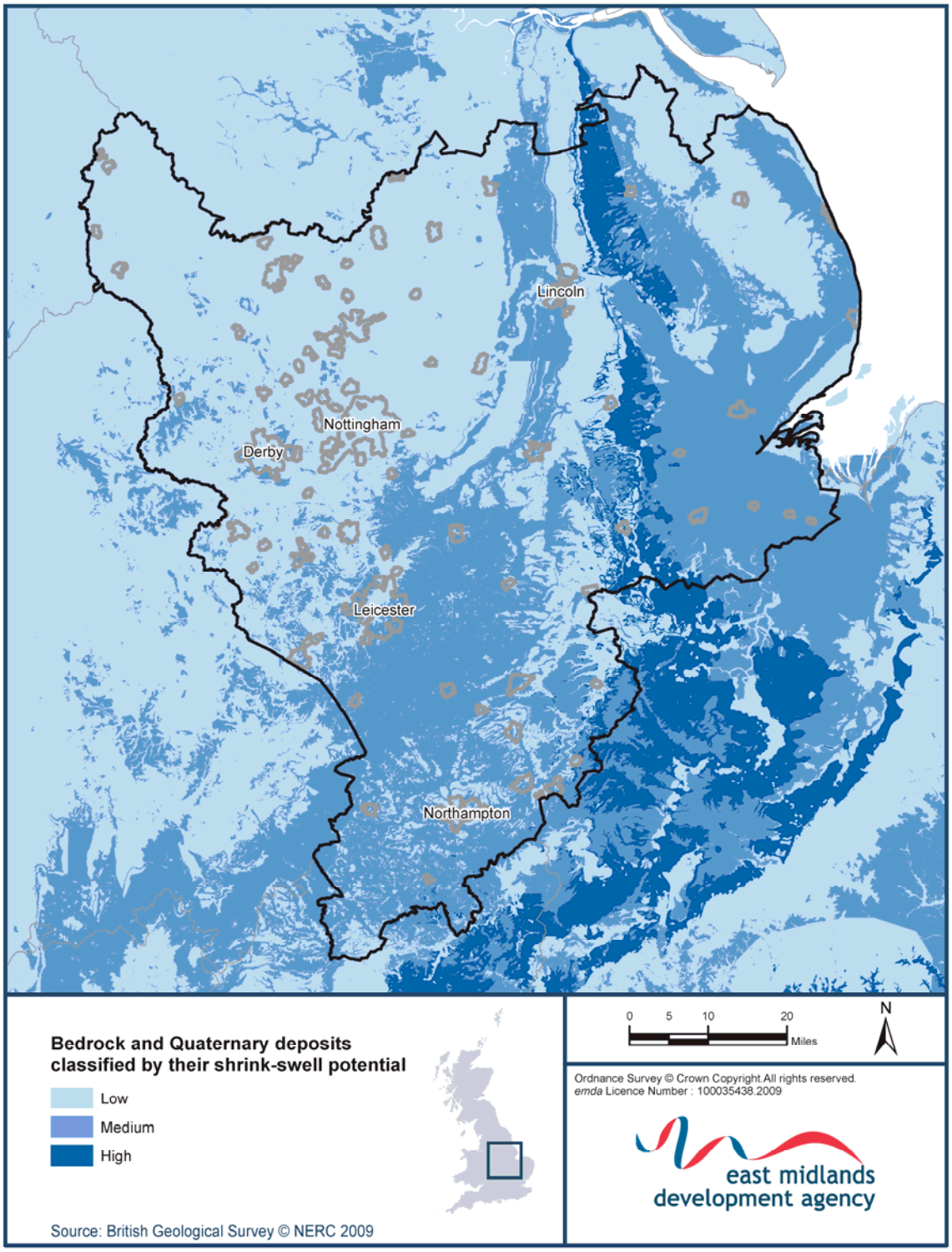
Map 2: Bedrock geology of the East Midlands (based on British Geological Survey digital geological map data at the 1:625,000 scale)



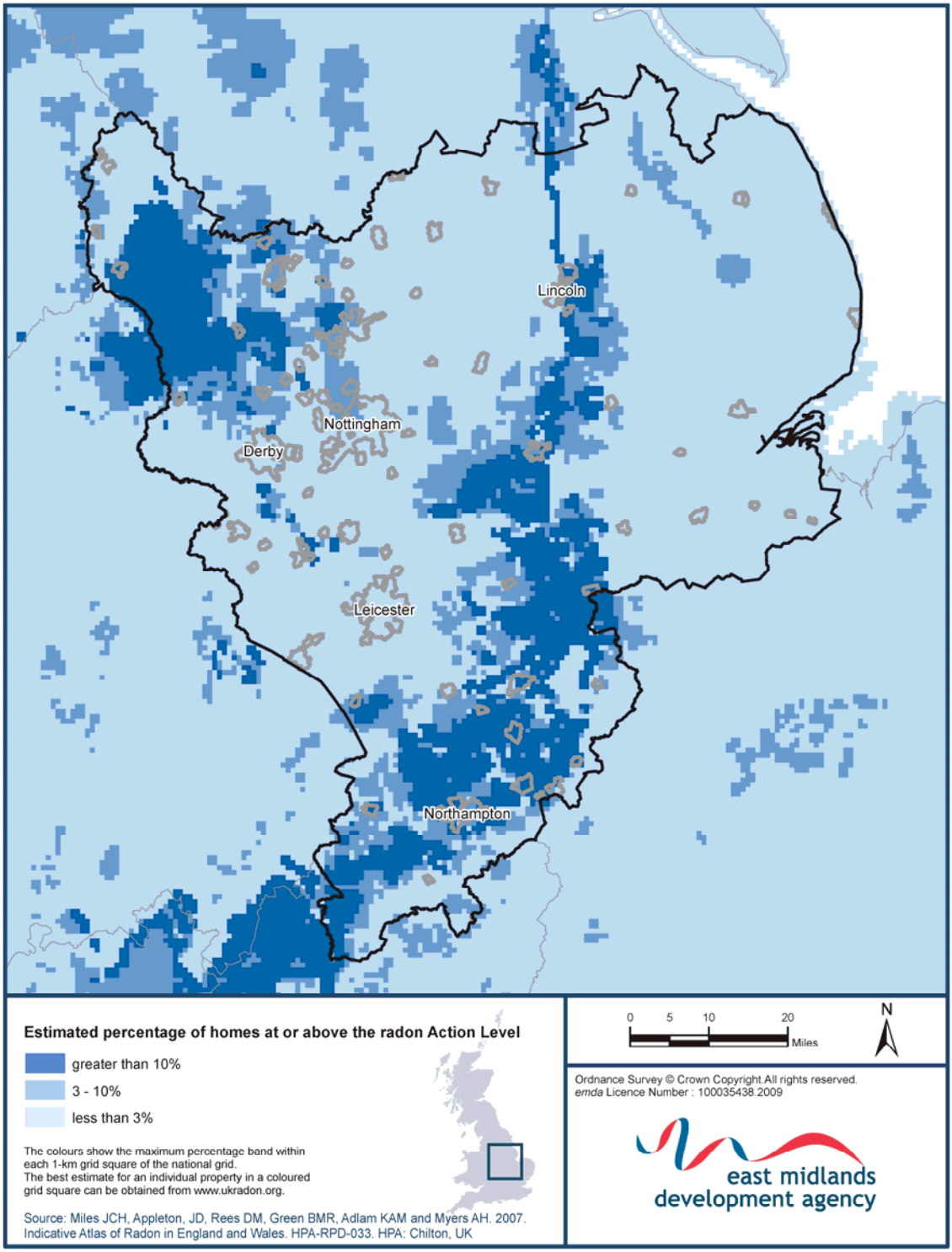
Map 3: Quaternary (superficial) geology of the East Midlands (based on British Geological Survey digital geological map data at the 1:625,000 scale)



Map 4: Shrink-swell clay potential for the East Midland (based on British Geological Survey "Geosure" digital data at the 1:50,000 scale)



Map 5: Areas of the East Midlands requiring radon protective measures to be installed in new buildings and extensions (based on British Geological Survey digital data at the 1:250,000 scale)



7.4.1.1 Bedrocks

The diversity of the bedrocks in the East Midlands (Map 2) has had a major impact upon landscape character, type of vernacular building materials[25] and current or past mineral wealth:

- The oldest rocks are exposed in Charnwood Forest and date back to Precambrian time, about 560-600 million years. The diversity and exotic nature of these rocks, and the unique landscape and recreational opportunities they afford, are enhanced by their rich assemblage of fossils. All of these assets have ensured the international fame of Charnwood Forest, both for academic reasons and for 'geotourism'.[26] This area is also important commercially, having experienced a long history of quarrying;[27]

- Cambrian [28] rocks of the 'Swithland Slates', also found in Charnwood Forest, were an historically important local resource of roofing slate through the 17th to the 19th centuries.[29] Although no longer worked, they remain much in demand for restoration and new vernacular building projects;

- Ordovician [30] granitic rocks, about 450 million years old, form prominent although small, hilly areas around Mountsorrel and Croft in Leicestershire. They have an economic importance out of all proportion to their small outcrop area and have been exploited for road and building stone;

- Carbonifer ous[31] strata underpin the dramatic landscapes that make the Peak District National Park of Derbyshire one of the most visited regions in the UK. The fossil-rich limestones of the 'White Peak'[32] are hosts to a historically important lead and fluorspar mining industry[33] and currently an important resource for cement making in northern parts of Derbyshire, and for road aggregates around Breedon on the Hill in North-West Leicestershire;

- Permian [34] limestones and dolomitic limestones from Nottingham northwards to Worksop represent an important resource for building stone, cement, refractory material and roadstone;

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[25] Lott, G. 2001, Geology and building stones in the East Midlands, Mercian Geologist, Vol. 15, 97-122.
[26] Ambrose, K. et al., 2007, Exploring the Landscape of Charnwood Forest and Mountsorrel, British Geological Survey.
[27] McGrath, A., 2007, The rock quarries of Charnwood Forest, Mercian Geologist, Vol. 16, 241-262.
[28] A period of geological time between 542 and 488 million years ago.
[29] Ramsey, D. 2007, Early slate quarries North West Leicestershire, Leicestershire Industrial History Society, Bulletin 18.
[30] A period of geological time between 488 and 444 million years ago.
[31] A period of geological time between 359 and 299 million years ago.
[32] Dalton et al., 1988, Classic landforms of the White Peak, The Geographical Association.
[33] Ford, T.D. and Rieuwerts, J.H. 2000, Lead mining in the Peak District, Peak District Mines Historical Society.
[34] A period of geological time between 299 and 251 million years ago.

- Triassic [35] strata are host to locally thick beds of gypsum, which are currently being mined around Barrow-on-Soar and Tutbury;

- The Jurassic[36] strata in the east of the region include the Lincolnshire Limestone which continues to be worked as a resource for high quality building stone;

- In terms of volume of production, however, the cement works at Ketton Quarry is pre-eminent; and

- The youngest strata are Cretaceous[37] rocks of the Chalk Group, which were laid down about 140 million years ago. The outcrop forms the Lincolnshire Wolds Area of Outstanding Natural Beauty.

7.4.1.2 Superficial deposits

The superficial deposits of the region (Map 3) are generally unconsolidated and because of this, and other physical properties, they can give rise to ground conditions that may be potentially hazardous to development. The extent of these deposits within the region is generally underestimated. They degrade rapidly, are in consequence seldom exposed, and may thus be confused with 'soils', particularly when disturbed by ploughing.

- Alluvium consists of clay, silt and sand forming the floodplains to the region's river systems. Similar deposits are also widespread across low-lying coastal tracts, where they include the former locations of tidal flats. The distribution of these deposits acts as a geological indicator of where flooding has occurred, or is likely to occur in the future. It also highlights ground that may pose problems for development.

- Peat deposits are accumulations of decayed and partially carbonised plant matter. They can occur in low-lying situations, such as coastal plain fens or in upland areas such as the Peak District. The physical properties of peat render it susceptible to shrink/swell behaviour, and it is also highly compressible when loaded with heavy structures.

- River terrace deposits represent the sands and gravels left behind by previous generations of the region's major river systems. These deposits are of significant economic importance to the East Midlands (see section 4.2.1).

- Glacial deposits include tills (boulder clays) left behind following the retreat of ice sheets that formerly covered large parts of the region. Sand and gravel deposits represent the outwash of melt waters that issued from within the ice sheets; they are less 'clean' than river terrace deposits, as

[35] A period of geological time between 251 and 200 million years ago.
[36] A period of geological time between 200 and 145 million years ago.
[37] A period of geological time between 145 1nd 65.5 million years ago.

they contain varying proportions of clay, but are locally thick and thus represent a further potential resource of sand and gravel.

7.4.1.3 Geology-induced hazards ('geohazards')

Compared to many parts of the world the East Midlands is geologically benign (for example, we do not have active volcanoes). Despite this, hazards posed by geology do exist and although they are generally subtle, their cost can be significant.[38] Engineering (geotechnical) ground conditions are related to the underlying geology and the key geotechnical issues (geohazards) in the region include:

- Swelling clays that will swell when wet and shrink as they dry out. This process can cause ground movement, particularly in the upper two metres of the ground that may enclose foundations, pipes or services. Clays with swelling properties are particularly widespread in the Jurassic bedrocks and Quaternary tills of the region (Map 4). Climate change models suggest that in future decades there will be an increasing incidence of predominantly dry, hot summers, followed by wet, stormy winters. Such predictions indicate that the economic consequences of ground movements caused by shrinkage and swelling is set to increase into the future;

- Radon is a radioactive gas that represents an unseen natural hazard to health and which is believed to cause more than 1,000 lung cancer deaths each year in the UK. Radon is quickly diluted in the atmosphere, so that concentrations in the open air are normally very low. However, radon that enters poorly ventilated buildings, caves, mines and tunnels can reach high concentrations. Radon in soil and rock under homes is the main source of radon in indoor air, and presents a greater risk of lung cancer than radon in drinking water. Map 5, extracted from the Indicative Atlas of Radon in England and Wales (Miles et al., 2007) [39] shows that areas with relatively high radon concentrations in homes are found across Northamptonshire, south Leicestershire, central Lincolnshire and much of Derbyshire. Basic radon protective measures are currently required in new buildings, extensions, conversions and refurbishments in areas where more than 3% of homes have radon concentrations above the Action Level (200 Bq m3) and full protective measures where more than 10% exceed the Action Level (Scivyer, 2007)[40]; and

[38] Charsley, T. J. et al., 1990, Nottingham: A geological background for planning and development, British Geological Survey Technical Report, WA/90/1.
[39] Miles, J.C.H, Appleton, J.D, Rees, D.M, Green, B.M.R, Adlam, K.A.M and Myers, A.H. 2007, Indicative Atlas of Radon in England and Wales, Health Protection Agency and British Geological Survey, ISBN 978-0-85951-608-2, Chilton: HPA.
[40] Scivyer, C. 2007, Radon: guidance on protective measures for new buildings (including supplementary advice for extensions, conversions and refurbishments), Building Research Establishment Report BR 211, ISBN 978-1-84806-013-5, Garston:BRE.

- Landslides are particularly common in the East Midlands, with Derbyshire, Leicestershire and Northamptonshire together having densities of reported landslides of 5.11 per 100km^2, which is significantly above the average for the Midlands as a whole.[41] They constitute a potential hazard to buildings and infrastructure in hilly areas such as the Pennines and in the central and eastern parts of the region. The correlation between landslides and unusually wet weather is well known, and there has been a significant increase in landslide activity across the region after the succession of wet autumns and winters in the last decade. In general, climate change models predict an increasing rate of change of seasonal and inter-annual variations in precipitation and temperature during the next 100 years. In turn, this will lead to a change in the frequency, distribution and mode of landsliding across the region.

Human influence on the geology of the region can also have an important effect upon ground conditions, in particular, the often unpredictable nature of ground resulting from opencast coal or ironstone reinstatement, and the restoration of quarries and sand pits. More insidious are the effects of subsidence due to deep coal mining[42] and the potential for the ground to collapse above ancient shallow coal workings, such as bell-pits. Lead mining in the Peak District[43] has also resulted in a legacy of potentially hazardous ground above shallow workings, exemplified by the well documented 'crown holes' that appeared near Matlock. Those collapses followed a period of prolonged heavy rainfall[44], and may point to a greater frequency of such events, should predictions of increasing climatic 'storminess' be fulfilled in future decades.

7.4.1.4. Earthquake risk

Earthquake risk tends to be ignored in the East Midlands, and yet there is a small but not negligible hazard from earthquakes. There are many large geological faults in the region, and these are sometimes reactivated by stresses which are attributed to modern plate tectonic movements, such as the 'drift' caused by the progressive expansion of Atlantic Ocean crust.

Earthquake size in the UK is measured from seismographs using the local magnitude scale (ML). Local magnitude scales give a magnitude approximately equivalent to the Richter scale. Map 6 shows the distribution of earthquakes in the region based on more recent events measured by instruments, and those estimated from historical records.

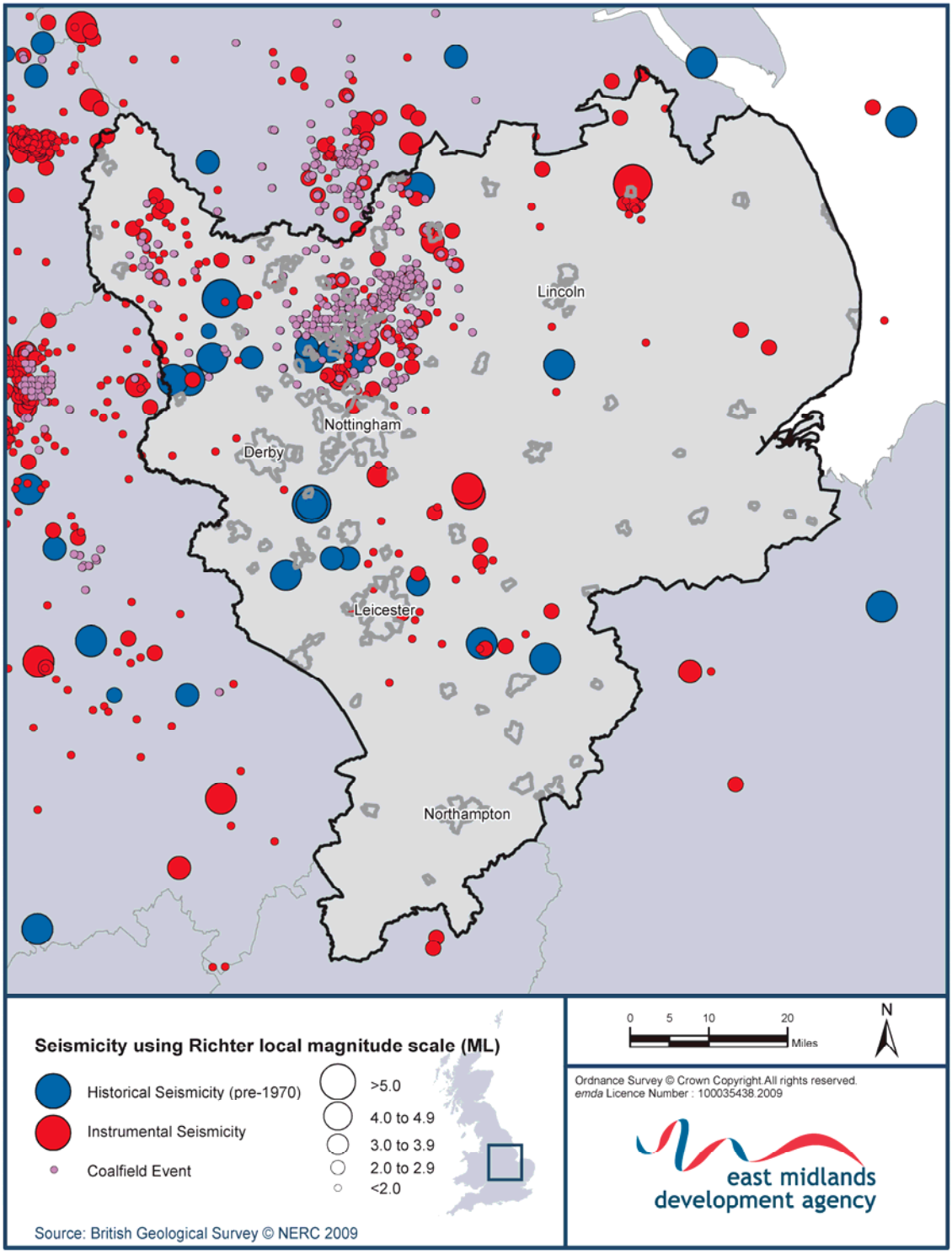
[41] Jones, D.k.C., 1999, Landsliding in the Midlands: a critical evaluation of the contribution of the National Landslide Survey. East Midlands Geographer, Vols. 21(2) & 22(1), 106-125.
[42] Donnelly, L. 2000, Fault reactivation induced by mining in the East Midlands, Mercian Geologist, Vol. 15, 29-37.
[43] Ford, T.D. and Rieuwerts, J.H. 2000, 'Lead mining in the Peak District', 4th Edition; Peak District Mines Historical Society.
[44] Jones, J., 2008, The Big Hole of Starkholmes, Mercian Geologist, Vol. 17, 19-22.

- Small to moderate earthquakes (magnitude 3-4ML), capable of being felt, occur on average every 3-4 years in the region.

- At longer intervals of 50-100 years there have been earthquakes of magnitude in the range 5 - 5.3ML.

- The largest instrumentally measured earthquakes in the East Midlands occurred near Derby in 1957 (5.3 ML) and Market Rasen in 2008 (5.2 ML).

Map 6: Seismicity of the East Midlands



Over the last 500 years for which archive studies provide the historical seismicity shown in Map 6, it is apparent that 5+ ML events are rare. The recent Market Rasen earthquake (27th February 2008, 5.2 ML) was relatively deep (around 20 km) and was felt over much of the UK.[45] Reports of damage

[45] Carney, J.N., Waltham, A. and Aram, J., 2008,' Two notable earthquakes in 2008', in Mercian Geologist, Vol.17, 43-47.

(mostly non-structural) were diffuse and were not concentrated at the epicentre. This is likely to be due to the depth of the earthquake, local site conditions and the unusual high energy release of the earthquake.

Mining for coal and other minerals can significantly alter the stresses and strength within rocks both at and above the mined depth. As a result of these changes, earthquakes may be generated by rock fracture and collapse, particularly in the vicinity of pre-existing natural fault-lines. These 'coalfield events' have produced the swarms of low-magnitude earthquakes shown on Map 6 in undermined areas to the north of Nottingham and south east of the Manchester conurbation. Their relatively shallow depth means that they can be felt more easily on the surface, and although they are associated in a general way with the processes that cause subsidence they cause little, if any, obvious damage apart from that produced by vibration. They can occur after a mine closes, though usually less frequently, due to the collapse of cavities.

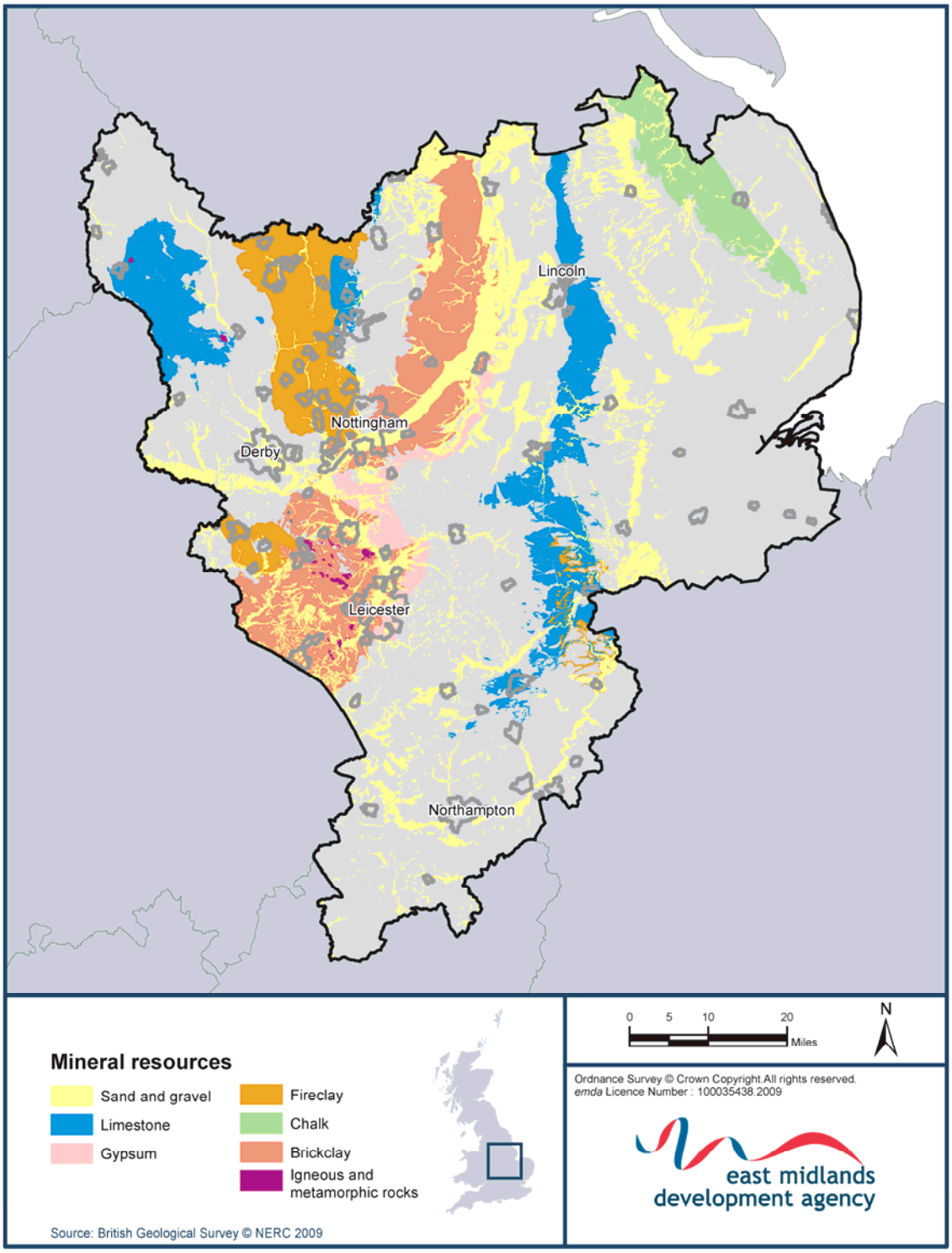
The indications are that that there is a 90% probability that intensity 6 on the European Macroseismic Scale (EMS) will not be exceeded in the next 50 years in the East Midlands.[46] However, the design of long lasting critical structures, such as power stations, must incorporate some allowance for earthquake hazard.

7.4.2 Mineral resources

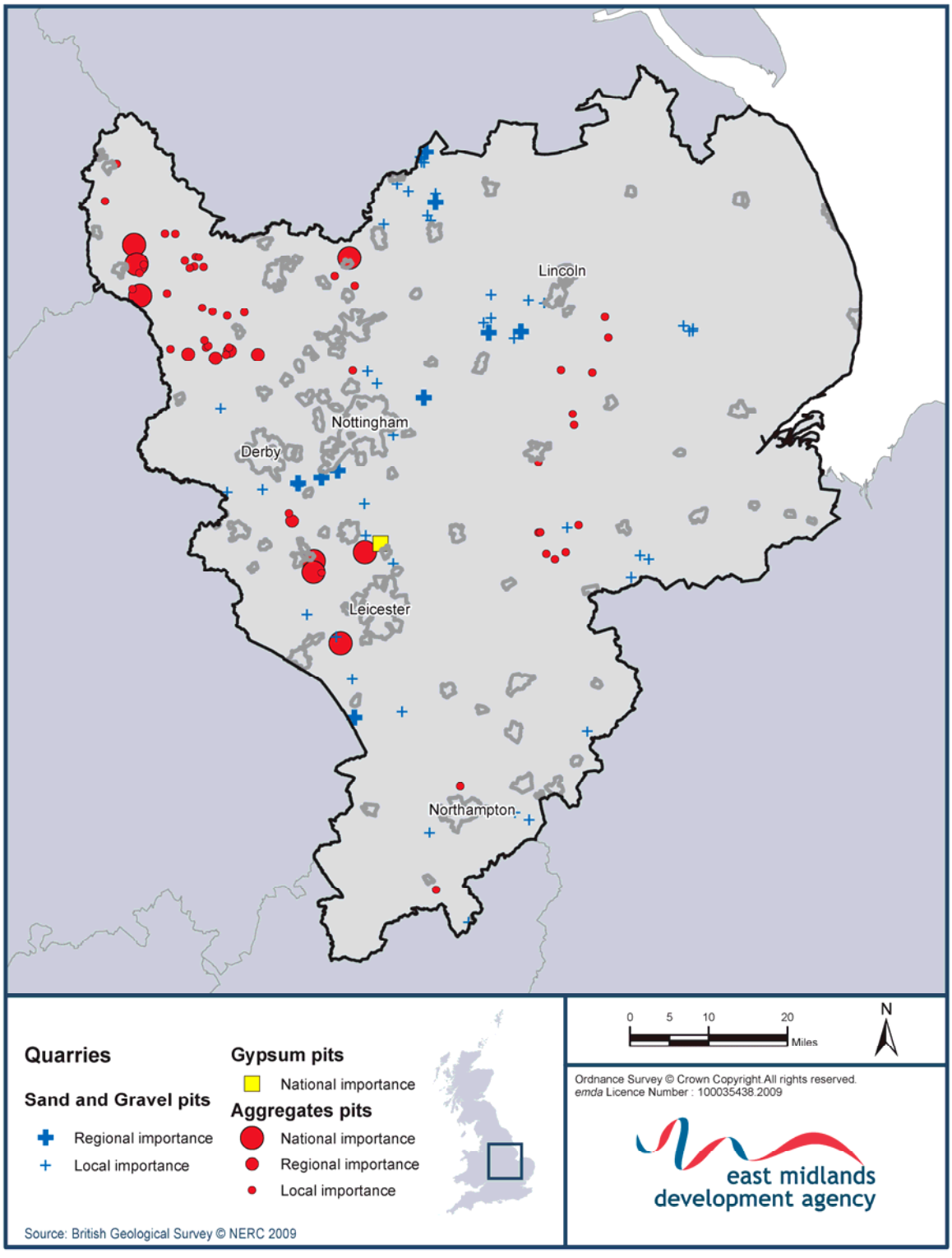
The East Midlands is an important producer of a wide range of minerals.[47] Mineral resources are shown in Map 7, with extraction sites shown in Map 8. Crushed rock aggregates, including limestone and igneous rock, satisfy local consumption and are exported in large amounts to other regions, especially the South East and North West. The region is Britain's major producer of gypsum and only producer of fluorspar. Manufactured goods from minerals, such as concrete blocks, plasterboard, ceramics, bricks and tiles are an important part of the region's economy, as are smaller uses of minerals for fillers and extenders. Historically the major coal and iron ore resources, as well as smaller amounts of lead and other mineral ores, have underpinned the region's development as a major industrial area. Despite the demise of significant sections of the minerals industry, not only is the region still the UK's leading minerals producer, it also hosts the national head offices of leading companies in production and related servicing industries, and of professional and research bodies. It also hosts the world's leading biennial trade fair for the industry. The East Midlands could thus rightly claim to be the "geocentre" of the UK.

[46] Musson, R.M.W. and P.W. Winter (1996): Seismic Hazard of the UK, A report produced for the Department of Trade and Industry, Rep. GNSR(DTI) / P(96)196.
[47] Minerals-related information for the East Midlands region provided by the BGS can be accessed online at http://www.bgs.ac.uk/mineralsuk/Web_GIS/min_arc_ims/home.html

Map 7: Mineral resources of the East Midlands (based on British Geological Survey digital mineral resource mapping at 1:50,000 scale)



Map 8: Mineral extraction sites in the East Midlands (created from BGS Britpits database)



7.4.2.1 Aggregates

Aggregates include crushed rock, sand and gravel. The East Midlands is the largest aggregate producer in the UK, having increased its production of crushed rock substantially since the mid-1980s (Charts 10 and 11). In 2008, just under a quarter of all primary aggregate supplied from England (onshore and marine) was produced in the East Midlands. The key resources are:

- The igneous and metamorphic rocks of Charnwood and south of Leicester in Leicestershire. Ninety nine percent of the region's igneous rock reserves are located in Leicestershire. The four igneous rock quarries in Leicestershire are some of the largest in Europe (in terms of tonnage extracted), each with annual outputs of over a million tonnes. In 2008, the region was the largest producer of igneous rock in England (with a regional total of 13.5 million tonnes, 64.1% of the national total);

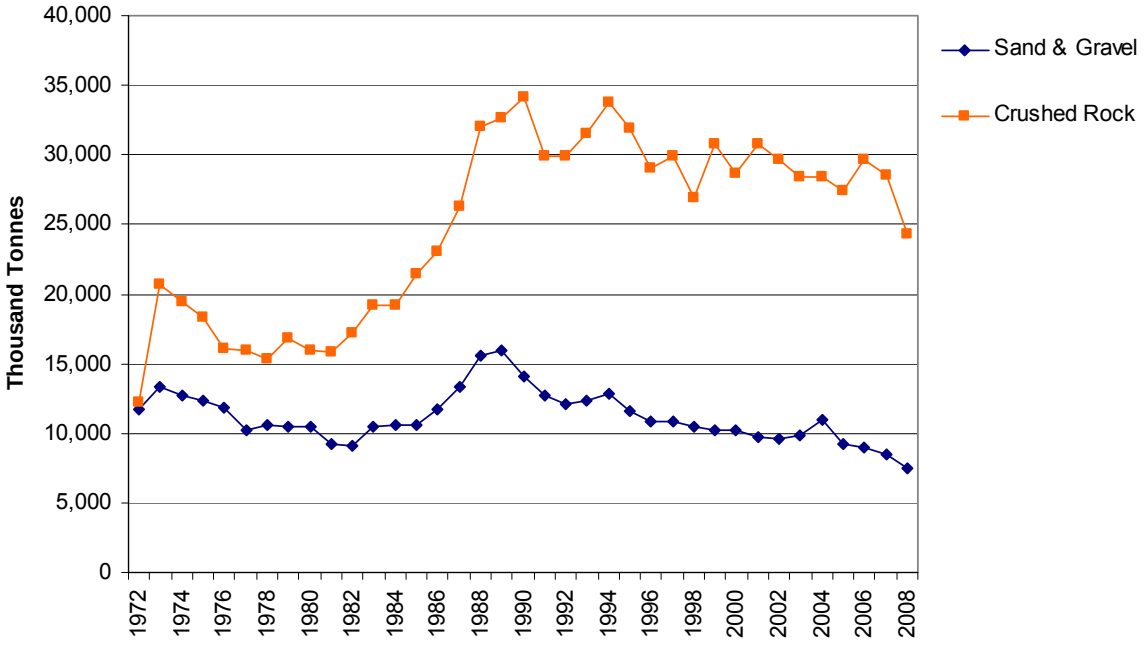
- The Carboniferous Limestone of Derbyshire and the Peak District (extending westward into a small part of Staffordshire). The majority of the region's limestone extraction occurs in Derbyshire, particularly in the Peak District, mainly around the fringes of the National Park. Eighty one percent of the East Midlands' limestone reserves are located there. In 2008, the region was the largest producer of limestone in England (over 19 million tonnes – 25.6% of total for England), exceeding the South West (which produced just under 19 million tonnes);

- The region's sands and gravel resources principally come from the Trent and its tributary valleys (from near Burton-upon-Trent through Nottingham almost to Gainsborough). In 2008, the East Midlands region produced 7.5 million tonnes of sand and gravel, 12.1% of the total amount produced in England;

- However, as Chart 10 shows, this has decreased over time, from a high point of 15.9 million tonnes in 1989; and

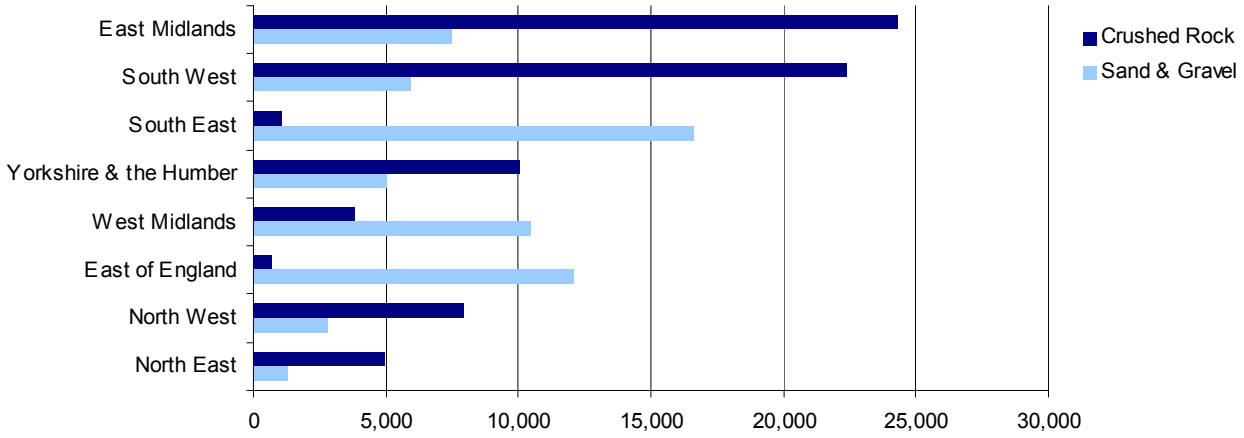
- In the case of crushed rock, the trend in production in the East Midlands has increased over time, doubling from 12.2 million tonnes in 1972 to 24.3 million tonnes in 2008.

Chart 10: East Midlands production of aggregates, 1972-2008



Source: ONS Crown Copyright, 'Mineral Extraction in Great Britain', 2008.

Chart 11: Aggregate production by region, 2008



	North East	North West	East of England	West Midlands	Yorkshire & the	South East	South West	East Midlands
Crushed Rock	4,928	7,962	683	3,850	10,045	1,029	22,355	24,328
Sand & Gravel	1,288	2,813	12,060	10,476	5,014	16,582	5,960	7,477

Source: ONS Crown Copyright, 'Mineral Extraction in Great Britain', 2008.

Chart 11 shows that the East Midlands accounts for the largest share of combined aggregate production in England, producing 23.2% of crushed rock and sand and gravel. Chart 11 also shows that the production of aggregate minerals is not uniformly distributed across England:

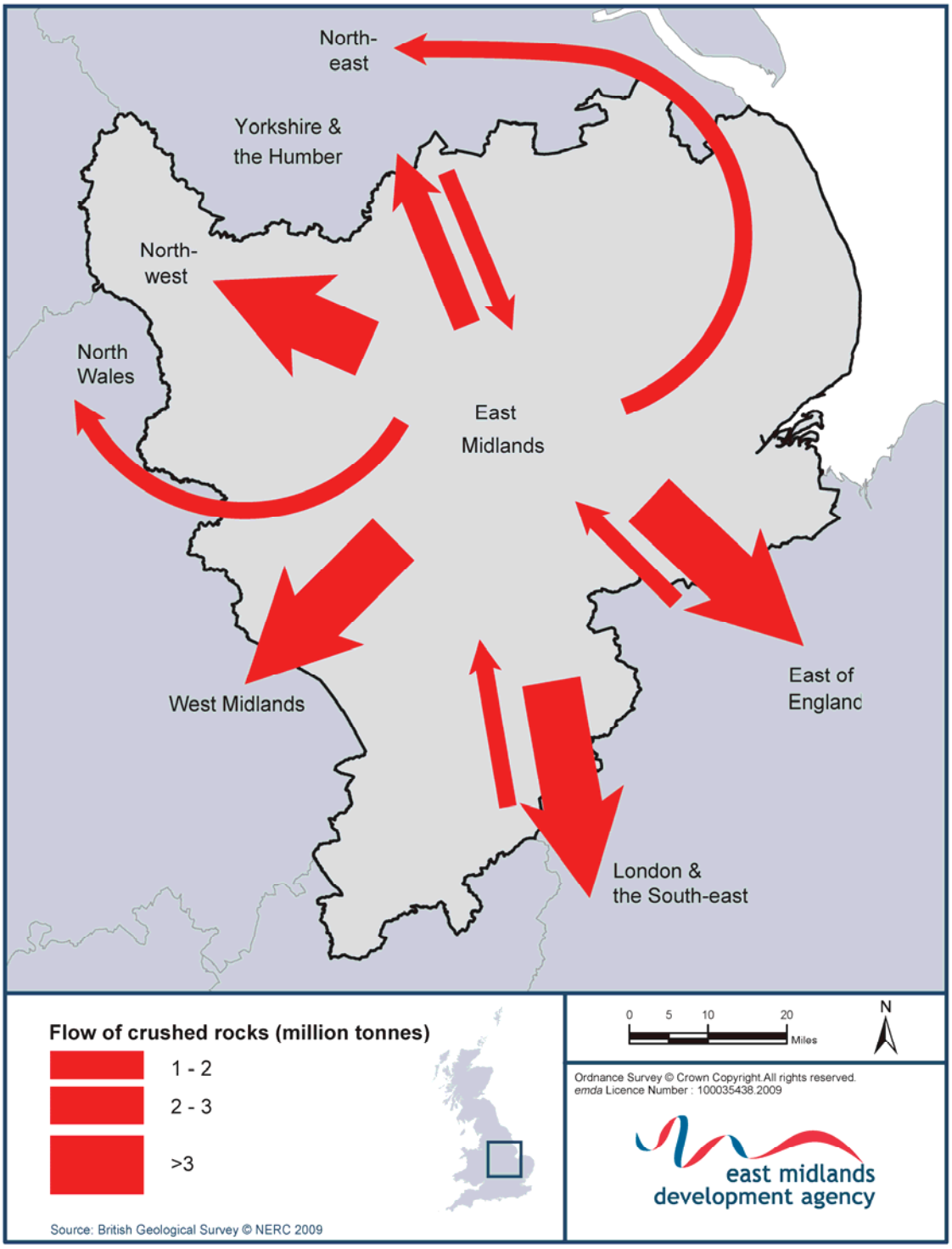
- Crushed rock aggregate output in the East Midlands accounted for 32.4% of English production in 2008. This is the largest share of the English regions. This reflects the availability of suitable hard rocks at or near the surface, coupled with the convenient geographical location of the region near the South East and London, which import much of their aggregates from the East Midlands; and
- Sand and gravel production is less dominant in the East Midlands. As the chart shows, the East Midlands is the fourth largest producer.

Not only is the region the largest producer of aggregates in the country, it is the largest aggregate exporter, dispatching 18 megatons, or 48% of the output to other regions in 2005 (Map 9).[48] By way of comparison, this is greater than the total production of aggregates in Wales and two and a half times the tonnage exported from the next largest producer, the South West. Substantial quantities of crushed rock are distributed to Yorkshire and the Humber (mainly limestone), the North West (mainly limestone) and the West Midlands (all types) – and to the South East, London and East of England (principally igneous rock plus some limestone).

In addition to large-scale exports, the region has consistently "consumed" a much higher than average tonnage of aggregates, mostly because of the use of aggregates as a feed to the concrete products industry. The region has some of the largest plants in this sector and its central location in the UK enables it to send these value-added products over considerable distances, as far as the south coast and southern Scotland.

[48] For national versions of the figures shown on this map, see Collation of the Results of the 2001 Aggregates Minerals Survey, British Geological Survey report CR/03/53N, available to download at: http://www.bgs.ac.uk/mineralsuk/free_downloads/downloads.html

Map 9: Inter-regional flow of crushed rocks



7.4.2.2 Other construction minerals

Total production of building stone in the UK is relatively modest but is of increasing significance as a contribution to the conservation of the built environment.[49] For building stone in 2008, the East Midlands was second to the South West in its output of limestone:[50]

- The most important sandstones for building occur extensively in Derbyshire and the Peak District within the Millstone Grit Group and Coal Measures. The region's sandstone building stone contribution is significant in that it serves a national market;

- The most important limestones for building are the oolitic and shelly limestones of the Lincolnshire Limestone from the Middle Jurassic age;

- The East Midlands is also an important brick-producing region with an output of 454 million bricks in 2006, accounting for about 20% of total brick production in England.[51] The Mercia Mudstone is the principal source of brick clay in the region. It has an extensive outcrop in the East Midlands most notably in Leicestershire, where it is used for brick making at five sites, and also in Nottinghamshire where it is worked at two. Carboniferous mudstones are worked in Derbyshire for brick making at one site;

- The East Midlands is an important cement-producing region accounting for approximately 26% of UK capacity. There are two large cement plants in the region located in Hope, near Castleton in the Peak District National Park, and in Ketton in Rutland. Capacity at a further plant in Buxton has just been greatly expanded (at a cost of £110 million);

- The East Midlands is also the principal source of high chemical purity (>97% $CaCO_3$) limestone for industrial applications in the UK. It is estimated that the East Midlands produced about 4.7 Mt or just under 54% of the UK requirements for high purity limestone/dolomite in 2007,[52] almost all of which was extracted in the Buxton and Wirksworth areas of Derbyshire; and

- Flue gas desulphurisation (FGD) places an additional demand for high purity limestone on the region. About 0.7 tonnes of high purity limestone

[49] BGS/CLG Mineral Planning Factsheet 'Building and Roofing Stone', available for download at http://www.bgs.ac.uk/MineralsUK/free_downloads/home.html#MPF
[50] ONS Crown Copyright, 'PA1007 Mineral extraction in Great Britain 2007'.
[51] BGS/CLG Mineral Planning Factsheet 'Brick Clay', available for download at http://www.bgs.ac.uk/MineralsUK/free_downloads/home.html#MPF
[52] National Stone Centre. In detail, this represents about a quarter of the UK materials for agriculture, 90% for specialist fillers (e.g. used in plastics, paper, paints, sealants), 100% for glass making and a substantial proportion (probably over 80%) of limestone utilised in the production of chemicals. The latter includes over a million tonnes annually destined for plants in Cheshire, the main one being the only works in the UK producing soda ash (sodium carbonate), the main alkali feedstock for the chemical industry.

are required for the production of 1 tonne of desulphogypsum.[53] All the large coal-fired power stations within the region and in neighbouring regions are now fitted with FGD plant. Ratcliffe-on-Soar power station in Nottinghamshire produced 253,000 tonnes of desulphogypsum in 2007, all of which was used for the manufacture of plasterboard at nearby East Leake.

7.4.2.3 Other minerals

The East Midlands is one of the most important sources of gypsum in Britain.[54] Production occurs in both Nottinghamshire and Leicestershire, the latter now being the most important source. The large Barrow Mine in Leicestershire has an output approaching 1 million tonnes per year. Total UK annual output of natural gypsum was approximately 1.7 million tonnes in 2007. Synthetic gypsum output is now estimated to be 0.9 million tonnes per annum.

Fluorspar production in the UK is now confined to the Peak District National Park.[55] Fluorspar occurs mainly as vein infillings in faults that cut limestones of Carboniferous age. Production is mainly by open pit methods. Fluorspar ore is processed at the Cavendish Mill, near Stoney Middleton to produce a high purity acid-grade fluorspar (>97% CaF_2) product. Barytes, a lead concentrate, and limestone are by-products of the process. The Cavendish Mill is the only source of barytes in England.[56]

[53] British Geological Survey, 'UK Minerals Yearbook 2007'.

[54] BGS/CLG Mineral Planning Factsheet 'Gypsum', available for download at http://www.bgs.ac.uk/MineralsUK/free_downloads/home.html#MPF

[55] BGS/CLG Mineral Planning Factsheet 'Fluorspar', available for download at http://www.bgs.ac.uk/MineralsUK/free_downloads/home.html#MPF

[56] BGS/CLG Mineral Planning Factsheet 'Construction Aggregates', available for download at http://www.bgs.ac.uk/MineralsUK/free_downloads/home.html#MPF

Key Points: Geology and natural resources

- The East Midlands has a rich geology, with a diverse variety of rock formations which makes it an important region for both quarrying and for sites of natural beauty, such as the Peak District National Park.
- The geology of the region is relatively benign. However, shrink-swell clay formations pose issues for development in some parts of the region and landslides are particularly common in Derbyshire, Leicestershire and Northamptonshire. Radon levels are relatively low and there is a relatively small earthquake risk in the region.
- The East Midlands is the most important producer of aggregates in England. In 2008, the region was responsible for just under a quarter of all national primary aggregate production. It was the largest producer of igneous rock (64.1% of the national total) and limestone (25.6% of the total for England). Sand and gravel production is less dominant compared to other regions.
- The East Midlands is also the most important exporter of aggregates in England, exporting 48% of output to other regions in 2005. This is equivalent to two and a half times the tonnage of the next largest exporter, the South West.
- In addition, the East Midlands has consistently 'consumed' a much larger tonnage of aggregates than other regions, principally to supply the concrete products industry. The region is responsible for 26% of the UK's concrete capacity.

7.5 Energy

International Energy Authority (IEA) projections[57] show global energy demand increasing by 50% by 2030, with 90% of that energy being derived from fossil fuels. In recent years energy has been relatively expensive, driven by oil prices that reached almost $150 per barrel in mid-2008 and energy is likely to be more expensive as demand recovers from the global recession.

Energy use will also become increasingly carbon-constrained, with CO_2 emissions from coal power stations and large industrial installations controlled under the EU Emissions Trading Scheme. This will bring significant challenges and opportunities to the region, which is well placed to develop and deploy new energy science, infrastructure and technology. To stimulate innovation, the Energy Technologies Institute (ETI), a major public-private partnership, was established in Loughborough in 2007. The UK Government forecasts that by 2020, 80% of our fuels are likely to come from overseas[58],

[57] IEA 2006. 'World Energy Outlook 2006', http://www.worldenergyoutlook.org
[58] DTI, 'UK Energy and CO_2 Emissions Projections', May 2007, www.dti.gov.uk/energy/whitepaper

and has also committed to achieving 15% of the UK's energy from renewables by 2020.[59]

7.5.1 Energy production and resources in the East Midlands

In the East Midlands, the majority of energy is generated from fossil fuels,[60] traditionally based on the production of coal in Derbyshire, Leicestershire and Nottinghamshire. Coal has been a vital source of the region's wealth and industrial development over the past 250 years. This abundant energy source, coupled with local demand and the nearby River Trent for cooling, led to the development of numerous major (~2,000 Mega Watts - MW) power stations in the Trent valley. Three of these, Ratcliffe-on-Soar, Cottam and West Burton, are in the East Midlands. Ratcliffe (along with Drax in Yorkshire) is one of the two largest generating stations in the UK, and has been retro-fitted with flue gas desulphurisation (FGD) equipment and other clean technologies to reduce sulphur emissions by 97% (note the fall in emissions of sulphur oxides since 1998 in Chart 7). The region's coal-fired power stations account for approximately 10-15% of the UK's total generating capacity, and are also major national point sources of CO_2 and are thus possible future candidates for carbon capture and storage (CCS).

There are two gas-fired power stations, at Spalding and Sutton Bridge, both of which utilise North Sea gas. Staythorpe (formerly coal-fired) Power Station is being reconstructed as a gas-fired station. E-ON have successfully applied for consent to rebuild Drakelow station, a demolished former coal-fired power station near Burton-upon-Trent, as a 1,220MW combined cycle gas-fired power station, which is now scheduled for completion by 2017. There are also plans for a biomass-fired facility on this site.

7.5.1.1 Coal

The region includes the Nottinghamshire-Derbyshire and Leicestershire Coalfields (Map 10). Two of the seven major deep coal mines still producing in the UK are located in the region (Thoresby and Welbeck).[61] Subject to market conditions and the viability of remaining coal seams, Harworth coal mine in Bassetlaw, north Nottinghamshire may be brought out of its current 'mothballed' state, pending decisions made by UK Coal.[62] A small drift mine still operates in North Derbyshire.

In December 2008, Long Moor (Leicestershire) and Lodge House (Derbyshire) were the only two operational opencast coal sites in the region,

[59] BERR, 'UK Renewable Energy Strategy Consultation, June 2008. www.berr.gov.uk/renewableconsultation

[60] Fossil fuels are coal, oil and gas, and are so called because they form over millions of years through the decay, burial and compaction of rotting vegetation on land (coal) and marine organisms on the sea floor (oil and gas).

[61] British Geological Survey, 'Directory of Mines and Quarries', 2008.

[62] UK Coal Ltd, 'Annual Report', 2007.

out of a total of 41 operational in the UK.[63] The bulk of existing accessible economic reserves are associated with the deep mines. Estimates of reserves and resources for deep mines and reserves at permitted opencast coal sites are given in Table 1.

[63] British Geological Survey, 'Directory of Mines and Quarries', 2008.

Map 10: Coal resources in the East Midlands (based on BGS digital data at the 1:100,000 scale)

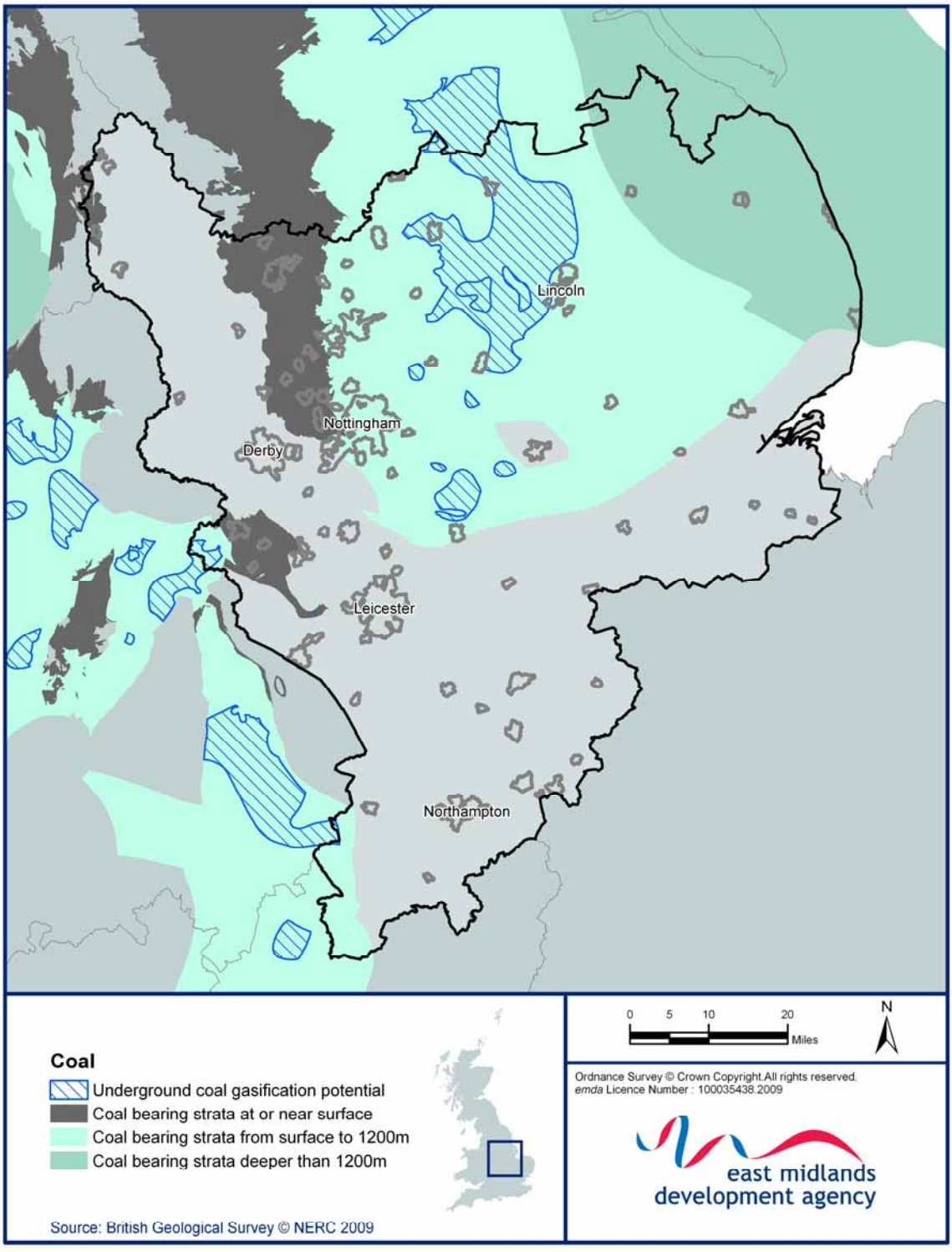


Table 1: Estimates of coal reserves and resources in the East Midlands, 2007

Deep mine	Production (million tonnes) 2007	Production (millions tonnes) 2008
Thoresby	1.4	0.9
Welbeck	1.0	0.9
Surface (opencast) mine	**Reserves (million tonnes) 2007**	**Reserves (million tonnes) 2008**
Long Moor (Leicestershire)	0.7	0.3
Lodge House (Derbyshire)	1.0	0.9

Source: UK Coal Ltd Annual Report, 2008

Output of coal from the region's deep mines was just less than 2 million tonnes in 2008, down from 2.4 million tonnes in 2007. This represents about a third of national deep mine coal production. Opencast coal production from the East Midlands was 127 thousand tonnes in 2007-2008, which represented only about 1.5% of UK output.[64] Moreover, coal reserves from open cast mining have fallen rapidly, halving at the Long Moor site between 2007 and 2008. Most of the coal produced in the region by both deep and surface mining is used to generate electricity.

Without new mine development it is likely that deep mine coal production will cease by 2030. Future deep mine prospect areas for which good exploration data exist include the Witham and Till Prospects on the Nottinghamshire/Lincolnshire border, and NE Leicestershire.[65] These sites represent the bulk of future deep mine prospects explored on the UK mainland. These would require major investment to access the resources, which are at depths of between 500 and 1200m. The total of reserves and resources estimated for the Witham prospect is 147 million tonnes.[66]

7.5.1.2 Clean coal extraction technologies

This is a portfolio of technologies that derive energy from coal without mining. Coal is present within the Pennine Coal Measures, which is preserved in the subsurface north of a line joining Melton Mowbray to the Wash. Coal is absent to the south of this line and in the far west of the region.

Abandoned Mine Methane (AMM): Most of the coal mines in the region have been abandoned. Gas derived from the coal accumulates in the voids created by mining. Abandoned Mine Methane can be an environmental and safety hazard because of the number of shafts, drifts and boreholes which reach the surface. Removing methane from abandoned mine workings

[64] British Geological Survey, 'UK Minerals Yearbook', 2007.
[65] The NE Leicestershire prospect was formerly worked from the Asfordby mine, which was forced to close in 1997 due to adverse geological conditions.
[66] International Mining Consultants, 'Review of Prospects for Coal Production in England, Scotland and Wales', 1999.

mitigates this potential hazard and has been used to generate electricity. Eight new AMM wells have now been drilled:

- Five are near former coal workings at Bevercotes, Whitwell, Steetley, Warsop, and Old Mill Lane (Sherwood); and

- Two wells are at Crown Farm (Mansfield) and Coalite Works (Bolsover). Markham Shaft 3 was left open by British Coal to vent gas from the abandoned colliery, which was then used to supply the Coalite Works (now closed) at Bolsover.

Shirebrook Colliery supplies AMM by Alkane Plc to Clarke Energy. Bentinck Colliery also supplies AMM to Stratagas and Warwick Energy (10.5 MW). All of these developments are used to generate electricity. Alkane plc has developed a modular generator that can be moved as and when the AMM diminishes.

Coal Mine Methane (CMM): This is the drainage and use of methane released from coal in active mines. It is widely practised and is currently used in colliery boilers, for generating electricity and some is flared, gaining carbon credits. The Harworth mine gas power station is rated at 7 MW, with 4.2 MW at Thoresby and 3 MW at Welbeck.

New licences were awarded in the 13th Onshore Licensing Round for additional developments and these would be increased, according to the Association of Coal Mine Methane Operators (ACMMO), if CMM and AMM were treated as renewable energy or encouraged in the way they are in Germany and France.

Table 2: Alkane's listed sites, generating capacity and estimates of CO_2 mitigation

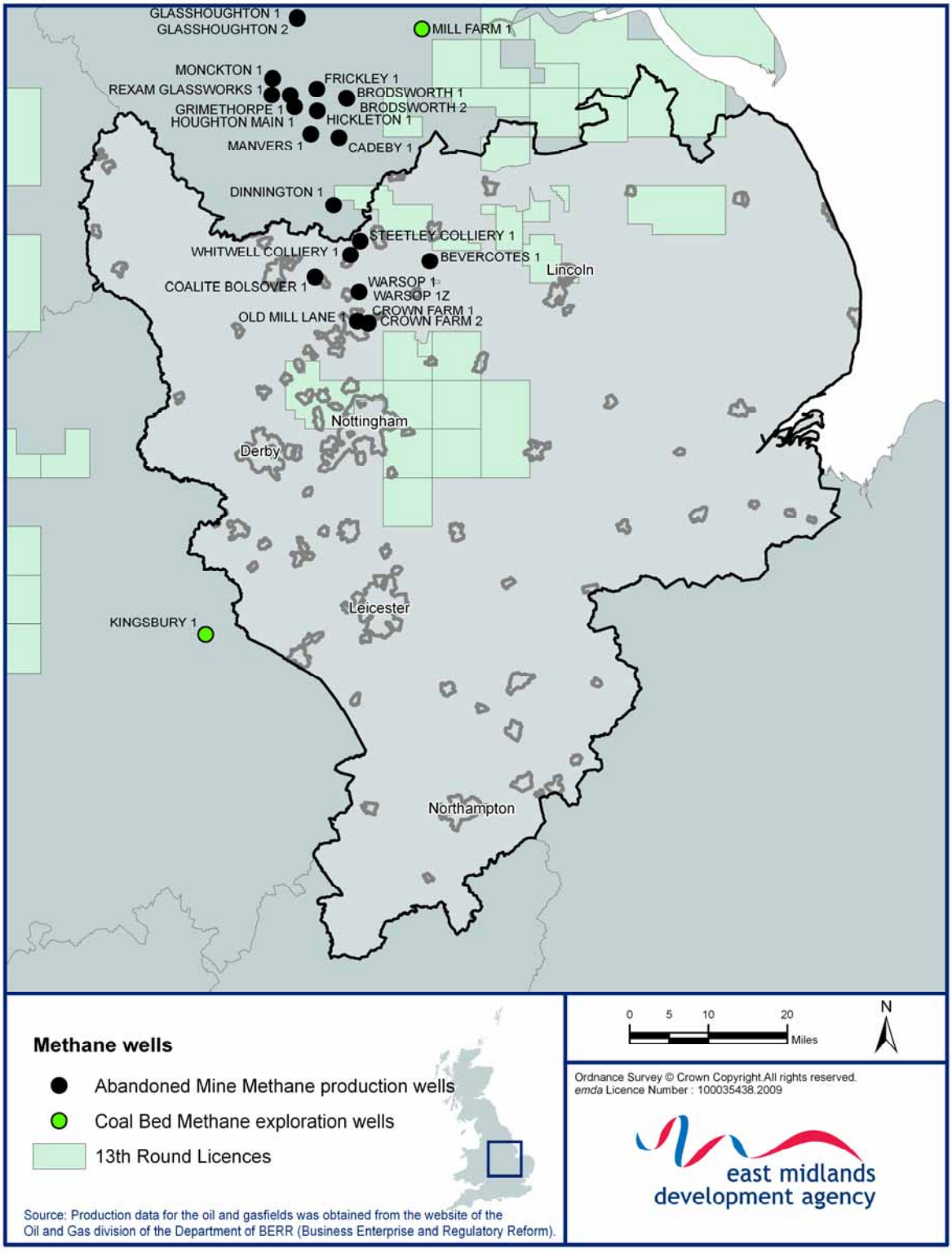
Site	Location	Capacity (MW)	Max CO_2 mitigation (tonnes)
Bevercotes	Nottinghamshire	4.05	138,155
Mansfield	Nottinghamshire	3.7	126,216
Sherwood	Nottinghamshire	0.66	20,467
Warsop	Nottinghamshire	1.35	46,052
Whitwell	Derbyshire	1.35	46,052

Source: www.alkane.co.uk

Coal Bed Methane (CBM): Extraction of methane from un-mined coal seams is likely to be developed, using horizontal drilling and fracturing of coal seams east of the coalfield (Map 11). New licences were awarded in the 13th Onshore Licensing Round, in the north of the region where the coals have higher gas contents, to Composite Energy who have pioneered this type of exploration at Airth in Scotland. Although the gas contents of the coal seams are lower than in the west of the UK other factors such as permeability may be higher. Other companies are beginning to consider CBM exploration in tandem with conventional exploration. In future enhanced CBM exploration

could be attempted, using carbon dioxide to displace methane in the deeper seams. The potential gas resource in the East Midlands is over 400 billion m^3 which is about 150 times larger than the largest onshore gasfield (Saltfleetby). This figure is however lower than western coalfields of the UK because the seams there contain more gas. The resource may be even larger because these figures are based on the former NCB seam gas content measuring technique which probably under-estimated the amount of gas present. The new licence holders will be providing revised estimates to DECC.

Map 11: Methane wells in the East Midlands, 2009

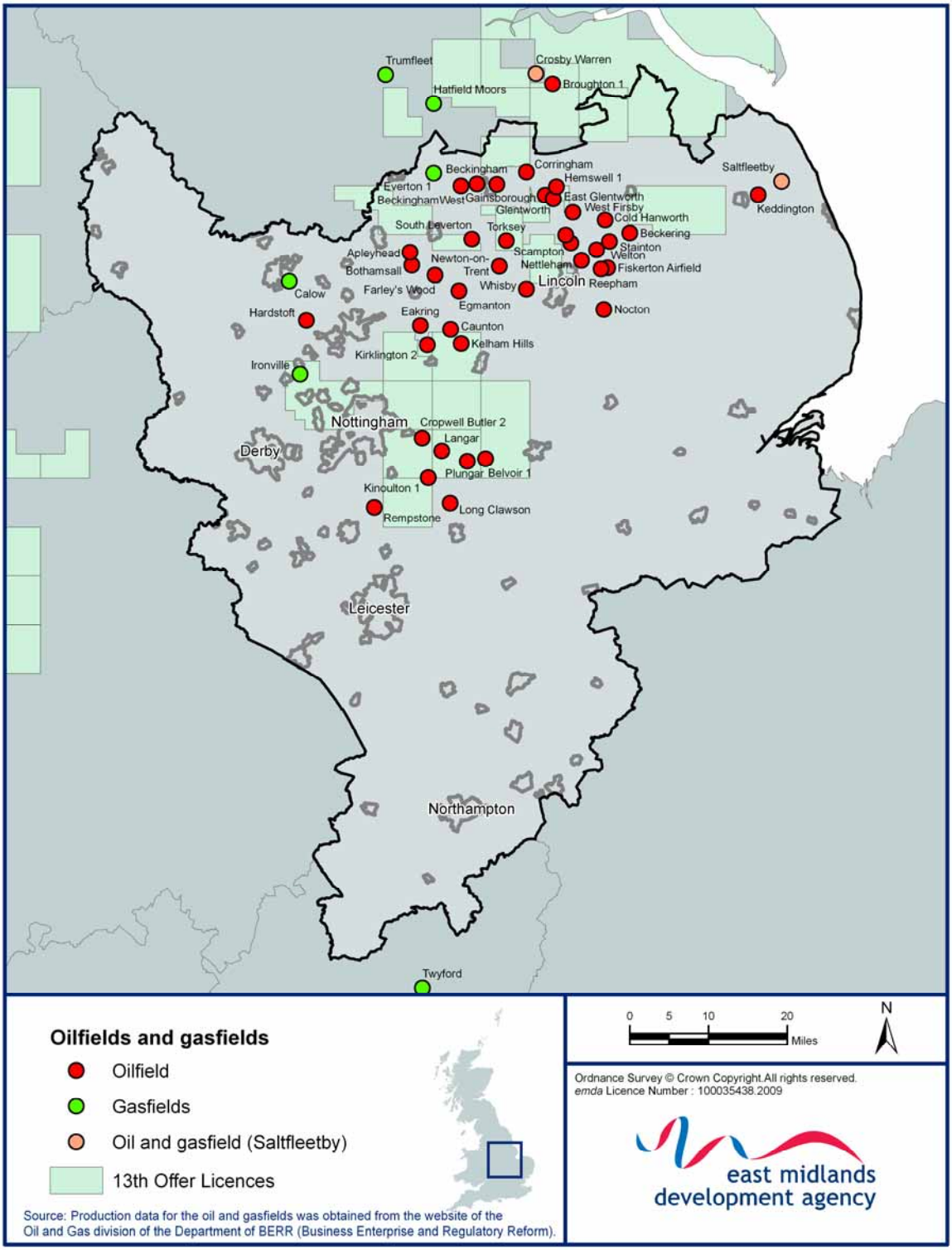


Underground Coal Gasification (UCG): Coal can be gasified in situ by burning it in a controlled way underground via boreholes, thus avoiding the high cost of mining. The gas is brought to the surface and used in electricity generation. UCG is potentially the most effective way of extracting energy from coal, but the technology is in its infancy and planning authorities are likely to require initial developments at least to be sited away from towns. The East Midlands has good prospects for the deployment of UCG. The most attractive prospects are coals at depths between 600 and 1200m. These include coals in and around the Till, Witham and parts of the NE Leicestershire exploration prospects. The volume of potentially suitable coal in the region is in excess of 2 billion m^3. UCG prospects are shown in Map 11.

7.5.1.3 Oil and gas

The East Midlands remains an important region for UK onshore oil production. About 25 fields have been discovered within the region (Map 12), and over 40 million barrels so far produced (about 11% of total historic UK onshore oil production – 65% excluding the giant Wytch Farm field in Dorset). Economic reserves are about 15m barrels. Most fields are small with less than 1 million barrels but Long Clawson, Nettleham, Scampton North and West Firsby and some of the Mining Licence fields have produced over a million barrels. However, Welton is the second largest onshore field in the UK, with over 16.5 million barrels produced, amounting to about half the East Midlands total.

Map 12: Oilfields and gasfields in the East Midlands, 2009



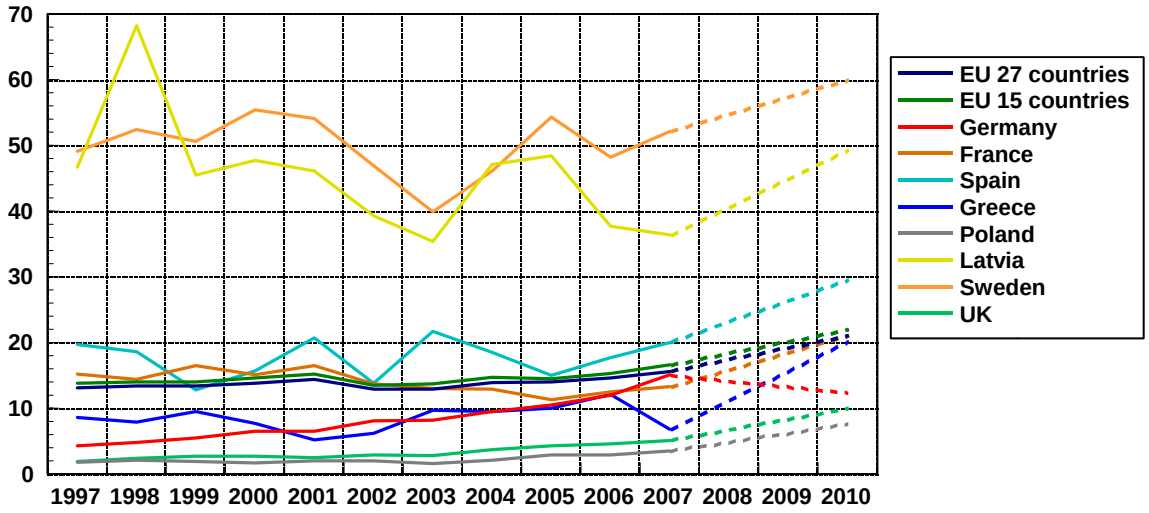
Exploration interest for oil and gas in the region fluctuates with the oil price, with high prices stimulating interest. It is likely that oil and gas prices will continue to rise over the coming decades. The Saltfleetby Gas Field is Britain's largest onshore gasfield. Since production started in 1999 it has produced 54 billion cubic feet (1.51 billion m^3) of gas and a million barrels of condensate (petroleum gas). The original recoverable gas reserves were approximately 90 billion cubic feet (2.52 billion m^3) of which about 30% are yet to be produced. Original condensate reserves were 1.26 million barrels of which about 20% are yet to be produced. This field has now been bought by Wingas for gas storage purposes and other depleting fields are likely to follow this path using the 1965 Gas Act. Depleted fields taken over by small companies may also contribute small production if energy prices rise again: Warwick Energy established brief production at Ironville to contribute gas to its Pye Bridge electricity generating site.

The region has potential for unconventional gas exploration and production known as shale gas, from fracturing relatively impermeable shale source rocks which supplied the hydrocarbons to the discovered conventional fields. This particular exploration and production technique has shown significant growth in the USA, and is poised to expand exploration effort in the East Midlands in the near future.

7.5.1.4 Renewable energy resources

The EU has set a renewables obligation that requires the UK to obtain 15% of the energy it consumes from renewable sources by 2020. As shown in Chart 12, the proportion in 2007 was only 5.1%, which is one of the lowest in the EU. Of this, biofuels provide the largest contribution, but wind energy is growing the most rapidly. This compares to an average for the EU27 Countries of 15.6% in 2007. Sweden and Latvia generate 40-50% of their electricity from renewables.

Chart 12: Share of electricity generated from renewable energy sources in gross electricity consumption, for a selection of EU countries (%)



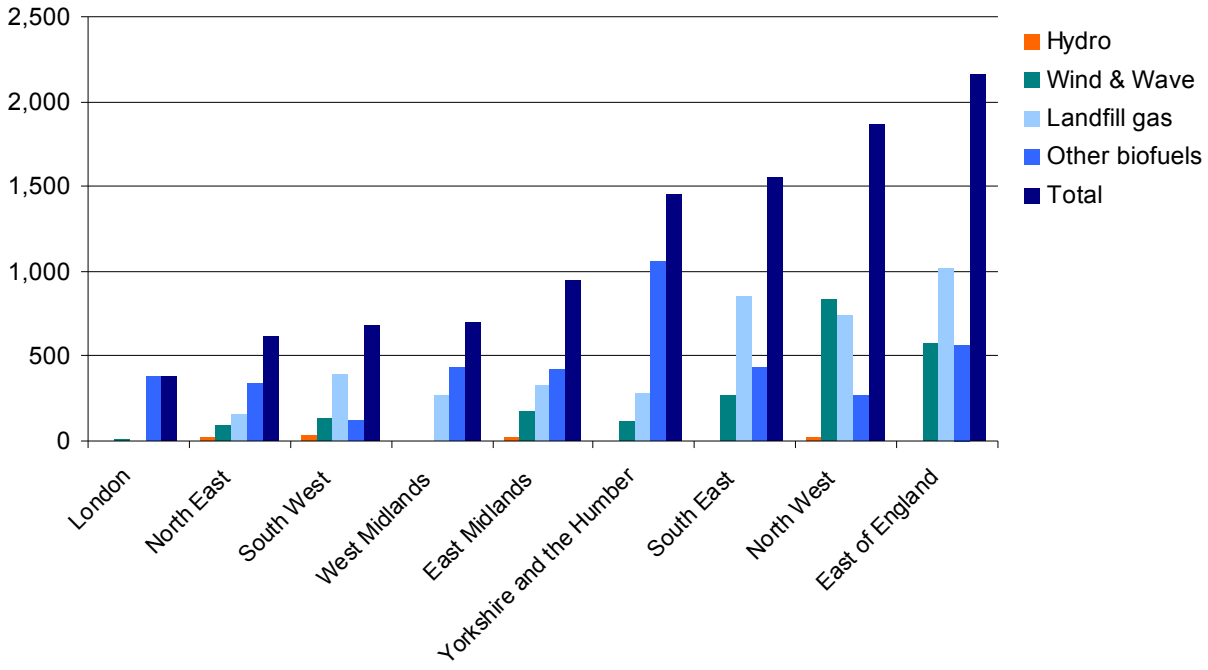
Source: Eurostat sustainable development indicators, 2008.
Note: data are only available up to 2007 and the dashed sections indicate estimated capacity to 2010.

In the East Midlands in 2008, there was approximately 180 MW of renewable electricity capacity in the region, 5.4 from hydro, 70.1 from wind, 60.8 from landfill gas and 43.5 MW from other renewable sources, including biofuels.[67] This is almost double the installed capacity in 2005. At present, 40 sites in the region generate a large share of renewable energy through the combustion of landfill gas. There are 17 hydropower plants, 18 wind or wave generation sites, and 24 biofuels and other renewable energy generation sites operating within the region.

From this capacity, East Midlands sites generated 946.8 Giga Watt hours of electricity in 2008 – 17.5 GWh from hydro, 176.5 from wind and wave, 333.5 from landfill gas, and 419.3 GWh from biofuels and other sources (see Chart 13 below).

[67] BIS Restats, 'Regional Renewable Energy Statistics 2008', 2009, see: http://www.restats.org.uk

Chart 13: Generation of electricity by renewable sources (Giga Watt hours), 2008



Source: Re newable Energy Stat istics for the UK (ReStats), 'Region al Ren ewable Energ y Statistics – 2008', 2009.

Chart 13 shows that the East Midlands accounts for the fifth lowest share of electricity generated from renewable sources of the nine regions, producing 9.2% of the total for England. The East of England accounted for the largest share, generating 2,164.1 GWh in 2008, 20.9% of total electricity generated from renewable sources in England. The East Midlands accounts for a larger share of hydro electric, generating 19.8% of the national total in 2008, the third largest share of the English regions. Generation from biofuels and other renewable sources accounts for the largest share of East Midlands electricity produced from renewable sources, whereas landfill gas accounts for the largest share in both the East of England and in England overall.

In 2000, there was 292 MW of combined heat and power (CHP) electricity generation capacity in the East Midlands (6.8% of UK CHP capacity). CHP systems involve the simultaneous generation of heat and power to achieve high overall efficiencies and to utilise heat that would otherwise be wasted in other electricity generation systems. A new CHP system has been installed at Queen's Medical Centre in Nottingham which generates 4.9 MW of electricity from a single gas turbine and the waste heat recovery boiler produces 12 tonnes of steam per hour. This is used for heating, cooling (via absorption chillers) and equipment sterilisation.

Renewable energy projects could bring many benefits to the region, not only for indigenous energy production, but also for reducing emissions of harmful greenhouse gases, with increased opportunities for the manufacturing, energy, agricultural, offshore supply and fisheries sectors. Potential renewable energy projects include:

- Offshore wind development consists of a 180 MW scheme offshore Skegness. Planned further developments offshore Lincolnshire have a potential of 1.25 GW with a potential offshore resource of 12.4 GW;[68]

- The East Midlands has a relatively poor onshore wind resource as westerly winds have travelled over a large land area before reaching the region. The majority of the current and planned capacity is in Lincolnshire. Onshore wind farms are currently restricted to a site at Mablethorpe in Lincolnshire that generates 6 MW [69] and a new site at Burton Wold in Northamptonshire, which has an installed capacity of 20 MW;

- The potential for hydroelectric is limited in the East Midlands due to the terrain;[70]

- The number of ground source heat pumps in the region continues to increase. Installations are currently estimated at 65-150 sites.[71] There is currently no exploitation of the heat resource contained within the deeper rocks of the region, although the potential resource at Cleethorpes has been investigated in the past with a deep borehole (Map 5);

- The utilisation of solar power with solar photovoltaics is confined to a number of small, but significant projects. It is estimated that there is 0.64 MW of energy generation capacity within the region;[72] and

- Biogas is already generated in the region from sewage sludge and food processing waste. Electricity is being generated using methane captured from landfill waste. Municipal and industrial waste is incinerated in Nottingham to generate 7 MW of electricity.

7.5.1.5 Biofuels

Due to work undertaken on behalf of Natural England, it is possible to provide more detailed analysis of biomass capacity in the region. Biofuels or 'biomass' refers to biological material that can be used as fuel or for industrial production. Most commonly, biomass refers to plant matter grown for use as fuel. Biomass fuels, unlike fossil fuels, are considered renewable as they are carbon neutral. When they are burnt the carbon they release is equivalent to the carbon they fix from the atmosphere during their growth. As such when burnt there is no net gain of carbon in the atmosphere.[73]

[68] East Midlands Regional Targets and Scenarios for Renewable Energy, Best Foot Forward Ltd, 2006.
[69] Ibid.
[70] Ibid.
[71] Ibid.
[72] Ibid.
[73] Wright, D., and Leivers, H, on behalf of Natural England, 'Regional Biomass Active Demand Mapping Project', 2007.

The Natural England assessment suggested that the East Midlands is particularly well placed in the UK biomass market, with approximately 5,500 hectares of energy crop planted, yielding 60,000 to 70,000 tonnes per annum of oven-dried biomass fuel. This regional asset is in part due to a legacy of projects in the 1990s which encouraged the growth of Short Rotation Coppice (SRC) Willow plants and also because of the importance of power generation in the region more widely, as identified earlier in this section. Legislation in 2002 introduced the Renewable Obligation Certificate (ROC), which requires all UK licensed electricity suppliers to obtain a proportion of the electricity they sell from a selection of eligible renewable sources. Every year the renewable obligation level increases, starting at 3% in 2002, increasing to10% by 2010, and 15.4% in 2015/2016. Because of the number of large power generation sites in the East Midlands, the ROC regime creates a strong regional demand for biomass fuel.

A number of sites in the region are now 'co-firing' plants, generating significant proportions of energy from biomass as well as coal. Two examples are the West Burton and Cottam power stations, both owned by EDF Energy, and both located near Retford in Nottinghamshire. Their combined annual biomass consumption is in the region of 100,000 tonnes, estimated to produce approximately 150GWh of renewable energy per annum, with a roughly equal share between the two stations.

On a smaller scale, there are an increasing number of biomass boilers installed throughout the East Midlands across the entire range of scales, from domestic boilers to large industrial heating boilers. As Table 3 demonstrates, the capacity of biomass boiler installations in the region is expected to double between 2007 and 2010, from approximately 30,000kW to 60,000kW.[74]

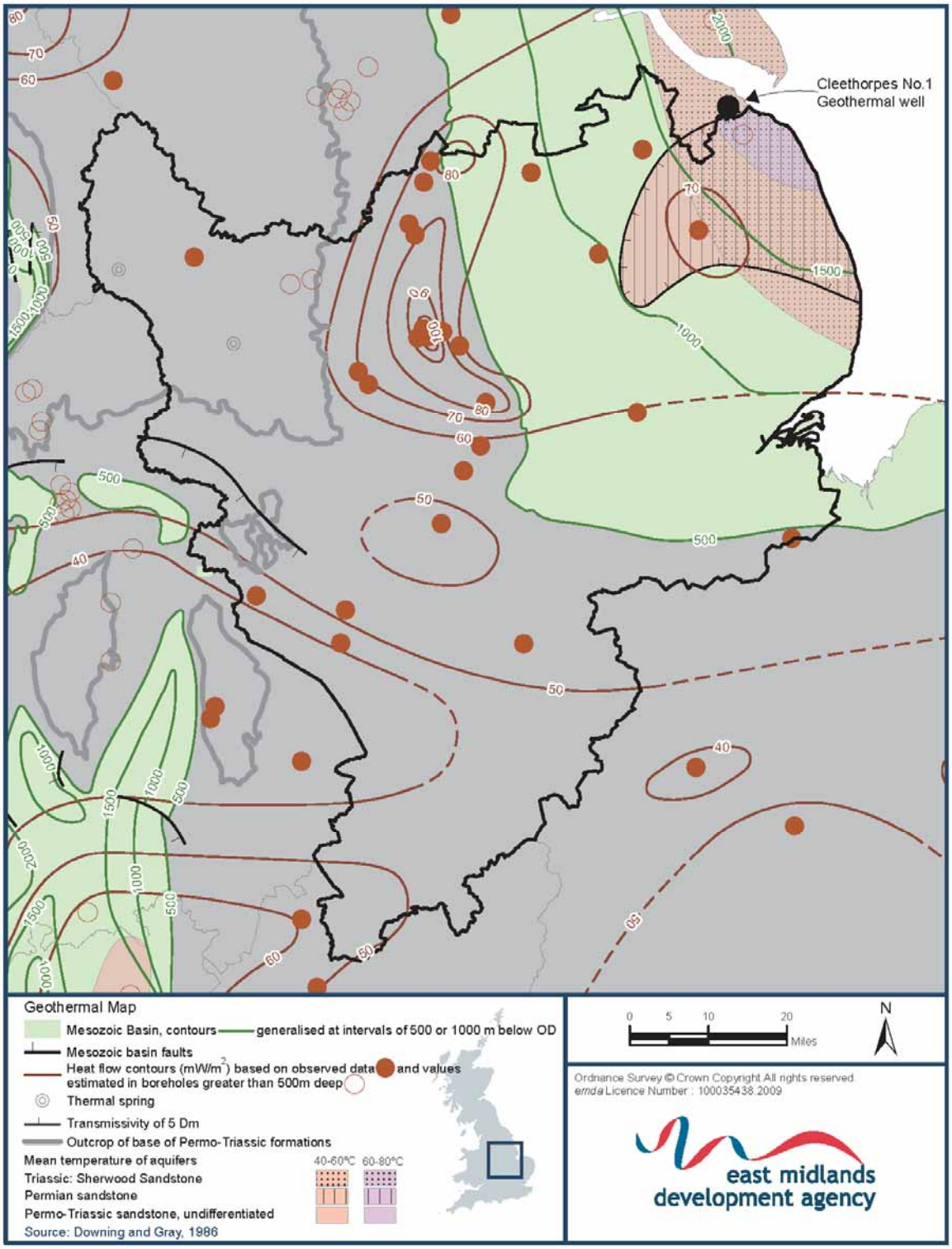
Table 3: East Midlands installed capacity in biomass boilers (estimated 2007 capacity and 2010 projections)

County	Currently Installed Boiler Capacity (kW)	Proposed Boiler Capacity by (kW)
	2007	2010
Lincolnshire	3740	15155
Nottinghamshire	11164	18902
Leicestershire	8798	10488
Northamptonshire	300	5300
Derbyshire	560	1460
Rutland	40	40
County Not Specified	2665	3790
Total	27267	55135

Source: Natural England, 'Regional Biomass Active Demand Mapping Project', 2007.

[74] Ibid.

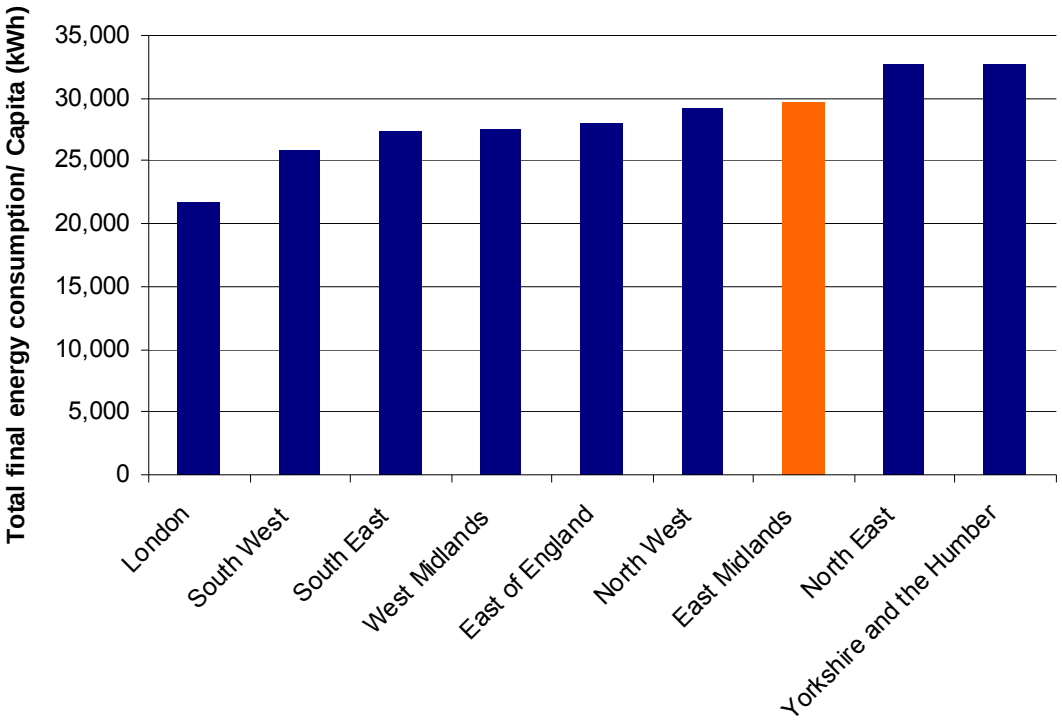
Map 13: Geothermal energy potential in the East Midlands



7.5.2 Energy consumption in the East Midlands

The Department for Energy and Climate Change (DECC) publish regional data on the estimated consumption of energy. This data is obtained through working with the power industry, which collects electricity consumption data for each customer meter or MPAN (meter point administration number). DECC has obtained this data for 2006, and has aggregated it up to Local Authority District and regional level. Data on gas consumption is sourced from National Grid estimates. This is combined with the electricity data alongside estimates of consumption of 'other fuels' (such as: domestic and industrial coal, solid fuels, non-road transport petroleum) and road transport petroleum consumption to produce total estimates of energy consumption by region. The data published in these tables does not cover the final consumption of energy in the UK, so regional estimates are not summed up to a national total.

Chart 14: Total energy consumption per capita by region (kWh), 2006



Source: Department for Energy and Climate Change, 'High Level Energy Indicators 2006', February 2009.

Chart 14 shows that the East Midlands has one of the highest levels of total energy consumption (electricity, gas, transport fuels and other fuels) of the nine English regions, at 29,700 kilo Watt hours (kWh) per resident in 2006. This compares to a total of 32,700 kWh per resident in Yorkshire and the Humber, the region with the highest total energy consumption, and 21,700 kWh per resident in London, the region with the lowest consumption.

The DECC data provides estimates of this total consumption broken down by type of energy and by type of use (including domestic, industrial and road transport). The key points for the East Midlands are:

- As reflected in CO_2 emissions by end user in Chart 4, the East Midlands accounted for relatively high energy consumption due to vehicle fuel. In 2006, 9.3 tonnes of fuel per capita were used in transport in the East Midlands, the third highest of the nine regions. The North East had the highest consumption of vehicle fuel, at 12.7 tonnes per capita, whilst London had the lowest, at 6.6 tonnes per capita;

- The East Midlands had a lower relative consumption of energy for domestic purposes, at 9,310 kWh per capita in 2006. This is the fifth highest of the nine regions;

- When this consumption is split into electricity and gas, an estimated 18,490 kWh per meter point of gas was consumed by domestic users in 2006 in the East Midlands, the fourth highest of the English regions, whilst 4,410 kWh of electricity was consumed per meter point by domestic users, the fifth highest of the English regions;

- The East Midlands had the fourth highest consumption of energy for industrial and commercial purposes, at 25,600 kWh per employee in 2006. The North East had the highest, at 25,600 kWh, and London had the lowest, at 14,700 kWh per employee; and

- In the case of industrial and commercial users in the East Midlands, 9,400 kWh of gas was consumed per meter point, the fourth highest of the English regions, whilst 8,100 kWh of electricity was consumed per meter point, the second highest of the English regions.[75]

[75] Department for Energy and Climate Change, 'High Level Energy Indicators 2006', February 2009

Key Points: Energy

- The East Midlands is a major producer of energy. The majority of energy is generated from fossil fuels. Currently, the region's coal fired power stations account for 10-15% of the UK's total capacity.
- The region's coal mining history provides opportunities for energy through clean coal extraction. This can be obtained from Abandoned Mine Methane (AMM) and from drainage of methane from active mines (Coal Mine Methane – CMM) and from unmined coal seams (Coal Bed Methane). Coal can also be gasified in situ through a process of Underground Coal Gasification (UCG).
- The East Midlands is also an important region for onshore oil production, with around 25 oil fields (producing about 11% of the UK's onshore oil). The East Midlands also hosts the UK's largest onshore gas field, at Saltfleetby.
- The East Midlands has approximately 180 Megawatts of renewable energy capacity, from hydro, wind, landfill gas and other sources. However, power generated from this capacity is only equivalent to 9.2% of total output from renewable sources in England, the fifth lowest of the nine regions.
- However, the East Midlands is particularly well placed in the UK biomass market. The East Midlands has an increasing yield of energy crops combined with a growing demand for such fuels due to the presence of two large 'co-firing' power stations alongside a growing number of small scale biomass boilers across the region.
- The East Midlands has one of the highest levels of energy consumption of the English regions, at 29,700 kilo Watt hours per resident in 2006. Consumption of energy through fuel for road transport is a key contributor to this.

7.6 Waste

7.6.1 Waste production and disposal

The latest figure for total waste arising in the East Midlands is 24.3 million tonnes, 10.1% of the 241.7 million tonnes produced in England as a whole in 2006.[76] Chart 15 shows that:

- Of this total, construction and demolition accounted for the largest proportion in the East Midlands, at 40.1% (above the average for England of 36.8%);

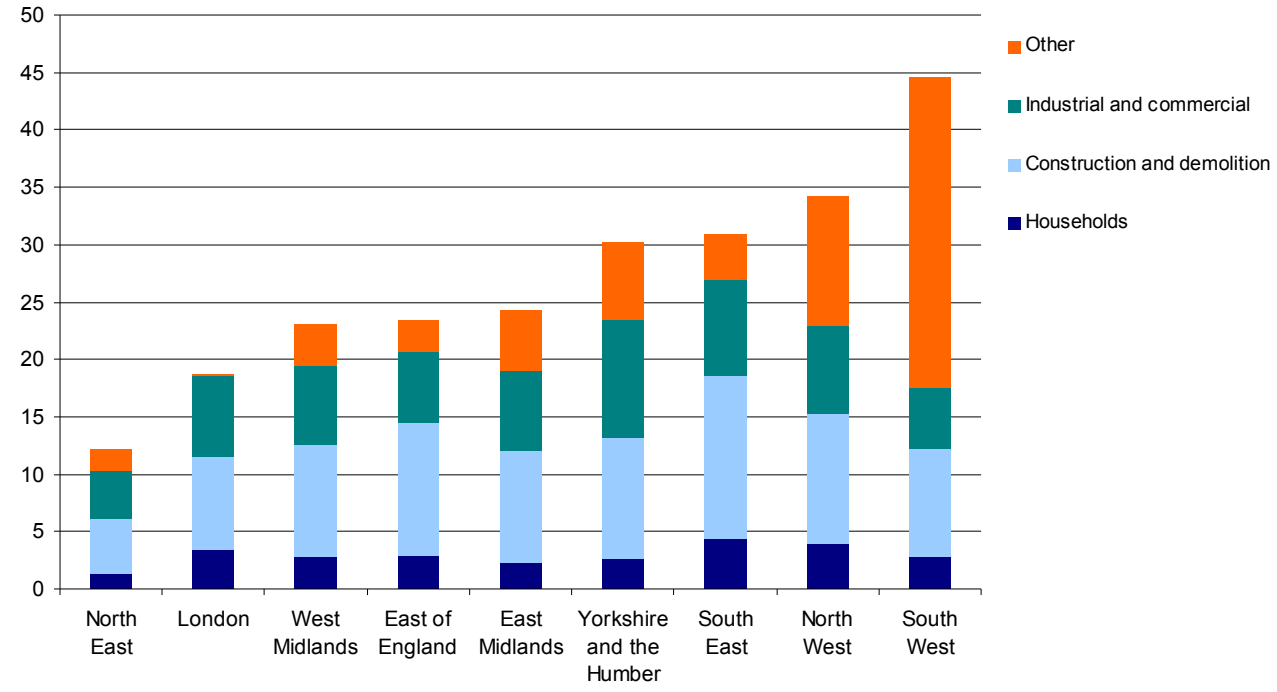
[76] Defra, 'Sustainable Development Indicators 2009, Sustainable Consumption and Production Datasets', 2010.

- Industrial and commercial sources accounted for 28.6%, compared to 26.1% in England overall;

- Household (i.e. domestic) sources accounted for 9.5% of the total waste produced in the East Midlands in 2006, below the England average of 11.1%; and

- 'Other' sources, which is principally based on the geographical distribution of mineral working sites, mining and quarrying, accounted for 21.8% of the East Midlands' total, compared to 26% in England overall. However, the national average is skewed by the very high contribution of 'other' sources in the South West (accounting for 60.8% of all waste arisings in that region). Because of the importance of minerals and aggregates extraction to the East Midlands, 'other' sources account for a higher share of total waste than most regions other than the South West.

Chart 15: Waste arisings by sector, 2006 (million tonnes)



Source: Defra Sustainable Development Indicators (2009), Environment Agency, Department for Communities and Local Government (CLG).

In 2006, Gross Value Added in the East Midlands totalled £73,614 million.[77] This means that 330.5 tonnes of waste were generated for every million pounds of GVA produced in the East Midlands, compared to 244.2 tonnes of waste per million pounds of GVA in England overall. Therefore the East Midlands is significantly less resource efficient than the national average according to this measure.

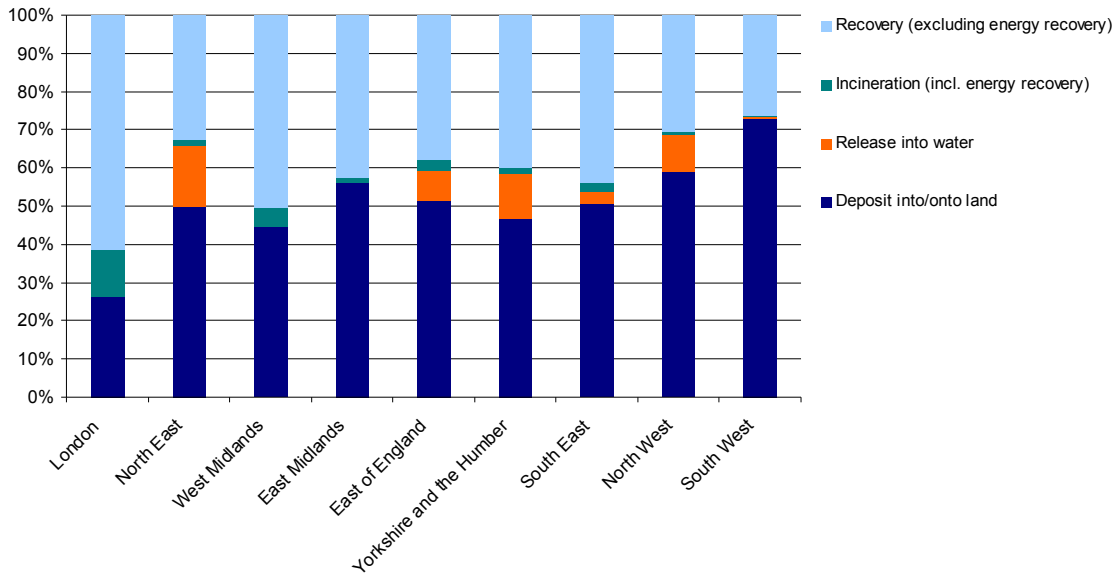
[77] ONS Crown Copyright, 'Regional, Sub-Regional and Local Gross Value Added', 9th December 2009.

Of the waste produced in the East Midlands in 2006, 42.6% was recovered or recycled, which was significantly higher than the average for England, of 37.5%. The highest proportion of waste recovery was in the West Midlands, at 50.3%, and the lowest was in the South West, at 26.2%.

As illustrated by Chart 16, disposal on to land – i.e. in landfill sites – remains the most prevalent method of waste disposal in most English regions. In 2006, 12.3 million tonnes of waste went to landfill in the East Midlands, 56.1% of the total, which is above the average for England of 55.0%.

More positively, no waste in the East Midlands was released into water, whereas in the North East, 15.8% of waste was disposed of in this way.

Chart 16: Waste arisings by disposal, 2006 (%)



Source: Defra Sustainable Development Indicators (2009), Environment Agency, CLG.

Chart 17 shows trends in the proportion of household waste recycled or composted across the English regions:

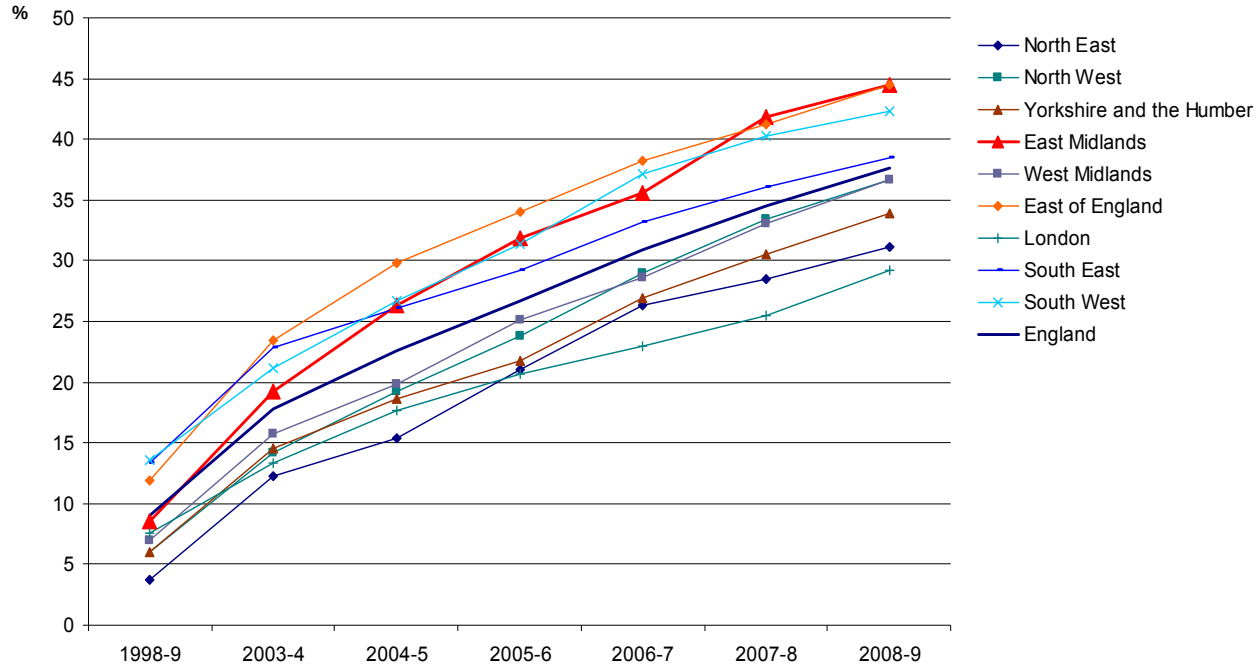
- Of the 481 kg per capita of municipal waste produced in the region in 2008-2009, the East Midlands had the joint highest proportion (alongside the East of England) recycled or composted out of the nine English regions at 44.5%, compared to 37.6% in England;

- The lowest proportion of waste recycled or composted in 2008-2009 was in London, at 29.2%; and

- The proportion of household waste recycled or composted has increased across all regions since 1998-1999. However, the proportion has increased in the East Midlands more than any other region over the

decade, by 35.9 percentage points, compared to a 28.6 percentage point increase in England overall.

Chart 17: Household waste recycled or composted by region, 1998-1999 to 2008-2009 (% of total household waste)



Source: Defra Sustainable Development Indicators (2009), Environment Agency, CLG.

The cost of dealing with the total amount of waste produced by the region is estimated to be at least £400 million per year. Local Authorities are making steady progress to recover or recycle more of the municipal waste streams, as shown in Chart 17. However, this is still significantly below the East Midlands Regional Waste Strategy targets.

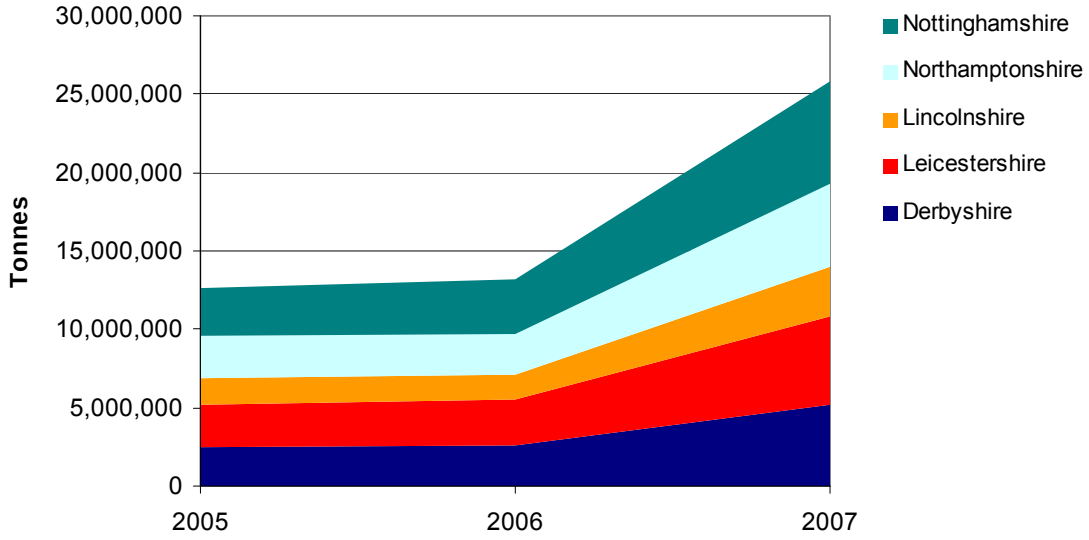
Categories of waste deposits reported to the Environment Agency are:[78]

- Inert / construction and demolition;
- Hazardous or special waste (including toxic and hazardous materials). This is waste considered as hazardous under current regulations, and includes waste such as lead acid batteries or fluorescent tubes. If a business creates hazardous waste, they have a duty to ensure that it is dealt with appropriately.
- Municipal waste; and
- Commercial and industrial waste (not including any special waste from these sources).

[78] Note: this data is not directly comparable to that presented in Charts 15 and 16, which attempt to estimate all waste arisings. The Environment Agency data in Chart 18 only presents data reported to the Environment Agency.

As Chart 18 shows, between 2005 and 2007, the total waste deposited into Environment Agency licensed waste management facilities in the East Midlands has risen from 12.7 million tonnes to 13.2 million tonnes. Management facilities in Nottinghamshire accounted for the largest share in 2007, at 27.6%, whist facilities in Lincolnshire accounted for the smallest share, at 11.1% of the regional total.

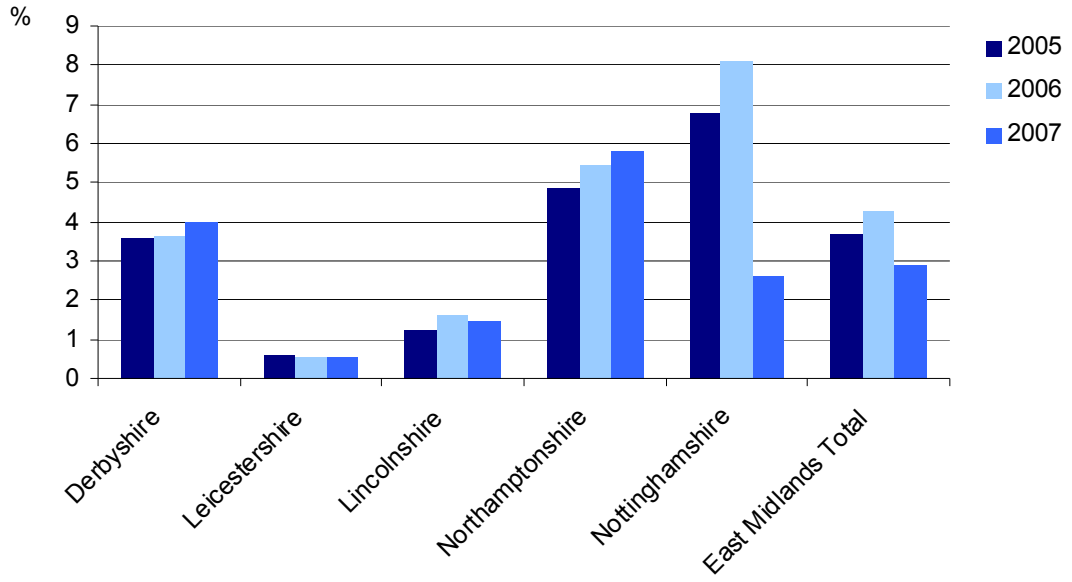
Chart 18: Total volume of waste deposited at East Midlands management facilities, 2005-2007 (tonnes)



Source: Environment Agency submission, March 2009.

Chart 19 shows the proportion of waste deposited in Environment Agency management facilities classed as 'hazardous'. In the East Midlands, this has decreased from 3.7% of all waste deposited in 2005 to 2.9% in 2007. However, in a number of local areas this proportion has increased. In Derbyshire, hazardous waste accounted for 3.6% of all deposits in 2005, increasing to 4% in 2007, and in Northamptonshire, hazardous waste accounted for 4.9% of all deposits in 2005, increasing to 5.8% in 2007.

Chart 19: Proportion of waste deposits to East Midlands management facilities classed as 'hazardous', 2005-2007 (%)



Source: Environment Agency, March 2009.

7.6.2 Recycled and secondary aggregates

As established in section 4, the East Midlands has the most significant natural aggregate resources of all English regions. Until the 1970s, the region could also tap into a wide range of other materials, by-products or "waste" from other industries and demolition. Important usable by-products from industry were iron and steel slag, pulverised fuel ash (PFA), furnace bottom ash (FBA), colliery spoil (burnt or unburnt), and brick/ceramic waste. Demolition waste principally comprised airfield concrete, especially in the eastern/southern counties. With the notable exception of PFA and FBA, most of these materials are now no longer available, and certainly not in the quantities previously experienced. Even supplies of PFA and FBA have greatly reduced with the closure of a number of coal-fired power stations. However no comprehensive or consistent series of figures are available to quantify such trends. The following summarises the present position.

Construction and demolition waste: the Office for the Deputy Prime Minister (ODPM – now the Department of Communities and Local Government) commissioned national studies relating to 2001 and 2003.[79] Attempts were made to derive regional figures but users were cautioned against over-interpretation. The results are summarised in Table 4:

[79] Survey of arisings and use of construction and demolition waste in England and Wales in 2001 (Symonds Group) for ODPM 2002-2004.

Table 4: Waste arisings from construction and demolition in the East Midlands, 2001 and 2003

Demolition/excavation waste: East Midlands			
Year	**Total arising (Million tonnes)**	**Used as aggregate (Million tonnes)**	**Confidence limits**
2001	10.59	4.09	±55%
2003	9.88	4.26	±14%

Source: Survey of arisings and use of construction and demolition waste in England and Wales in 2001, for ODPM 2002; Survey of arisings and use of construction and demolition waste in England and Wales in 2003, for ODPM 2004.

Over 40% of demolition/excavation waste is used as aggregate and the bulk of the remainder includes soil and material unsuitable for use as aggregates. This was employed in landfill, backfilling quarry voids, land reclamation, landscaping for leisure projects, etc. No records of the waste arising within various parts of the region are held, but these are likely to be heavily concentrated in the three main cities and the former coalfield area.

PFA and FBA: Coal-fired stations produce significant volumes of pulverised fuel ash and furnace bottom ash. These materials can be processed and used as aggregates (estimated at 33-50%), most of the remainder being employed in the systematic restoration of sand and gravel workings.

Road planings: the East Midlands Aggregates Working Party is currently collecting information from Highways Authorities. In the past, levels recorded have been extremely modest, amounting to only a few tens of thousands of tonnes. However the practice and related facilities have increased since the last surveys (in the 1990s). In addition to the recycling of aggregate per se, the rising price of bitumen will also act as a spur. Many of the main routes in the region (notably the M1) are programmed for surface renewal, and recycling is now normally a condition of contract.

Key Points: Waste

- The East Midlands accounts for 10.1% of the waste produced in England. Construction and demolition accounted for the largest share.
- For every million pounds of GVA generated in the East Midlands, 330.5 tonnes of waste were produced, compared to 244.2 tonnes of waste per million pounds of GVA in England overall. Therefore the East Midlands is significantly less resource efficient than the national average according to this measure.
- Landfill remains the most prevalent method of waste disposal in the region (56.1% of the total, compared to 55.0% in England).
- However, in terms of municipal waste alone, the East Midlands has the joint highest proportion (along with the East of England) recycled or composted, at 44.5% compared to 37.6% in England. The East Midlands has also experienced the largest percentage point increase in the proportion of household waste recycled or composted between 1998-1999 and 2008-2009 of all nine English regions.
- Management facilities in Nottinghamshire accounted for the largest share of waste deposits in the region, whilst Lincolnshire accounted for the smallest share.
- The proportion of waste classed as 'hazardous' deposited in the region has decreased from 3.7% in 2005 to 2.9% in 2007.
- Currently about 40% of demolition/excavation waste in the East Midlands is used as aggregate, but this proportion is much lower than previous levels due to resources like airfield concrete and colliery spoil no longer being available.

7.7 Water

Water is essential for life and is used for water supply as well as recreation and maintaining habitats in rivers and wetlands. Surface water from the River Trent and major tributaries, together with groundwater in the Sherwood Sandstone, the various limestone formations, and the gravels along the River Trent that form the main aquifers, comprise the main water resources in the region.

7.7.1 Water resources

Rainfall: Water resources within the East Midlands are under pressure, with parts of Lincolnshire that are amongst the driest in the country, receiving less than 600 mm/yr of precipitation. In addition, this area also has large requirements for water to irrigate the high quality agricultural land. In contrast, the upland areas in the northwest of the region receive higher amounts of rainfall, in excess of 1300 mm/yr in parts. Over the entire region the average annual precipitation is around 670 mm/yr, which is significantly less than the

England average of 828 mm/yr.[80] Due to losses to vegetation and evaporation the effective rainfall for the East Midlands is not spread evenly throughout the year, with the majority occurring during the winter months.

Surface water: The main watercourses in the region can be split into those rivers that run into the Humber Estuary to the north of the region and those that flow into The Wash, off the Lincolnshire Coast. In the north and west of the region, the main rivers and their tributaries flow into the River Trent, which runs north of the region into the Humber Estuary. The Rivers Derwent, Dove, Soar and Erewash all flow into the Trent. The River Ancholme, in northern Lincolnshire, flows directly into the Humber. The western moors and uplands of Derbyshire are principally drained by the Derwent, whilst the Leicester vales are drained by the Soar. The eastern part of the area generally drains towards The Wash, with the Rivers Welland and Witham flowing into The Wash and the River Nene running between The Wash and the Grand Union Canal. Many users abstract directly from these rivers, although most water is drawn from the Derwent and Dove, rather than the Trent itself. The region also contains large public supply reservoirs, for example the Derwent Valley, Carsington, Ogston, Rutland and Pitsford.[81]

Groundwater: Approximately 40% of the region is underlain by useable aquifers, comprising bedrock formations as well as the superficial deposits (mainly the gravels associated with the River Trent). Bedrock aquifers include the Sherwood Sandstone, Cadeby Formation, Carboniferous Limestone, Lincolnshire Limestone, Spilsby Sandstone and Chalk. Table 5 summarises the hydrogeological classification of the region. Aquifers are recharged from rainfall and from streams flowing along their outcrops. The locations of the aquifers are shown in Map 14.

[80] Meteorological Office, Hadley Centre.
[81] Environment Agency, 'A water resources strategy for the East Midlands', 2001.

Map 14: Hydrogeology of the East Midlands, 2009

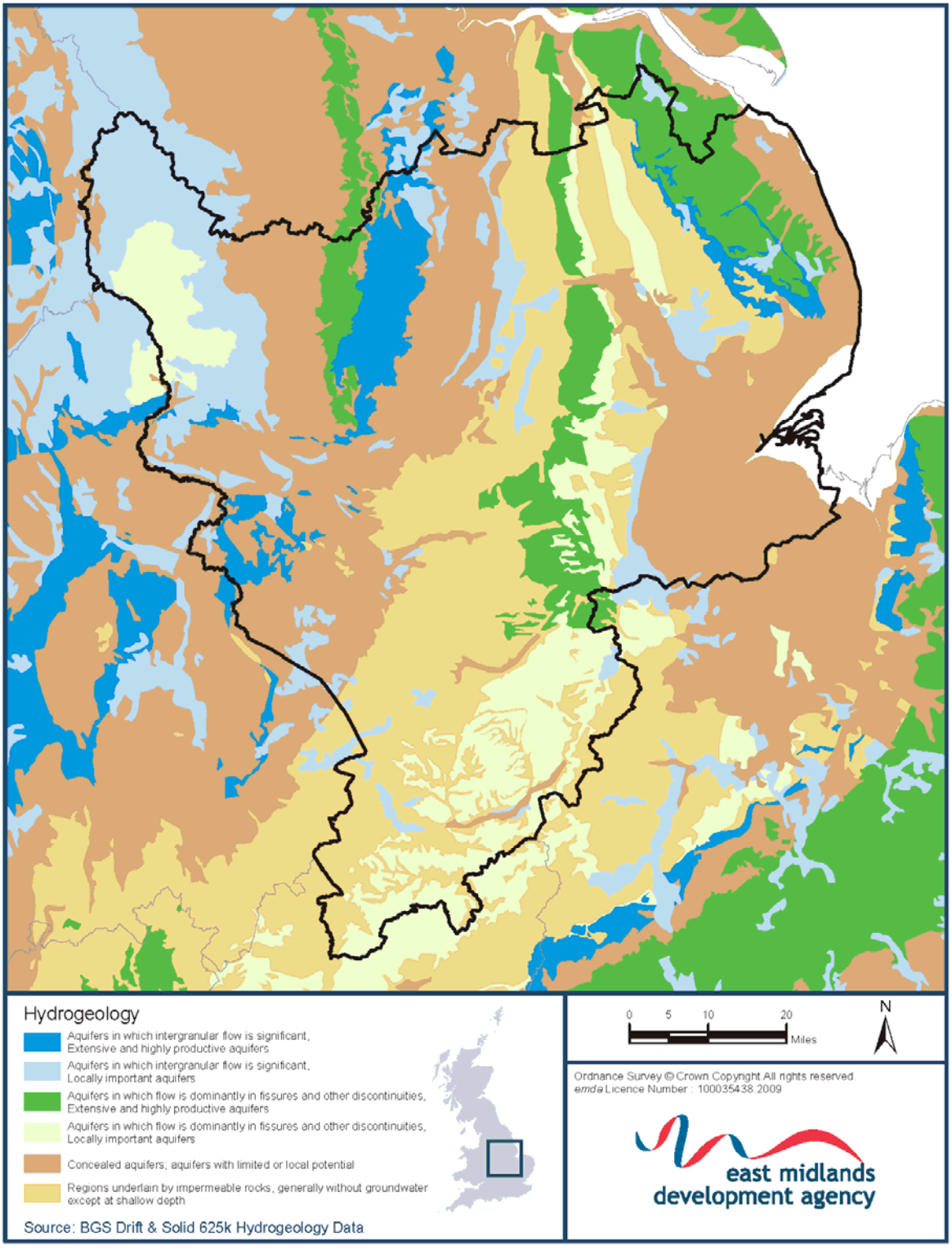


Table 5: Hydrology in the East Midlands

Superficial deposits	Lithology	Permeability
Blown sand	Sand	Permeable
Peat	Peat	Low permeability
Alluvium	Clay, silt and sand	Generally low permeability
River terrace deposits	Sand and gravel	Permeable
Glacial sand and gravel	Sand and gravel	Permeable
Till	Boulder clay	Low permeability

Bedrock	Lithology	Aquifer classification
Chalk	Chalk	Aquifer
Carstone and Roach Formations	Sandstone underlain by sandy limestone and mudstone	Mainly aquifer
Tealby Formation	Mudstone and subordinate limestone	Mainly aquitard
Spilsby Sandstone	Sandstone	Aquifer
Kimmeridge Clay, Ampthill Clay, West Walton and Oxford Clay Formations	Mudstone	Aquitard
Cornbrash	Limestone	Aquifer
Blisworth Clay Formation	Mudstone	Aquitard
Blisworth Limestone Formation	Limestone	Aquifer
Lincolnshire Limestone	Limestone	Aquifer
Whitby Mudstone, Marlstone Rock, Dyrham and Charmouth Mudstone Formations	Mainly mudstone	Aquitard
Mercia Mudstone Group	Mudstone with occasional siltstones	Aquitard
Sherwood Sandstone Group	Sandstone	Aquifer
Brotherton Formation	Dolomitic limestone	Aquifer
Edlington Formation	Mudstone	Aquitard
Cadeby Formation	Dolomitic limestone underlain by mudstone	Aquifer underlain by aquitard
Coal Measures	Mudstone, siltstone, sandstone and coal	Multi-layered aquifer
Millstone Grit	Mudstone, siltstone and sandstone	Multi-layered aquifer
Carboniferous Limestone	Limestone	Aquifer
Precambrian	Volcanic rocks and slates	Aquitard

Source: British Geological Survey, 2009.

Table 5 identifies the main geological sources of groundwater in the East Midlands, in terms of 'superficial deposits', such as alluvium (deposited by rivers and streams), and water sources found in 'bedrock', such as aquifers (underground layers of water-bearing rock from which groundwater can be extracted).

The river terrace deposits form an important aquifer, particularly along the Trent. The water is on hydraulic continuity with the associated surface water with both water levels and quality reflecting that of the rivers.

Over the Wolds, where there are no overlying superficial deposits, there is little or no surface runoff with rainfall directly recharging the aquifer. Springs issue from the base of the formation along the scarp slope and also at the western margin of the coastal plain, at the junction with the overlying till.

Groundwater in the Lincolnshire Limestone is generally of good quality, though hard and of calcium bicarbonate type near the outcrop. The water softens eastwards due to caution exchange, but eventually deteriorates with increasing depth and distance from outcrop, becoming dominated by sodium and chloride ions.[82]

The Mercia Mudstone Group predominantly consists of impermeable mudstones with occasional thin strata of siltstones and sandstones which may transmit limited quantities of groundwater through fractures.

The Sherwood Sandstone Group forms the second most important aquifer in England, supplying around a quarter of licensed groundwater abstractions in England and Wales. Historically, over-abstraction in Nottingham led to a decline in water levels that has been reversed since 1965 by a reduction in industrial abstraction.[83] Groundwater in the Sherwood Sandstone is generally of good quality. Nitrates are locally elevated due to agricultural practices. Around Nottingham the water quality is poorer, probably due to the effect of domestic and trade effluents over time.

The Coal Measures Group comprises alternations of sandstone, siltstones and mudstones, with frequent coal seams. Coal Measures sandstones generally possess little permeability, thus groundwater storage and movement occurs predominantly within and through fractures. The mining of numerous coal seams has been widespread and has largely disrupted natural hydrogeological conditions of the Coal Measures Group by the creation of open shafts, roadways and galleries, as well as collapsed disused workings and the production of subsidence-induced fractures. Yields are therefore from boreholes and are very variable, but can be large if old workings are intercepted. The water can be of drinkable quality at shallow depths. However, water from deep mines tends to be of poor quality with high total hardness, sulphate, chloride and iron concentrations. Mining activities tend to lower water tables compared with natural conditions, particularly where shafts are actively dewatered by pumping. Once mine dewatering ceases, and water levels naturally rebound, the quality of groundwater in the Coal Measures may be worse than before.

River flows around the Peak District are almost entirely fed by groundwater springs. Hydrographs indicate the large seasonal variations of water levels are due to the aquifer's low porosity and also the spiky response to individual rainfall events. The quality of water from the Carboniferous Limestone tends

[82] Griffiths K J, Shand P and Marchant P, 2006, Baseline Report Series 23: The Lincolnshire Limestone, British Geological Survey Commissioned Report CR/06/060N.
[83] Charsley T J, Rathbone P A and Lowe D J, 1990, 'Nottingham: A geological background for planning and development', British Geological Survey Technical Report WA/90/1.

to be hard and the karstic [84] nature of the aquifer leads to rapid flow of water and thus the aquifer is vulnerable to contamination from the surface. After heavy rainfall, the water can become turbid and polluted, with high concentrations of suspended solids, organic matter, bacteria and nitrates.

7.7.2 Groundwater vulnerability

The main aquifers are very vulnerable at outcrop to surface pollution at the outcrop, where they are not protected by overlying, impermeable superficial deposits. This is particularly relevant to the Sherwood Sandstone.

7.7.2.1 Nitrate Vulnerable Zones

Nitrate Vulnerable Zones cover 55% of England and 3% of Wales and are designated in order to prevent nitrates entering groundwater by limiting the amount of nitrogen fertiliser applied to farmland. Within the East Midlands 19,120 hectares of agricultural land are designated as Nitrate Vulnerable Zones – mostly in the northern and central parts of Nottinghamshire and Lincolnshire and in southern Northamptonshire. This, however, represents only a small proportion of the ground and surface waters in the region vulnerable to nitrate pollution from agriculture, with much larger EU Nitrate Directive Nitrate Vulnerable Zones designated.[85]

7.7.3 Present water use and availability

Water abstractions from surface streams and underground aquifers support a range of uses. Water companies supply domestic, commercial and industrial users, and also supply to high volume users like agriculture, fisheries and power generation. In rural areas, some households also have their own domestic supplies.

Public water supply is the dominant use of water and constitutes in excess of 1,150 million litres per day (Ml/d). This is provided primarily by Severn Trent Water and Anglian Water, with a small area in the north west supplied by United Utilities and two small rural areas south west of Derby supplied by South Staffordshire Water. These companies utilise and distribute water via a combination of reservoirs, rivers and groundwater.

Additionally industry abstracts approximately 350 Ml/d. The majority of this water is treated and subsequently returned to the river network, where it is available for re-abstraction downstream. However, the treated water is

[84] 'Karstic' refers to an area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams and caverns.
[85] Defra, England Rural Development Programme (ERDP) Regional Chapters – East Midlands, May 2005.

frequently discharged to the network a considerable distance from where it was first abstracted.

Agriculture is important within the region with 77% of available land being used for agriculture. This is dominated by arable farming, notably cereal crops.[86] Agricultural abstraction for spray irrigation of these crops accounts for a further 90 Ml/d, and is mainly obtained during the summer months when river levels are at their lowest. Peak daily irrigation demands may exceed public supply demand and little of this water is returned to the river network.

Chart 20 offers a comparison between the Environment Agency's regions in terms of the volume of water abstractions between 1995 and 2005. It is important to note that the East Midlands cannot be isolated from the data, as it is covered by parts of the Midlands and Anglian regions. Nonetheless, useful comparisons can be drawn out:

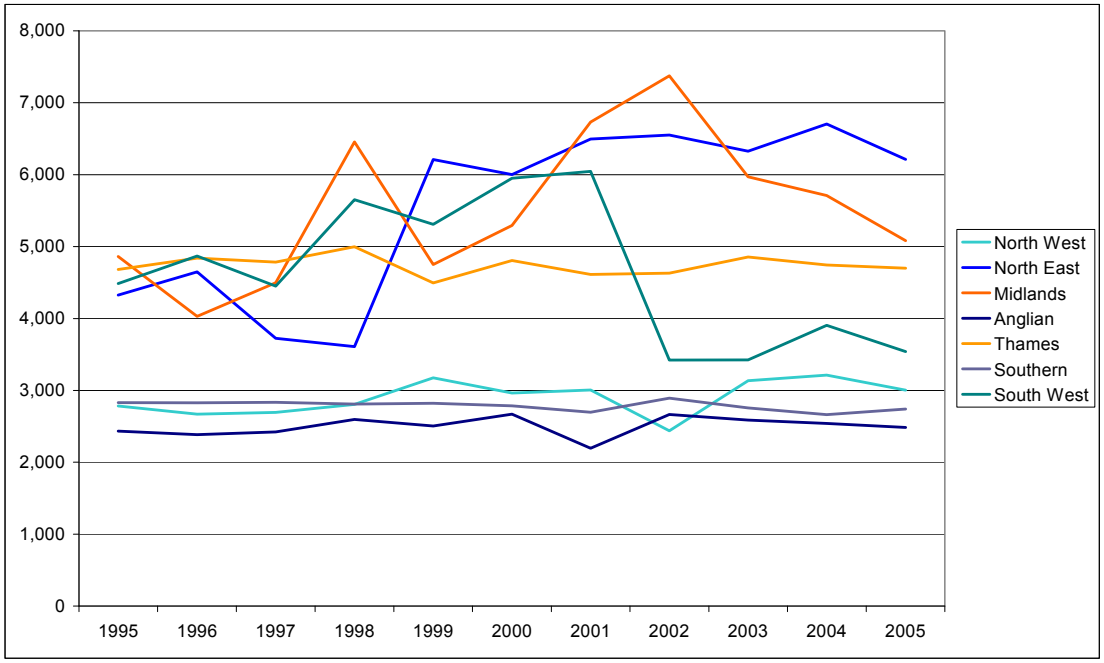
- Water abstractions in the Midlands as a whole have been amongst the highest in England since 1995, peaking at 7,376 Ml/d in 2002. In 2005 they totalled 5,082 Ml/d;

- The lowest volume of abstractions has been from the Anglian region in most years, at around 2,500 Ml/d; and

- In most regions, water abstractions remained fairly steady or declined between 1995 and 2005, but abstractions in the North East, and to a lesser extent the Midlands, increased markedly in this period.

[86] Entec, 2008, East Midlands Development Agency: Water and Physical Developments (Environmental Infrastructure), scoping and characterisation report.

Chart 20: Estimated total abstractions from non-tidal surface waters and ground waters, 1995 to 2005 (million litres/day)



Source: Environment Agency submission, March 2009.

The majority of surface water bodies are already fully committed to existing abstractions during the summer. Additional summer abstraction would only be possible from the River Trent and parts of the Soar, although additional winter abstraction may be possible across the region.

On the local scale the Environment Agency's Catchment Abstraction Management Strategy (CAMS) also highlights the strain on regional water resources. The majority of resources are classified as no water available (water resources fully allocated at low flows), over-licensed (if users abstract their full allocated volume there is potential for unacceptable environmental impact at low flows) or over-abstracted (existing abstraction is causing unacceptable environmental impact at high flows).

The Environment Agency has declared rivers and streams in over half of the region's catchments closed to further summer abstraction to protect the aquatic ecology and environment, and to prevent flows artificially falling below the requirements of other river uses such as for navigation. Similarly, many aquifers are now considered fully committed. The level of abstraction from some aquifers has reduced baseflows in watercourses and is causing adverse environmental effects.

7.7.4 Future water issues

As described in Chapter 1, 'The East Midlands Demography', the region's population is projected to increase by 460,425 additional residents between 2006 and 2016. This is likely to intensify the demand for water resources in the area, although it is likely that these additional households would be more

water efficient. The Environment Agency forecasts suggest that future water demand due to this population increase could range between a 40% decrease and a 25 to 40% increase depending on a combination of economic pressures, more sustainable ways of using water and technological innovation. Additionally agricultural spray irrigation demand could decrease by 15% or increase by 60% by 2025 depending on customer and supermarket produce quality demands, international competition, crop varieties grown and efficiency of water use. This will have a significant effect on river and wetland habitats as already some abstractions exceed the current sustainable limit.[87]

Climate change is likely to result in higher temperatures with drier summers and wetter winters. This is likely to further exacerbate the pressures on water resources as demands for water are usually greatest in the summer. However increased winter rainfall should improve aquifer recharge and reservoir storage volumes, although increased variability in rainfall could make this less predictable.[88]

7.7.5 Water quality

The quality of rivers is affected by discharges from sewage treatment works and industries, and by diffuse drainage and discharges from agriculture. Unpolluted rivers should contain a wide diversity of organisms with no single species in great abundance. The effect of pollution is to selectively remove certain types of organisms, possibly resulting in other species becoming excessively abundant. The quality of rivers can therefore be classified by the presence of chemicals that indicate pollution and the extent and variety of biological organisms that inhabit them.

There has been a change in methodology used to make these assessments. The General Quality Assessment (GQA)[89] network has been reduced in its extent, due to the introduction Water Framework Directive into UK law in 2003. The methodology for chemical quality has also changed, with Biochemical Oxygen Demand no longer assessed. The result is that the figures will not be comparable with previously released GQA data. The GQA classifications themselves will cease to exist beyond 2010 so will cease to be the long term indicator for water quality.

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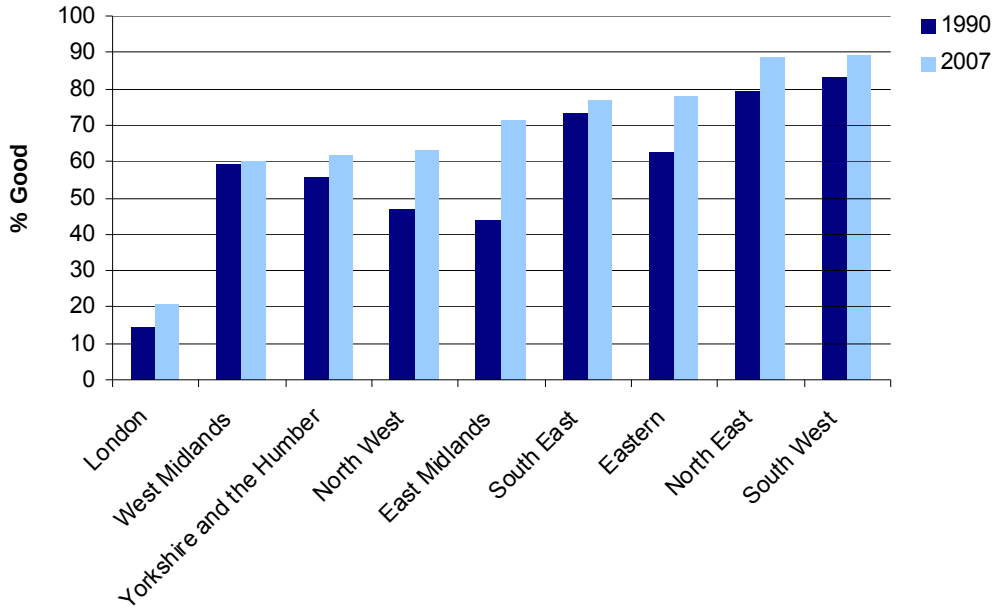
[87] Environment Agency website http://www.environment-agency.gov.uk
[88] Waters B, 2004, 'The potential impact of climate change in the East Midlands'.
[89] The two principal elements of the General Quality Assessment (GQA) scheme for rivers cover chemical quality and biological quality. Chemical quality is defined by concentrations of Biochemical Oxygen Demand (BOD), ammonia and dissolved oxygen. These have been selected as indicators of the extent to which water has been affected by waste water discharges and rural land use run-off containing organic, biodegradable material. Biological quality is assessed by an evaluation of micro-invertebrates and plant life, which act as indicator species for the wider ecology of the water system. In terms of both chemical and biological quality, rivers are classified as 'very good', 'good' (where ecosystems are natural or close to natural) 'fairly good', 'fair', 'poor', or 'bad' (where ecosystems are impoverished or severely restricted).

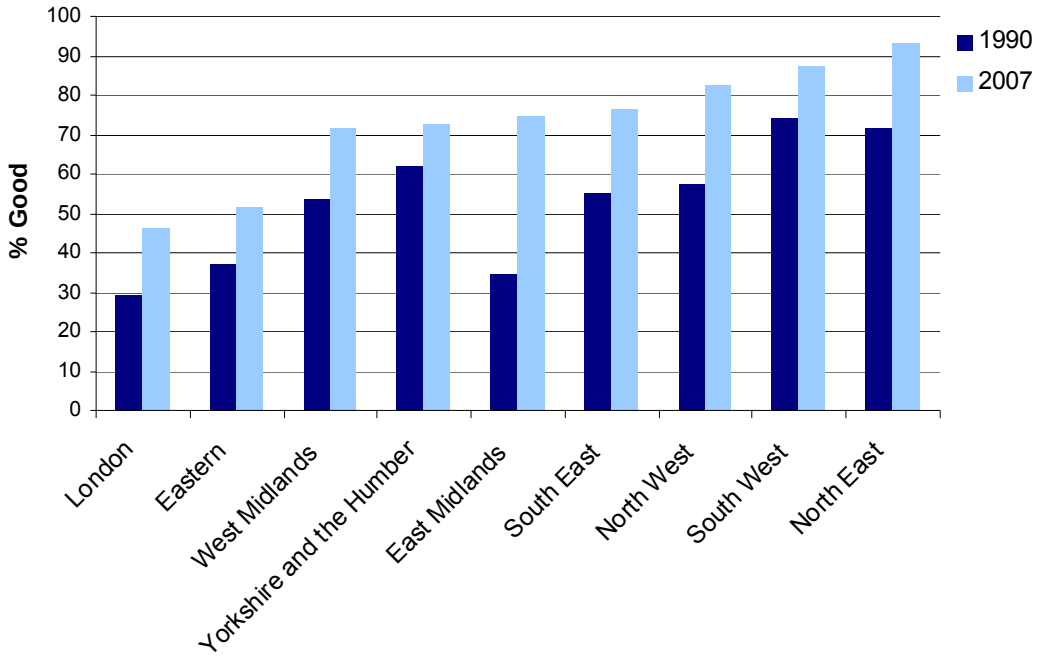
Chart 21: Rivers classified as being of 'good' biological quality by region, 1990 and 2007 (%)



Source: Environment Agency, February 2009.

Chart 21 shows that in every region, the proportion of river length achieving good biological GQA quality has increased since 1990. The East Midlands has experienced a significant improvement – the largest increase of any region, at 27 percentage points from 44% to 71% in 2007.

Chart 22: Rivers classified as being of 'good' chemical quality by region, 1990 and 2007 (%)



Source: Environment Agency, February 2009.

The proportion of river length achieving good chemical GQA quality has also increased since 1990 across all regions (Chart 22), again with the highest increase in the East Midlands, from 34% to 75% in 2007.

In 2008, the draft River Basin Plans were published according to the new classifications data required for the Water Framework Directive.[90] This supersedes GQA data and will become the key water quality dataset for England and Wales.

Assessment required by the Water Framework Directive means that river lengths are split into stretches known as 'water bodies'. They are categorised according to their 'naturalness'. Those considered less natural are put forward as candidate 'artificial' or 'heavily modified' water bodies. The standards that each stretch is required to meet depends on its 'naturalness'. The methodology for classifying 'non-natural' rivers is still being refined so results are only currently available for rivers categorised as 'natural' only. In the East Midlands the summary assessments of 'naturalness' and the results for assessments of the ecological and chemical classes of those water bodies assessed as 'natural' are shown in Table 6.

Table 6: Water Framework Directive assessments from draft River Basin Plans in the East Midlands, 2009

Summary assessment	'Artificial' or 'Heavily modified'	'Natural'		Total	
Length of water bodies in km	2,613	2,402		5,015	
% of total length	52.1	47.9		100.0	
Ecological class (of all water bodies categorised as 'natural')	**Good**	**Moderate**	**Poor**	**Bad**	**Not yet assessed**
Length of water bodies in km	329	1,368	622	44	38
% of total length	13.7	57.0	25.9	1.8	1.6
Chemical class (of all water bodies categorised as 'natural')	**High**	**Moderate**	**Not yet assessed**		
Length of water bodies in km	658	48	1,695		
% of total length	27.4	2.0	70.6		

Source: Environment Agency submission, February 2009.

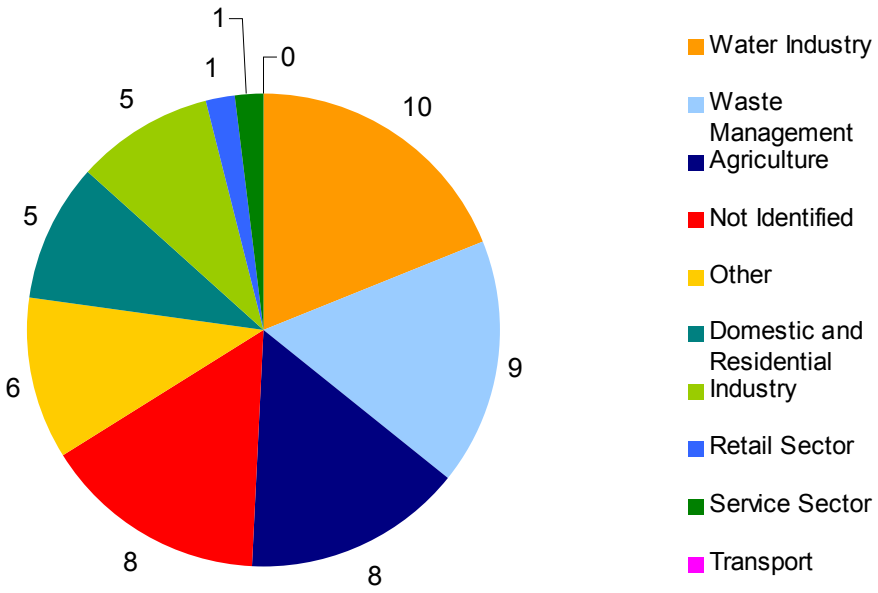
[90] The Water Framework Directive (WFD), which became legislation in the UK in 2003, is the most substantial piece of water legislation from the European Commission to date and is designed to improve and integrate the way water bodies are managed throughout Europe. In the UK, much of the implementation work will be undertaken by competent authorities. Member States must aim to reach good chemical and ecological status in inland and coastal waters by 2015.

Table 6 shows that, of the 5,015 km of water bodies in the region, 47.9% has been assessed as being in a 'natural' state. Of those water bodes classed as being in a 'natural' state, 25.9% of the length assessed so far was classed as being in a 'poor' ecological state and 1.8% in a 'bad' ecological state. A much lower proportion of the water bodies had been assessed for chemical class at the time of writing (70.6% had not yet been assessed), and all assessments so far had classed the river bodies as being of either 'high' or 'moderate' chemical status.

7.7.6 Pollution incidents

Pollution incidents have been reported showing the latest full year's data provided by the Environment Agency. There were 53 pollution incidents in the 'major' (category 1) and 'significant' (category 2) impact categories for 2008, compared with 99 in 2003.[91]

Chart 23: Pollution incidents with major or significant impacts in the East Midlands, 2008 (number of incidents)



Source: Environment Agency submission, February 2009.

Chart 23 shows the distribution of the pollution incidents reported in 2008. For those where the source has been identified, 'water industry' and 'waste management' accounted for largest proportion of incidents in 2008, at 19% (10 incidents) and 17% (9 incidents) respectively. 'Waste management' was also a significant cause of incidents in 2003, accounting for 19% of all incidents in that year.

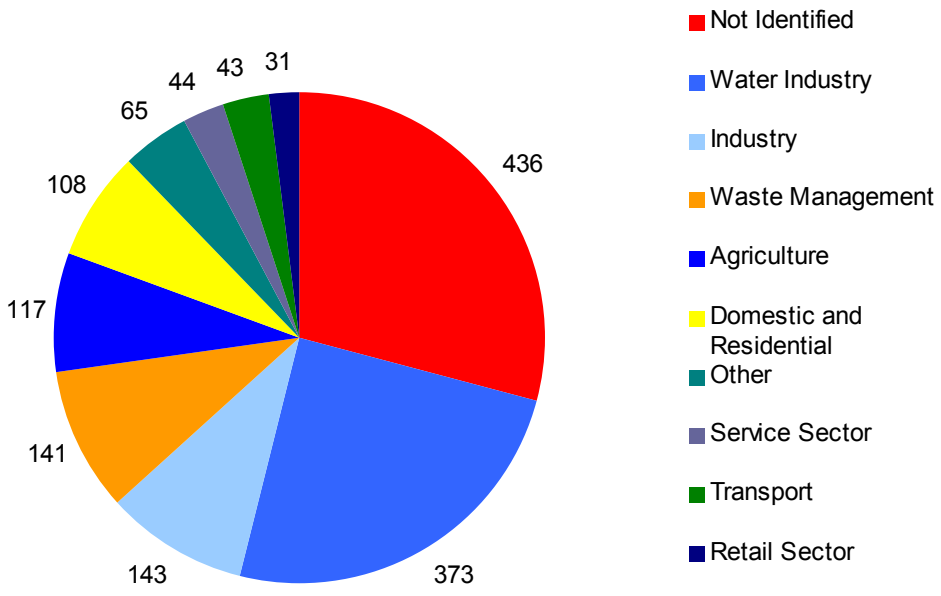
[91] Pollution incidents are ordered in categories from 1 to 4, with category 1, 'or 'major' incidents having the most serious impact on water quality.

'Industry' (including manufacturing, power generation and supply, construction and demolition) accounted for a large proportion of incidents in 2003 with 19%, but this has fallen to just 9% in 2008. Incidents attributed to 'agriculture' have experienced the greatest increase, from 8% of all recorded pollution incidents in 2003 to 15% in 2008.

In interpreting this data it should be noted that:

- No source has been identified for 15% of incidents reported in 2008; and
- The total number of incidents attributed to each of the sectors is small. For example, 'water Industry' accounts for 19% of the total, but this equates to only 10 incidents in the year.

Chart 24: Pollution incidents with any environmental impact in the East Midlands, 2008 (number of incidents)



Source: Environment Agency submission, February 2009.

A similar analysis has been carried out for pollution incidents with any environmental impact (Chart 24). In total, 1,501 incidents were recorded in 2008 compared to 2,329 in 2003, a significant decrease.

Of those where the source was identified, 'water Industry' was the highest contributor followed by 'industry' and 'waste management'. Although the water industry also accounted for the largest number in 2003, it now accounts for an even greater percentage of incidents – rising from 12% in 2003 to 25% in 2008. 'Industry' continues to account for 10% of the incidents. The

proportion of incidents not identified at source has also fallen, from 43% in 2003 to 29% in 2008.

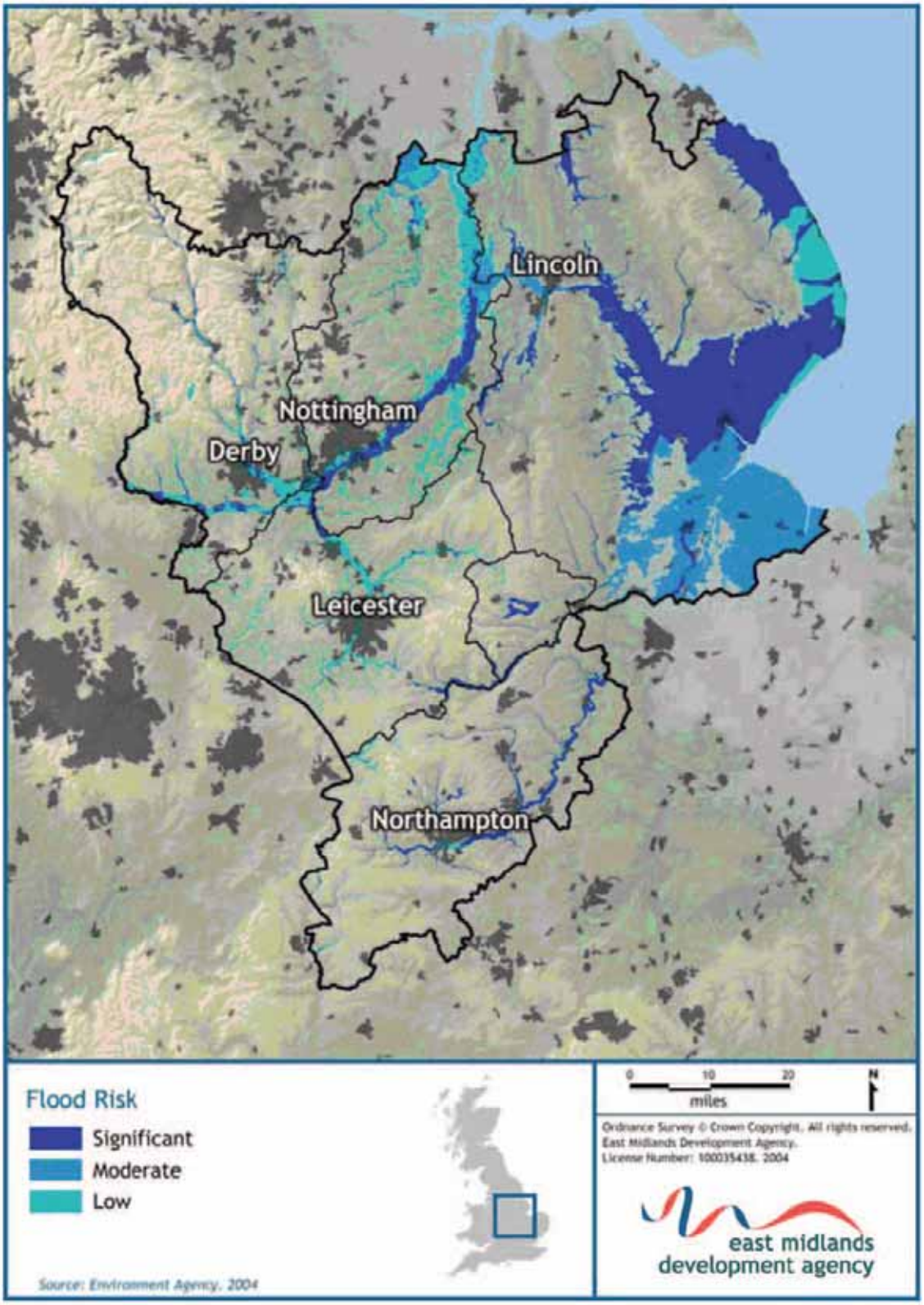
7.7.7 Flood risk

Flooding is a natural process and can happen at any time, with a wide variety of locations and geographical settings proving vulnerable. Flood risk areas cannot be defined precisely as the speed and duration of inundation varies greatly depending on the type of flooding. This is because floods can arise from different combinations of weather, sources, rainfall or oceanic patterns, local topography and modifications to the land surface caused by patterns of development.

Flooding from rivers occurs when the amount of water in them exceeds the flow capacity of the river channel. Most rivers are surrounded by a floodplain and where this is not impeded by barriers or development its natural function is to accommodate any excess water that spills over from the channel. Flooding from land happens when intense rainfall, often of short duration, either runs rapidly down slopes or, in poorly drained areas, is unable to soak into the ground or enter drainage systems. This type of flooding commonly involves sewerage overflow, and can be of long duration in low lying areas. It is exacerbated by local topography and urban building development, particularly when this increases land area that water is unable to permeate.

Please note that Map 15 illustrates only ‘unmanaged’ flood risk – i.e. it does not take into account the impact of current and planned coastal defences, flood protection and drainage schemes.

Map 15: Unmanaged flood risk



In the East Midlands, flood risk is a major economic and social issue in low lying inland areas. The region also contains some of the most extensive flood prone coastal areas in the UK. It is estimated that approximately 17% of the land area in the East Midlands is at risk of flooding, affecting over 350,000 people in 143,000 homes and significant numbers of businesses. Significantly, 20% of the region is low lying and protected by drainage and flood defences and over half of the best and most versatile agricultural land is situated less than five metres above sea level. Extrapolations over the next 50 or so years suggest that the social, economic and environmental consequences of climate change could be severe.[92]

Geological maps, and the Strategic Flood Risk Assessments carried out by the Environment Agency for the Trent and Soar valleys depict the distribution of flood risk for all major and minor floodplains (Map 15). Flood mapping shows that the floodplains of major rivers, such as the Trent, can extend up to 2.5 kilometres away from the main channel. For the River Trent, historical records dating back to 1674 reveal that there have been at least 32 major floods,[93] which will have caused widespread inundation of the floodplains. More recent examples of major floods in the region include:

- In November 2000, widespread inundation of the River Trent and Soar floodplains took place during an event with an estimated 'return period' of 1 in 35 years. It demonstrated that inundation is not only a problem across arable tracts that border river channels, but is particularly damaging in urbanised parts of the floodplain, where housing is dense and drain or sewer systems are unable to cope with significantly raised groundwater levels; and

- In June 2007, after a month's rain fell over parts of the East Midlands in 24 hours, the floodplains of many relatively small valleys were partially inundated. These 'flash' flood events typically affected smaller towns and villages that have grown up along minor streams, the courses of which commonly follow the main street. In these situations flooding is typically localised around constrictions to the stream caused by footpath or road bridges, or poorly maintained culverts.

The floodplains of the East Midlands commonly sustain high water tables due to a combination of high river levels and run-off from the valley sides. The groundwater causes damage by entering cellars or underground facilities, or by causing drains and sewage systems to overflow. Groundwater can also result in flooding behind barriers intended to prevent surface flooding from river channels. Limited groundwater flooding in the East Midlands has been found in valleys underlain by a permeable bedrock aquifer, such as the sandstone beds that underlie much of Nottingham. The hazard can also be expected in ground underlain by Carboniferous Limestone of the White Peak (Derbyshire), or by strata of the Chalk Group in the east of the region.

[92] Environment Agency website http://www.environment-agency.gov.uk
[93] Communication to BGS from Roger Fell, Gunthorpe Flood Action Group, 2004.

Flooding from reservoirs, canals and other artificial sources can be caused by the sudden release of water that is normally retained above the natural ground level, by the impedance of surface flow paths, or by readjustments to groundwater levels upon cessation of pumping. Industrial sand and gravel extraction may unintentionally increase floodwater depths and velocities in adjacent parts of floodplains. Disruption to flow paths and floodplain constriction due to the dumping of colliery spoil, or the opening of opencast mines, may have the same effect.

Industrial flooding can occur when pumping ceases and groundwater returns to its natural level, for example in urban areas where industrial water abstraction is reduced from its previous rate (see above). In Nottingham a short-term solution (by direct pumping) has been adopted where the problem is at its worst, but should levels continue to rise some remedial dewatering of boreholes may have to be commissioned. Where aquifers are hydraulically connected to Coal Measures strata, the rise of mine waters upon cessation of pumping has the potential to cause contamination of local supplies.

7.7.7.1 Coastal flooding and coastal erosion

Coastal regions are particularly sensitive to environmental change. Climate change will have a profound impact on the coasts of Britain, especially the east and south coasts. Pressures will come from sea level rise and increases in severe weather events and storm surges.

A large and increasing body of scientific evidence is showing that that sea levels are changing as a result of human activity. UKCP09 include projections of future sea level rises over the next 100 years. Table 7 shows the central estimates (where there is a 50% probability) of sea level rises affecting London for each of the scenarios and main forecast periods published in UKCP09. The UKCIP02 findings referenced in 'The East Midlands in 2006' provided projections specific to the East Midlands coastline alongside regional forecasts of temperature and precipitation. UKCP09 publishes marine data separately and has significantly more detail on changes to the marine environment alongside estimates of likelihood of storm surges.

Table 7: Central estimates of sea level changes compared to 1990 (cm) for England (London)

	Low emissions	Medium emissions	High emissions
2020s	8.2	9.7	11.5
2050s	18.4	21.8	25.8
2080s	30.5	36.3	43.3

Source: UKCP09.

The sea level rises for the high emissions scenario reflect a faster melting of the arctic ice sheets. By the 2050s, coastlines around England could experience an increase of 25.8cm on 1990 levels if future emissions trends progressed in line with this scenario. Under the medium emissions scenario,

the sea level could increase by 21.8cm by the 2050s, and would increase by 18.4cm on the 1990 level under the low emissions scenario.

UKCP09 projects only a small change in future storm surges. The surge level expected to be exceeded once in a two, 10, 20 or 50 year period is not projected to increase by more than 9cm in the next 100 years anywhere in the UK (this is in addition to mean sea level changes). The largest increase in surges is projected to be in the Bristol Channel and Severn Estuary.

The Lincolnshire coast was badly affected by the storm surge of 31st January /1st February 1953. Large areas between Mablethorpe and Skegness were inundated as a number of breaches to the existing defences and sand dunes occurred during the storm. Forty three people lost their lives, property was damaged or destroyed and farmland was made infertile by the saline waters. The event led directly to the improvement of the defences along the coast of the East Midlands. A similar surge on 11th January 1978 caused far less damage and loss of life as a result.

The Lincshore Project was initiated to improve the level of defence for the coastline between Donna Nook in the north to Gibraltar Point in the south. The beaches were renourished using 7.6Mm^3 of sand dredged from an offshore licence area off Lincolnshire, which was then placed on the beach to build up the level. The project commenced in 1994 and was completed in 1998 at a total cost of £37 million. Some additional renourishment was carried out near Chapel St Leonards in 1999.

With the threat of rising sea levels and increased storm risks in the future, coastal erosion is likely to increase. Re-nourishment may be required more frequently to maintain beach levels and ultimately the technique may become economically or environmentally unjustifiable.

The 'open coast' section of the Lincolnshire coastline is not the only area of the region's coastline affected by climate change. Inter-tidal saltmarshes and mudflats provide us with natural defences against storm surges because they reduce the energy of storm waves as they pass over.[94] In The Wash itself, erosion of the salt marsh affected the viability of the sea defences at Freiston Shore in the late 1990s. This led to the managed realignment of the sea defences and creation of salt marsh as part of a long-term sea defence strategy focused on recreation of salt marshes.[95]

The Government's national policies on different aspects of land use planning with respect to flood risk in England are set out in Planning Policy Statement 25: Development and Flood Risk[96] (PPS 25), which was issued in 2006. The key aims of PPS 25 are to:

[94] Natural England, 'No Charge? Valuing the Natural Environment', 2009.
[95] Natural England, Consultation Response to 'The East Midlands in 2009', November 2009.
[96] Communities and Local Government, 'Planning Policy Statement 25: Development and Flood Risk', December 2006.

- Identify land at risk from flooding;
- Prepare regional or strategic flood risk assessments;
- Frame policies for the location of development to avoid flood risk;
- Reduce flood risk to and from development; and
- Use opportunities presented by development to reduce flood risk by working effectively with the Environment Agency and related agencies to ensure best use is made of expertise available.

An important feature of PPS 25 is the incorporation of a directive which compels the owner or developer to produce a Flood Risk Assessment of the development, to the satisfaction of the Local Planning Authority (LPA). It is then incumbent upon the LPA to consult the Environment Agency and other relevant bodies (e.g. adjacent LPAs) before approving an application for a major development that may have flood risk implications.

Key Points: Water

- Water resources in the East Midlands are under pressure, as parts of Lincolnshire are amongst the driest in England, but require large quantities of water for irrigation of agricultural land.
- The main watercourses in the region are the Rivers Trent, Derwent, Dove, Soar, Anchome, Witham, Welland and Nene, along with their tributaries. Rivers in the north west of the region mainly flow into the Trent, which in turn flows into the Humber Estuary, whilst rivers in the east and south of the region flow directly into The Wash.
- Approximately 40% of the region is supplied with groundwater from useable aquifers.
- Water abstractions from the Midlands as a whole have been amongst the highest in England since 1995, peaking at 7,376 million litres per day in 2002. The Environment Agency projects that future demand for water will increase by between 25 and 40% by 2025. Drier summers could mean that supply may decrease.
- The East Midlands has experienced the most significant increase in water quality of all English regions between 1990 and 2007. In 2007, 71% of rivers were assessed as being of 'good' biological quality and 75% were assessed as being of 'good' chemical quality.
- The water and waste management industries accounted for the largest proportions of water pollution incidents in the region, but the total number of 'major' or 'significant' incidents have decreased, from 99 in 2003 to 53 in 2008.
- Climate change projections suggest that sea levels could rise by 21.8 cm in the 2050s (compared to 1990 levels) in a medium emissions scenario. This would significantly increase flood risk in parts of Lincolnshire, which are already exposed to coastal flooding in maps of 'unmanaged' flood risk (which do not take account of current or planned flood defences and drainage).

7.8 Biodiversity, landscapes and heritage

7.8.1 Biodiversity

According to the International Convention on Biological Diversity, the term 'biodiversity' describes: "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."[97] In its widest sense, biodiversity is required for ecosystems to sustain themselves, and life on earth is thus dependent on the maintenance of biodiversity.

Natural habitats, which form functional ecosystems, can provide a range of other benefits as 'ecosystem services'. Along with the intrinsic value they provide in enabling people to encounter wildlife and appreciate the landscape, these services enable the environment to absorb some of the causes and effects of climate change:

- Healthy peat bogs and woodlands lock in carbon, thus helping to tackle the effects of climate change. It is estimated that peat soils in England store around 296 million tonnes of carbon, equivalent to around two years of total national carbon emissions;[98]

- Forests also accumulate carbon in their soils and trees. The entire UK woodland and forestry estate stores around 150 million tonnes of carbon (approximately equivalent of one year's carbon emissions);

- Grasslands store more carbon than any other land use in England (around 686 million tonnes) whilst arable land stores the second largest amount (583 million tonnes);[99]

- Naturally functioning rivers, wetlands and their catchments reducing the risk of flooding in our towns, cities and agricultural land; and

- Coastal habitats, like saltmarshes and sand dunes, providing effective natural defenses against rising sea levels. Salt marshes and mudflats also store significant amounts of carbon, and the largest carbon sink is provided by the ocean itself. Methods to manage ecological processes in the sea to sequester more carbon are the subject of much current research. [100]

[97] The 1992 Convention on Biological Diversity, signed at the United Nations Conference on Environment and Development at Rio de Janeiro by 150 countries. It is now legally binding on most UN members, including the UK, enshrining a commitment to conserve biological diversity in UK law, including the planning system. In UK planning guidance, biodiversity is covered in PPS 9: Biodiversity and Geological Conservation.
[98] Natural England, 'No Charge? Valuing the Natural Environment', 2009.
[99] Ibid.
[100] Ibid.

As well as these roles, ecosystem services enable recreational use and passive enjoyment of the natural world whilst diverse habitats are a key contributor to the attractiveness of landscapes – generating tourism and contributing to a positive sense of 'place'. The Biodiversity Action Plan (BAP) was the UK Government's response to signing the Convention on Biological Diversity. It was published in 1994 and updated in 2007, and set out a priority list of species and habitats that required urgent conservation. The review of the BAP criteria identified 1,149 species and 65 habitats, which were then detailed in the Natural Environment and Rural Communities (NERC) Act 2006.

The 2006 NERC Act also identifies and protects Sites of Special Scientific Interest (SSSIs). SSSI status gives legal protection to the best sites for wildlife and geology and their conservation has to be taken into account in the planning process. All owners and occupiers of land considered to be of special interest because of its flora, fauna, or geological and physiographical features must be notified and the area is then registered as a local land charge, which means that all future owners and occupiers will be bound by the laws protecting SSSIs.

There are currently 4,114 Sites of Special Scientific Interest (SSSIs) in England, covering around 8% of the country's land area. The majority of SSSIs are small, with 40% under 10 hectares in size and 82% smaller than 100 hectares. More than 70% of land area of these sites are internationally important for their wildlife, and designated as Special Areas of Conservation (SACs), Special Protection Areas (SPAs) or Ramsar sites. SSSI condition is monitored regularly, and categorised in the following terms:

- **Favourable:** this means that the SSSI land is being adequately conserved and is meeting its 'conservation objectives', however, there is scope for the enhancement of these sites;

- **Unfavourable – recovering:** often known simply as 'recovering'. SSSI units are not yet fully conserved but all the necessary management measures are in place. Provided that the recovery work is sustained, the SSSI will reach favourable condition in time;

- **Unfavourable – no change:** this means the special interest of the SSSI unit is not being conserved and will not reach favourable condition unless there are changes to the site management or external pressures. The longer the SSSI unit remains in this poor condition, the more difficult it will be, in general, to achieve recovery;

- **Unfavourable – declining:** this means that the special interest of the SSSI unit is not being conserved and will not reach favourable condition unless there are changes to site management or external pressures. The site condition is becoming progressively worse;

- **Part destroyed:** lasting damage has occurred to part of the special conservation interest of a SSSI unit such that it has been irretrievably lost

and will never recover. Conservation work may be needed on the residual interest of the land; and

- **Destroyed:** lasting damage has occurred to all the special conservation interest of the SSSI unit such that it has been irretrievably lost. This land will never recover.

In June 2009, 81.1% of SSSIs in England were in 'favourable' or 'recovering' condition. This proportion has increased from 58.3% in 2003. The Government's Public Service Agreement target is for 95% of SSSI land to be in 'favourable' or 'recovering' condition by 2010.[101]

7.8.1.1 Biodiversity in the East Midlands

As shown in Chart 25, 10% of the East Midlands land area is covered by an SSSI. This compares to the North East, where 20% of the region's area is covered by land designated as an SSSI, and the West Midlands, where only 2% of the region's land area is designated as an SSSI.

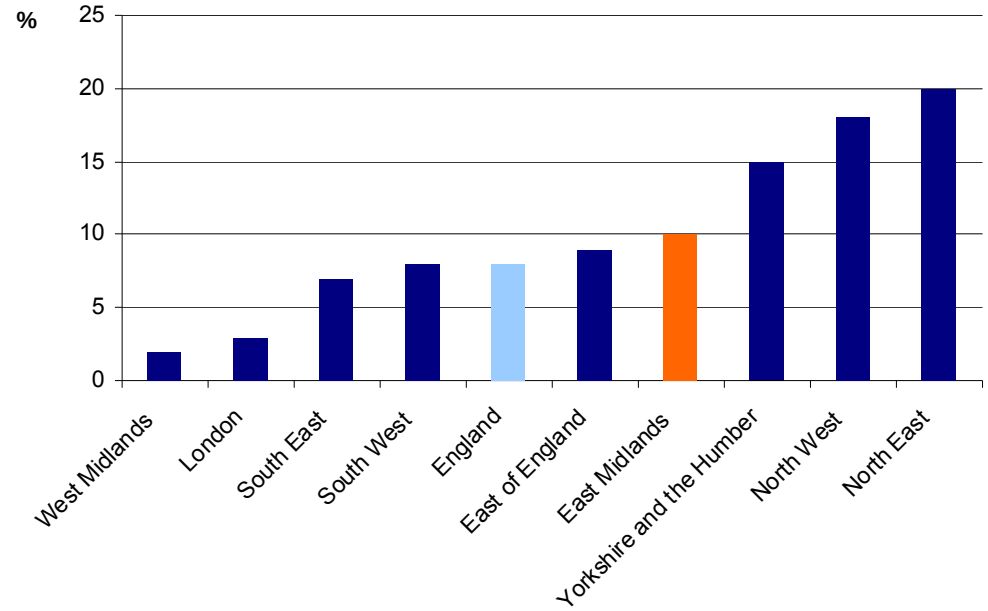
The Wash, much of which is in Lincolnshire, is the largest SSSI in England, covering 62,046 hectares, almost 40% of the total SSSI area in the region, and is particularly noted as a coastal habitat for bird life.

However, this and subsequent data on SSSI condition by Government Office Region need to be interpreted with care, as the boundaries of SSSIs follow the extent of the natural phenomena they represent, and thus do not necessarily match regional boundaries. Therefore there are several significant SSSIs in the East Midlands which overlap other regions, such as The Wash (which extends into the East of England and has an unclear boundary)[102] and a number of large cross-boundary sites in Derbyshire. For the purposes of administration and reporting, such sites are entirely attributed to one Government Office Region, but where the site is as large as The Wash, conditions in neighbouring regions may influence the results for the East Midlands overall.[103]

It total, there are 392 SSSIs wholly or partly within the East Midlands, covering an area of 165,228 hectares. SSSIs in the East Midlands account for 15.3% of the total surface area covered by SSSIs in England.

[101] Natural England, 'State of the Natural Environment 2008', 2008.
[102] The Wash is a particularly problematic site to attribute to an administrative boundary. It contains significant areas of land below mean water level which cannot be measured accurately or apportioned to a given region or county, as its nature as a tidal site means that the extent of its boundaries change over time.
[103] Natural England, Consultation Response to 'The East Midlands in 2009', November 2009.

Chart 25: Total SSSI area as a proportion of regional land area, 2008 (%)

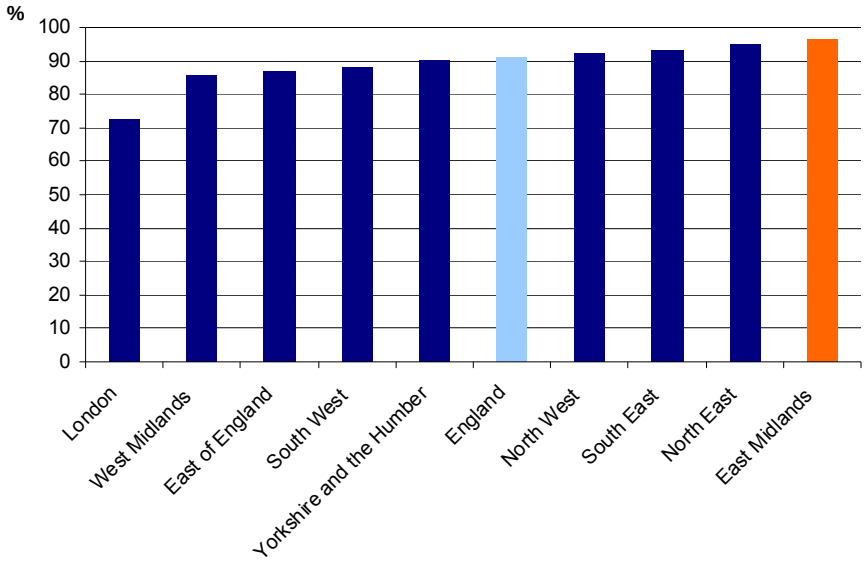


Source: Natural England, 'State of the Natural Environment 2008', 2008.

Chart 26 shows the proportions of SSSIs that are in 'favourable' or 'recovering' condition by English region, demonstrating that the East Midlands currently has the highest proportion of all English regions, at 96.2% according to the March 2010 assessment. This exceeds the PSA target for 2010 of 95%, and also exceeds the England average by 5.1 percentage points.

London has the lowest proportion of SSSIs in a 'favourable' or 'recovering' condition, at 72.7% in March 2010.

Chart 26: Proportion of SSSIs in a 'favourable' or 'recovering' condition by region, March 2010 (%)



Source: Natural England, SSSI regional reports, 1st March 2010.

The Natural England publication, 'The State of the Natural Environment 2008' provides some additional detail on SSSI condition. This relates to assessments carried out in 2008, so is not comparable to the above data (for the first quarter of 2010), but provides a useful indication of the variation in SSSI condition across different categories of habitat in the East Midlands:

- Of the grassland SSSIs in the East Midlands in 2008, 67% were in a 'favourable' or 'recovering' condition, which was below the proportion in England overall (83%). However, grasslands make up a relatively small proportion of SSSIs in the region;

- Of heathland SSSIs in the region, 72% were in a 'favourable' or 'recovering' condition, level with the national average of 73%. Again this type of habitat accounts for a relatively small land area in the East Midlands;

- Woodland SSSIs were also less likely to be in a 'favourable' or 'recovering' condition in the East Midlands than nationally, at 79% compared to 86% in 2008. Again this habitat accounts for a relatively small area in the region;

- Open water SSSIs, which account for a significant share of the region's land area, were more likely to be in a 'favourable' or 'recovering' condition than nationally, at 82% compared to 55%;

- Wetland SSSIs were also more likely to be in a 'favourable or 'recovering' condition in the East Midlands, at 76% compared to 69% in England overall. However, this habitat accounts for a relatively small surface area;

- SSSIs in urban areas were more likely to be in an unfavourable condition in the East Midlands – with only 66% of urban SSSIs categorised as 'favourable' or 'recovering' in 2008, 10 percentage points lower than the English average; and

- Finally, coastal habitat SSSIs, which make up a very large share of SSSI land area in the East Midlands, were significantly likely to be in a 'favourable' or 'recovering' condition, with 100% categorised as such in 2008, compared to 89% in England overall.

In its regional report for the East Midlands, Natural England suggest that some recent initiatives have made significant contributions to the good condition of coastal SSSIs (i.e. The Wash), such as the sustainable shellfish management policy. It also suggests that improvements in SSSIs in the Peak District could be due to work with water companies and tenant farmers to address over grazing and over drainage to improve the condition of blanket bogs.

SSSIs are designated for their biological, geological, or geomorphological interest, or a combination of these interests. Although the status of SSSIs in the region is favourable, the coverage of biological SSSIs is poor. Regional

SSSI statistics overestimate actual coverage, as they include very large sites which cross regional boundaries. Biological SSSIs sites are particularly small compared to other regions: 56% of biological SSSIs are 20 hectares or less, and 20% are smaller than 5 hectares, which can make them more vulnerable to external factors and more challenging to protect.[104]

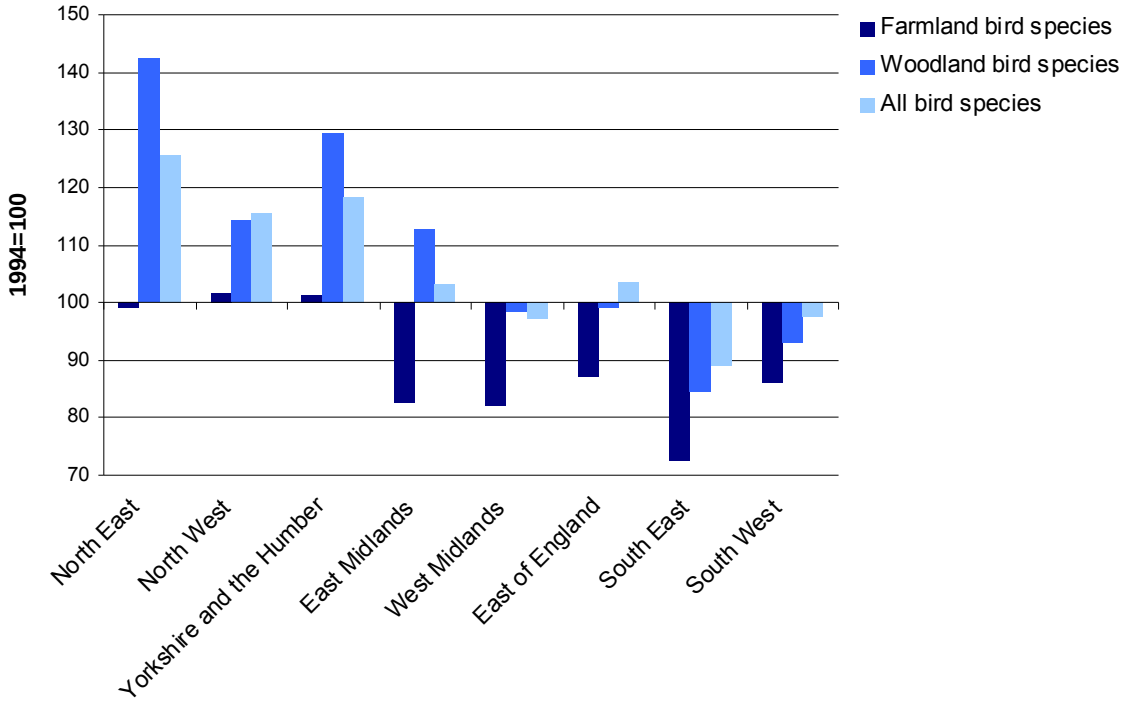
Outside of designated areas such as SSSIs, the quality of biodiversity in the East Midlands is relatively impoverished, largely due to the impacts of intensive farming practices. For example, the region has a low woodland coverage compared to other regions and high species extinction rates. Recent research by Natural England has examined the ability of biodiversity habitats to form ecological networks. This suggests that the East Midlands has relatively few functional ecological networks compared to other regions. This reflects the large scale, historic losses of habitats in the East Midlands.[105]

The health of biodiversity across the region can be monitored by proxy indicators. The Government's preferred indicators used to monitor progress against its sustainable development objectives are the populations of woodland and farmland birds (part of the Defra PSA 28 on sustaining a healthy natural environment).

Between 1994 and 2007, farmland bird populations in the East Midlands, decreased by 17.4%, whilst there was a 12.6% increase in woodland bird populations. This led to an overall increase of all bird species of 3.1%. During the same period, out of the 18 farmland bird species monitored in the region, the population of 10 species decreased by 10% or more whilst eight species increased by 10% or more. Species of farmland birds that experienced decreases in the region included the Yellow Wagtail, Turtle Dove and Linnet. Out of the 30 species of woodland bird monitored in the region, 18 species increased by 10% or more whilst 10 species decreased by 10%.[106] These trends are shown as an index of the 1994 baseline (1994 = 100%) in Chart 27.

[104] Natural England, Consultation Response to 'The East Midlands in 2009', November 2009.
[105] English Nature, 'Habitat losses in the East Midlands', 2002.
[106] Defra and Royal Society for Society for the Protection of Birds, 'Wild bird population indicators for the English regions: 1994-2007', May 2009.

Chart 27: Populations of wild bird species by region, 2007 (1994=100*)*



Source: Defra, Sustainable Development Indicators 2009, Natural Resources Datasets.

The chart shows that the farmland bird species has declined relative to 1994 in the East Midlands, to 82.6% in 2007. This could be due to a loss of hedgerow and field margins habitats due to the intensification of agricultural practices. Natural England estimated that in 2008, only 22% of hedgerows in Great Britain were in favourable condition. As stated above however, the population of woodland birds in the region has increased relative to 1994, to 112.6% of the baseline in 2007. Conversely, this could be due to an improvement in woodland habitats in recent years, with Natural England estimating that 86% of woodland SSSIs nationally were in favourable or recovering condition.[107]

7.8.2 Environmental assets: Landscapes

Landscapes are a vital and diverse resource for the East Midlands region, which is noted for its agricultural productivity, recreational value, cultural associations, heritage and biodiversity assets. The region's landscape includes the transition between the low lying agricultural landscapes of the east of England and more complex landscapes farther west. Between the two extremes lie a multitude of landscapes, comprising limestone and chalk hills,

[107] At a sub-regional level, data has recently become available on Local Authority progress towards the biodiversity National Indicator, NI197: Improved local biodiversity – proportion of Local Sites where active conservation management is being achieved. However, this simply indicates where actions have been taken by Local Authorities (e.g. the introduction of management schemes) and does not reflect the outcomes of this activity on the quality of the habitats in question. Moreover, there are currently no regional or national comparator data available, meaning that NI 197 is presently of little analytical value.

ancient forests, rolling farmlands interspersed with rural villages, remote lowland heaths and stretches of dramatic coastline.

The East Midlands has the lowest proportion of land designated as an Area of Outstanding Natural Beauty (AONB) of the nine English regions, at 3% in 2007, compared to an average of 15%. Although the region also has just 0.3% of England's common land, it plays host to some internationally and nationally significant landscapes that also contribute to the region's tourism offer:

- Visitors to sites in the East Midlands accounted for 10% of the total national number of visits to National Nature Reserves (NNR) in 2005-2006, with a total of 1,674,000 visits. This is higher than the share accounted by the North East, North West and Yorkshire and the Humber;

- The Peak District National Park is the second most visited National Park in the world, accounting for 22 million visitor days per annum in 2008.[108] It includes areas incorporated by three regions (895 out of the total of 917 square kilometres lies within the East Midlands, accounting for a total of 6% of the region's land area);

- The Lincolnshire Wolds is the only designated AONB in the region. It covers 519 sq km; and

- There are other important designations which benefit landscape, for example the Derwent Valley Mills World Heritage Site.

Whilst the nationally designated landscapes in the region are rightly considered to be very important assets, this has tended to encourage the idea that the region's non-designated landscape are of limited importance. However, this lack of designation does not mean that the rest of the region lacks distinctive character, or that efforts are not needed to conserve and enhance its distinctive range of landscapes. For example, remnants of ancient landscapes can be found across the region, notable examples being the ancient forests of Sherwood, Charnwood and Rockingham.

At the national level, the Countryside Character Initiative and National Landscape Typology provide a broad overview of the region's key landscape characteristics. It has defined a total of 159 National Character Areas (NCAs) and of these, 27 NCAs relate entirely or in part to the East Midlands region.

There have been no detailed studies of landscape change specifically in the East Midlands. However, information can be obtained from Natural England's Countryside Quality Counts (CQC) project,[109] which has measured landscape change for NCAs, classifying them as neglected, diverging, maintained or enhancing (Table 8). The results of this study indicate that, when compared

[108] Natural England, 'State of the Natural Environment 2008', 2008.
[109] Countryside Quality Counts assessment: http://www.countryside-quality-counts.org.uk/publications/CQC_HeadlineIndicator_A1.pdf

to England as a whole, more NCAs in the region are judged to be diverging from their intrinsic character. This is perhaps most notable close to large urban areas and major transport infrastructure. By contrast in the more rural areas, character is judged to be maintained, and in the Fens character is being enhanced.

Table 8: Summary of landscape change statistics for NCAs in the East Midlands region

	Maintained	Enhanced	Neglected	Diverging
East Midlands	44% (12)	11% (3)	19% (5)	26 % (7)
England	51%	10%	20%	19%

Note: The figures in brackets refer to the number of NCAs (mainly in the East Midlands) relating to each of the categories of change.

Further evidence for the potential pressures and risks on the landscape is provided by Natural England's 'State of the Natural Environment Report'[110] which demonstrates that, as with many areas in England, landscape quality and diversity is under pressure from a range of influences:

- The growth of cities and towns such as Derby, Leicester, Northampton, Nottingham and Lincoln together with the principal transport infrastructure features, such as motorways and airports, have all had a major influence on the landscape, as well as wider perceptions of landscape quality, tranquillity and remoteness; and

- In the countryside, agriculture, forestry, recreation and the growth of the rural economy have fuelled equally dramatic landscape changes over recent decades.

These drivers of past change will continue. However, the pressure for change on our landscapes will be escalated particularly in light of the high levels of population growth and associated levels of development that will need to be accommodated in what is the fastest growing English region. Furthermore, climate change, and the associated mitigation and adaptation measures, including a shift to renewable energy supply, will be particularly influential.

The European Landscape Convention (ELC) was the first international convention to focus on landscape, and its text became part of UK legislation in March 2007. The ELC encourages organisations to prepare their own landscape action plans with the aim of embedding landscape considerations into organisational ways of working.

In order to further assist in the implementation of the objectives in the ELC, Natural England's East Midlands regional office commissioned an East Midlands regional landscape character assessment (EMRLCA). This study is now complete in draft and will be available as a fully adopted tool from early 2010. It is a hierarchical framework that identifies 31 landscape types in the region, and for each landscape type it then identifies key characteristics, forces for change and future landscape management strategies. The

[110] Natural England, 'State of the Natural Environment 2008'.

EMRLCA signposts the way to the local landscape character and historic character assessments and should be used in conjunction with them to inform strategic decisions, such as where new development could be appropriately accommodated, and how development design should respond to landscape character and key environmental features.

Draft landscape characterisation from the EMRCLA project are shown in Table 10.

Table 10: Regional Landscape Character Types

Broad type	Sub-type
Coast and sea	Coastal saltmarsh Coastal dunes and sands Intertidal flats Shallow coastal waters Offshore industry and fisheries Small scale shipping channel Protected marine wildscape Major navigation channel
Fenland and fenland fringe	Settled fens and marshes Planned fens and carrlands Marsh and fen fringe farmland
Major river valley floodplain	Floodplain valley Sandland farmland
Lowland vale	Unwooded vale Wooded vale
Village farmland	Village farmlands Wooded village farmlands
Lias hills	Lias hills and valleys
Limestone farmland	Limestone scarp and dipslope Limestone dale Limestone farmland
Chalk wold	Chalk wolds Wolds scarp and ridges
Clay wold	Clay wold
Coalfield	Settled coalfields farmlands
Woods and forest	Forest hills and ridges Sandstone forests and heaths Wooded slopes and valleys
Gritstone moor and moorland fringe	Open moors and farmed moorland fringe Moorland dales and valleys Settled valleys and enclosed gritstone uplands Upland pastoral hills and valleys

Please note: Regional Landscape Character Types are in draft form at the moment and will be subject to review.

In consulting on these character assessment types with regional stakeholders, Natural England presented the following 'indicative forces for change' which it felt needed to be considered when developing regional strategies:

- Built development, including housing provision and provision of employment land;

- The development of infrastructure, including transport and energy provision – especially wind turbines and offshore turbines and tidal generators which can have significant impacts on landscape character;

- Minerals and waste, including quarrying and mining, and especially open cast extraction and sea bed dredging. In terms of waste, landfill was clearly seen as having the most significant impact on landscape character;

- Fishing, agriculture and land management, including the diversification and specialisation of agriculture, such as energy crops;

- Forestry and woodland, including deforestation and fragmentation;

- Tourism and leisure, including access to the countryside, coast and sea; and

- Environmental processes and climate change, including coastal flooding and erosion and changing temperatures and rainfall.

7.8.3 Environmental assets: Forests and woodland

Forests and woodlands are part of the above landscape classification, but merit some additional discussion given their importance in a number of different respects.

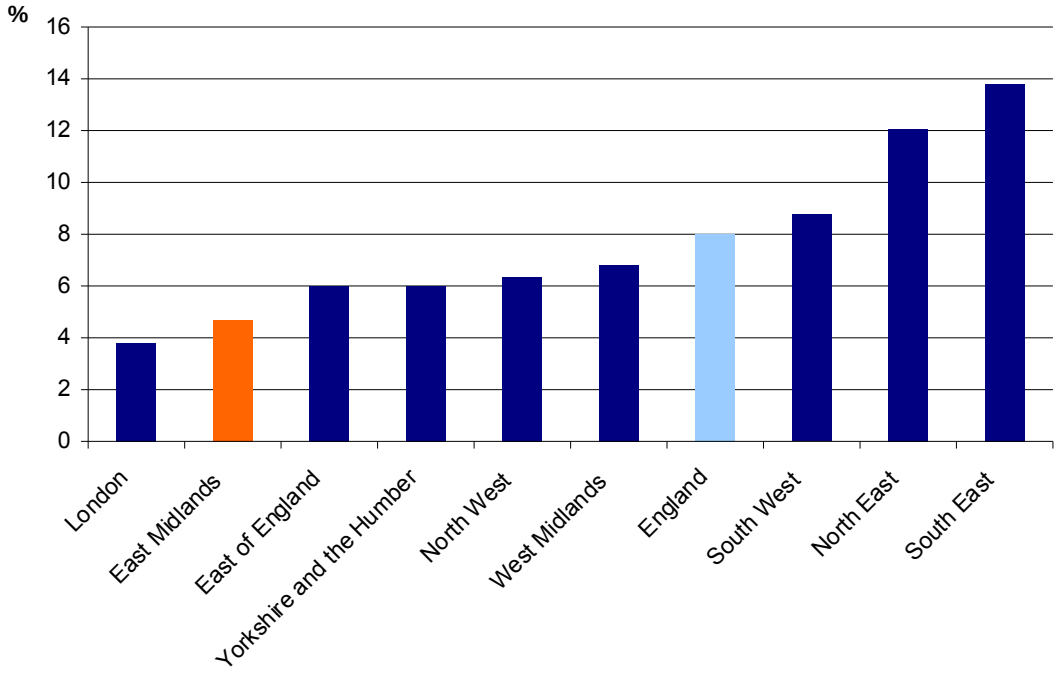
As stated in the introduction to this section, forests and woodlands play a very important role as providers of ecosystem services, storing significant quantities of carbon, and well as providing habitats for a large range of flora and fauna. The Government's 'Low Carbon Transition Plan' recognises this role, and attempts to encourage significant private sector funding for woodland creation, aiming to establish an additional 10,000 hectares of woodland nationally over the next 15 years in order to remove 50 million tonnes of carbon from the atmosphere. It has also been demonstrated that woodland provides an effective service in reducing pollution entering water courses. Flood risk can also be significantly reduced when woodland is located in flood plains, as it can absorb or delay major floods and entirely prevent smaller water flows.

As well as exploiting benefits from large wooded green spaces, there are also opportunities in providing smaller areas of woodland in and around urban areas, in order to cool urban heat island effects. Wooded areas tend to be cooler than grassland, although the effect varies with the season and type of tree. The University of Manchester calculated that a 10% increase in the amount of wooded green space in built-up areas could reduce urban surface

temperatures by as much as 4%. Trees can also be utilised as part of sustainable urban drainage systems, as increasing tree cover in built-up areas reduces surface water run-off, increasing the capacity of engineered drains to cope with excess water.[111]

England is one of the least wooded areas in Europe, and woodland is a particularly scarce resource in the East Midlands, covering only 74,443 hectares, or 4.7% of the region's total land area, compared to 8% in England overall. Woodland in the East Midlands accounts for only 7% of the total woodland area in England. Chart 28 below illustrates that this is the second lowest proportion of the nine English regions, with the lowest proportion in London (at 3.8%). The highest proportion of land area covered by woodland is in the South East, at 13.8%.

Chart 28: Proportion of land area covered by woodland (%)



Source: Woodland Trust, 'Space for People', 2004.

PPS9 prioritises the need to protect ancient woodland, as such habitats have grown over a long period of time and have thus become so complex as to be effectively irreplaceable. Of the woodland in the East Midlands, only 24,000 hectares are 'ancient woodland', amounting to less than 2% of the total East Midlands area.

Along with providing ecosystem services, woodlands provide quality of life benefits to residents when they are publicly accessible. According to research by the Woodland Trust and Forestry Commission, 48% of woodland area in the East Midlands is publicly accessible. This exceeds the average for

[111] Woodland Trust, Consultation Response to 'The East Midlands in 2009', November 2009, citing: The University of Manchester, in 'Public Health News', May 2007.

England of 46%, but is significantly lower than accessibility in the north of the country (at 93% in the North East and 54% in the North West).[112]

7.8.4 Environmental assets: Tourism, rights of way and open access land

Access to a good quality natural environment is an important contributor to individual quality of life and can also provide significant economic returns. According to work commissioned by East Midlands Tourism, the total number of tourists (both from other English regions, UK nations and internationally) visiting the region increased from 139.8 million in 2003 to 144.1 million in 2007. Over this period, the number of day trips has increased from 125 million to 127.8 million and the number of trips involving an overnight stay has increased from 14.8 million to 16.4 million.[113] The Peak District, especially, experiences a high number of visits (estimated to be between 18 and 22 million day visits per year, almost a third of all annual visits to English National Parks)[114] and this places heavy pressure on infrastructure and the natural environment. There is currently a lack of available data on levels of access to the countryside (and, in particular, the urban fringe) for people living in urban areas of the region, although data from 2000 indicates that the extent of signposting and ease of use of public rights of way is significantly below the national average.

The region has an extensive network of statutory rights of way, including National Trails, which provide a well-used recreational resource. These public rights of way provide approximately 18,000 km of local routes, which is around 10% of the national network.[115]

Open country access land in the East Midlands has been mapped in three areas. Area 2 (Lower North West), which includes the Peak District National Park, provides significant areas of open access land. Access in this area has already legally commenced. In Area 8, (Nottinghamshire and Lincolnshire) and Area 7 (all other parts of the East Midlands) access land is minimal. Overall however, the East Midlands has a very small proportion of open access land – with only 2.1% of the regional total land area designated as open access, compared to an average for England of 6.5%.[116]

[112] Woodland Trust, 'Space for People: Targeting action for woodland areas', 2004.
[113] Global Tourism Solutions UK on behalf of East Midlands Tourism, 'Annual Headline Figures', using data from the Scarborough Tourism Economic Activity Monitor (STEAM), 2009.
[114] Peak District National Park Authority, 'Tourism in the Peak District National Park', Fact Sheet 2,
[115] Ibid.
[116] Natural England, 'State of the Natural Environment 2008', 2008.

7.8.5 Environmental assets: Heritage and the historic environment

7.8.5.1 Policy context for conserving and enhancing the historic environment

'World Class Places – The Government's strategy for improving the quality of place' was launched in May 2009 by the Secretaries of State for Culture, Media and Sport and Communities and Local Government. The strategy lays out how the Government will bring together public and private partnerships to create places where regeneration and public services provide an environment where people and families want to live.[117] This includes objectives to ensure standards for "well designed and maintained buildings and open places" whilst also ensuring "sensitive treatment of historic buildings and places". Building on previous policy developments regarding the historic environment,[118] the strategy advanced both an economic and a social inclusion argument for the preservation of heritage sites alongside other environmental assets. Traditionally, the importance of preserving heritage sites has been advocated in terms of both their educational benefits along with the civic responsibility to maintain sites of historic significance for the benefit of future generations.

However, the current strategy adds new emphasis on the economic value of well maintained heritage sites in attracting tourism and investors. Overseas residents made 32.8 million visits to the UK in 2007, which is an all time record.[119] The strategy also provides evidence that historic buildings increase the value of surrounding properties. Finally, accessibility to heritage sites and complementary surroundings can increase community cohesion, participation in outdoor activities and can create a sense of 'civic pride' which the Government views as a key outcome of the Place Making agenda.

These policy objectives have links to measures aimed at improving the design of new developments described in the Housing Chapter. Key quality criteria for new developments advocated in frameworks such as 'Building for Life' include the need for designs that are sensitive and complementary to adjacent and nearby historic buildings. The need to view heritage as an important asset for attracting investment and facilitating regeneration is reflected in the new PPS 5, 'Planning for the Historic Environment', published in March 2010. This emphasises the positive contribution of heritage assets to local character and sense of place and the importance, wherever possible, of keeping them in viable uses that are consistent with their conservation.

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[117] Department for Culture, Media and Sport, 'World Class Places – The Government's strategy for improving the quality of place' http://www.culture.gov.uk/reference_library/publications/6158.aspx

[118] Including the DCMS policy statement 'The Historic Environment: A Force for Our Future' (2001) and the 'Heritage Protection for the 21st Century' White Paper (2007).

[119] Office for National Statistics, 'Travel Trends in 2007' – Data and commentary from the 2007 International Passenger Survey: http://www.statistics.gov.uk/downloads/theme_transport/Travel_Trends_2007.pdf

7.8.5.2 Heritage assets in the East Midlands

The region's historic towns, cities and landscapes provide evidence of multiple phases of human activity, dating back through industrial and pre-industrial times. This complex interaction of human activities and environmental factors over time, often on a landscape or townscape scale, gives rise to local distinctiveness, a sense of place, identity and pride, and attractiveness to investment.

Many historic sites in the East Midlands are subjected to high recreational use and also form part of its cultural assets, generating benefits for the economy from visitors. These sites include the historic parks of Clumber, Rufford, Chatsworth and Althorp. There are also important archaeological remains such as Creswell Crags, remnants of former hunting forests (such as Sherwood and Rockingham) and field systems, such as medieval ridge and furrow and enclosure landscapes. Historic buildings include castles like Tattershall and Fotheringay, country houses, such as Chatsworth and Boughton House, and many other buildings spread across the region.

There are more than 1,000 Conservation Areas in the East Midlands, with outstanding examples including the Cathedral City of Lincoln, Stamford and Buxton. A number of sites in the East Midlands reflect the important industrial heritage of the region, including the Derwent Valley Mills World Heritage Site. The network of waterways is also an integral part of the region's industrial past, linking historic buildings and structures with the natural environment.

Whilst the East Midlands has a rich and diverse historic environment, it is often under-valued and under threat. In 2008 English Heritage published its first register of Heritage at Risk – a region-by-region list of all the Grade I and II* listed buildings[120] Scheduled Monuments (archaeological sites) and registered parks and gardens, as well as registered battlefields and world heritage sites known to be 'at risk'.[121] This included the following findings for the East Midlands region:

- In 2009, the East Midlands contained 135 registered parks and gardens, two more than in 2002. There are 15 Grade I listed parks and gardens in the East Midlands which represents 11.8% of the national total;

- There are five registered battlefields, including Bosworth Fields;

- The region has one of England's 17 World Heritage Sites – Derwent Valley Mills in Derbyshire;

[120] The buildings are graded to show their relative architectural or historic interest. Grade I buildings are of exceptional interest, Grade II* are particularly important buildings of more than special interest. Grade II buildings are of special interest warranting every effort to preserve them. http://www.heritage.co.uk/apavilions/glstb.html

[121] English Heritage, 'Heritage Counts 2009 East Midlands Regional Data Report', 2009.

- There were over 1,509 Scheduled Monuments in the region in 2009, accounting for 7.6% of the national total and 29,615 listed buildings in the region (representing 7.9% of the national total); and

- Grade I listed buildings are well represented in the East Midlands as the region has 10.7% of the total for England.

Based on the Taking Part survey,[122] between 2005 and 2007, 93% of East Midlands residents agreed or strongly agreed that it was important to save historic features, which is marginally above the national average of 92.1%. The proportion of adults who agreed or strongly agreed that they are interested in the history of their place of residence was very similar in the East Midlands and in England at 69.1% and 70.7% respectively.

However, 31.7% of East Midlands residents were not really interested in the history of the place where they lived, which is a slightly higher proportion than the English average of 29.1%.[123] The Taking Part survey also shows that 71.5% of adults in the region had visited a heritage site in the last 12 months, marginally above the national average of 69.6%.[124]

The region's heritage assets are important attractions for East Midlands residents and tourists from other regions and countries. Chart 29 shows that the proportion of adults visiting heritage sites was slightly higher in every age group in the East Midlands than in England. The highest proportion of adults visiting heritage sites in the last 12 months was among the 45 to 64 year olds, at 77.5% in the East Midlands and 75.2% in England overall. In contrast, only 52.6% of individuals over 75 reported visits to heritage sites in the last 12 months in the East Midlands. However, this is still slightly higher than the average in England of 51.8%.

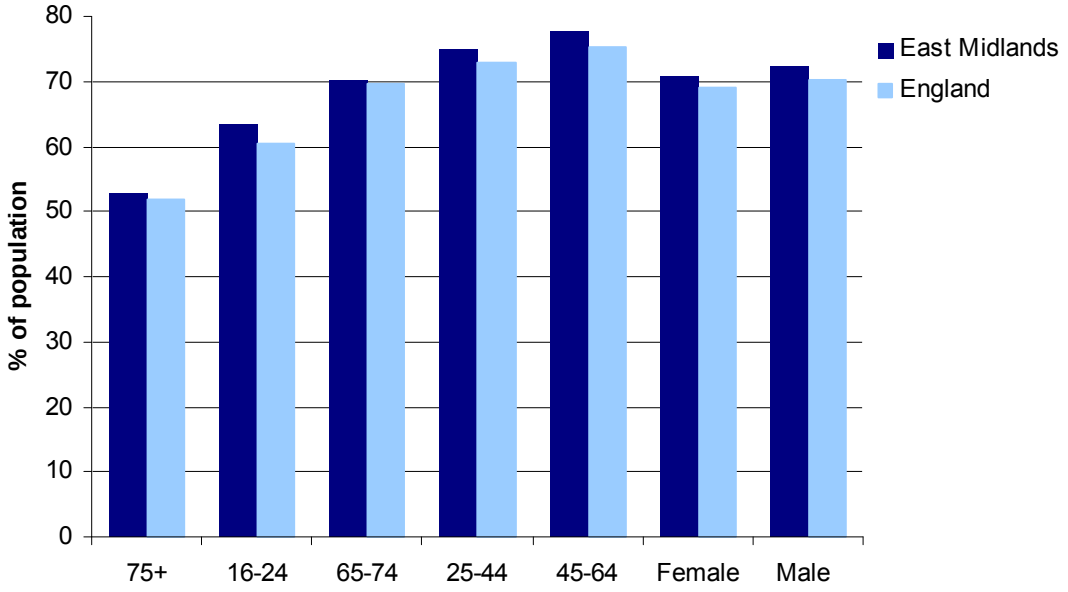
Both men and women are slightly more likely to visit heritage sites in the East Midlands than in England. However, in the East Midlands a higher proportion of men than women visited heritage sites over the last year at 72.3% and 70.8% respectively.

As well as physical historical assets, residents of the East Midlands can also interact with the historical environment through museums, libraries and archives. There are 213 museums in the East Midlands (52 in Derbyshire, 39 in Leicestershire, 52 in Lincolnshire, 32 in Nottinghamshire, 35 in Northamptonshire and three in Rutland). There are 348 static public library service points provided by local authorities, and 52 library vehicles in the region. Additionally, there is extensive library provision in the education, commercial and industrial sectors. For example the region's Higher Education Institutions collectively operate 31 libraries. There are 74 archive holding

[122] 'Taking part' is a survey of leisure, culture and sport in England which gathers data about the encouraging and hindering factors of participation and attendance of individuals in cultural and sporting activities.
[123] English Heritage, Heritage Counts 2008 East Midlands Regional Data Report, 2008. http://www.english-heritage.org.uk/hc/upload/pdf/EM_Data_Report_2008.pdf?1246274790
[124] Combined figures covering the period between July 2005 and July 2007.

organisations including six main archive services and a regional film archive.[125]

Chart 29: Adults visiting heritage sites in the last 12 months by age and gender (2005-2007 combined figures)



Source: Taking Part survey 2005-2007 combined figures. English Heritage, 'Heritage Counts 2008 East Midlands Regional Data Report', 2008.

7.8.5.3 Heritage and participation

As the Economic Inclusion and Deprivation chapter highlights, the level of volunteering may indicate how cohesive and active a given community is, and interaction with the historic environment can be of key importance in creating and maintaining a shared relationship between individuals and their surroundings. In the East Midlands in 2009, there were 51,259 members of English Heritage regionally (7% of all membership nationally) and 288,852 National Trust members (8.1% of all members in England).[126] The actual numbers of volunteers actively working at National Trust properties in the East Midlands in 2008-2009 was 4,545, which accounted for around 237,000 hours worked and £1,700,000 generated. In addition, historic sites looked after by English Heritage attracted 244,800 visitors to the region in 2008-2009. The most visited three sites were Bolsover Castle, Hardwick Hall and Peveril Castle.[127]

[125] Museums, Libraries and Archives Council (MLA), Consultation Response to 'The East Midlands in 2009', November 2009.
[126] Membership data refer to March 2008 and June 2008. English Heritage, Heritage Counts 2008, East Midlands Regional Data Report, 2008.
[127] English Heritage, 'Heritage Counts 2009 East Midlands Regional Data Report', 2009.

7.8.5.4 Heritage sites at risk

The region's heritage sites are safeguarded through the system of designation, locally or nationally, of the various types of 'heritage assets'. Conservation Areas have a particularly important role to play in guaranteeing the quality of places, as their designation means that they should be protected and actively managed by local planning authorities. However, as in the case of biodiversity, when analysing statistics on the state of heritage assets it needs to be born in mind that the data focuses on designated areas only. As there are also a large number of locally important heritage sites that are not designated, the condition of heritage assets based on designated sites needs to be interpreted carefully, as it can misrepresent the wider state of the region's historical environment.

According to the 2009 'Heritage at Risk' assessment, 'Buildings at Risk' are a particular challenge for the East Midlands. Of the region's Grade I and Grade II Listed Buildings, 4.6% are classified as 'at risk' compared to 3.1% in England as a whole. Out of all the entries in the first 'Buildings at Risk' register in 1999, the East Midlands had the largest proportion that was still at risk in the 2009 register. If Grade II listed buildings are taken into account, there are at least 1,560 Listed Buildings at Risk in the region.

In contrast, the region has the smallest proportion of Scheduled Monuments at risk in England, as a result of a significant improvement in condition since 2006. Broadly speaking Scheduled Monuments form the core of our designated archaeological heritage, while Listed Buildings represent its nationally-designated built heritage. Listed Buildings are therefore far more numerous as a type of heritage asset compared to Scheduled Monuments. According to 'Scheduled Monuments at Risk', in 2009, 9% of Scheduled Monuments were at risk, which is equivalent to 130 monuments. This is significantly lower than the proportion of monuments at risk in England overall, which was 18% in 2009.

The proportion of registered parks and gardens at risk in the 2009 'Heritage at Risk' report was 4.4% in the East Midlands (or six parks or gardens), which is also lower than the proportion in England overall, at 6%.[128]

Finally, within the wider context of this chapter, it is important to consider the risks posed by climate change to the region's heritage assets. This is particularly the case in coastal heritage sites. Such areas, such as the mediaeval port town of Boston as well moorland archaeological sites in the Peak District are amongst those sites most at risk from changing weather patterns. Historic assets can also contribute to the region's response to climate change, particularly given the amount of embodied energy in existing buildings.[129]

[128] English Heritage, 'Heritage Counts 2009 East Midlands Regional Data Report', 2009.
[129] English Heritage, Consultation Response to 'The East Midlands in 2009', November 2009.

7.8.6 Environmental asset density

Map 16 gives an indication of the density of environmental assets in the East Midlands.[130] Environmental and cultural assets can be anything that society places a value on. They are numerous and diverse, and not only valued by society for their landscape, biodiversity and heritage quality, but also their recreational, educational and tourism value. Planning and development must take these assets into consideration, but the large range and number of assets can make it difficult to gain a strategic overview of an area for planning purposes. The environmental sensitivity map is designed to help overcome this, by creating a single composite layer of a wide range of assets. Assets included in the Environmental Sensitivity Map are set out below (but note that this includes only selected nationally designated sites, with listed buildings, for example, being excluded).

- Agricultural Land
- National Park
- Ancient Woodland
- Parks and Gardens of Historic Interest
- Areas of Outstanding Natural Beauty
- RAMSAR Wetland Sites
- Community Forests
- RSPB Important Bird Areas
- Doorstep Greens
- RSPB Reserves
- Scheduled Ancient Monuments
- Local Nature Reserve
- Sites of Special Scientific Interest
- Millennium Greens
- Special Areas of Conservation
- National Forest
- Special Protection Areas
- National Nature Reserve
- Woodland Trust Sites

Map 16 demonstrates that the areas with the largest number of assets are concentrated in the far north of Derbyshire and along the Lincolnshire coast. The darker colours on the map indicate a higher number of environmental and cultural assets in an area.

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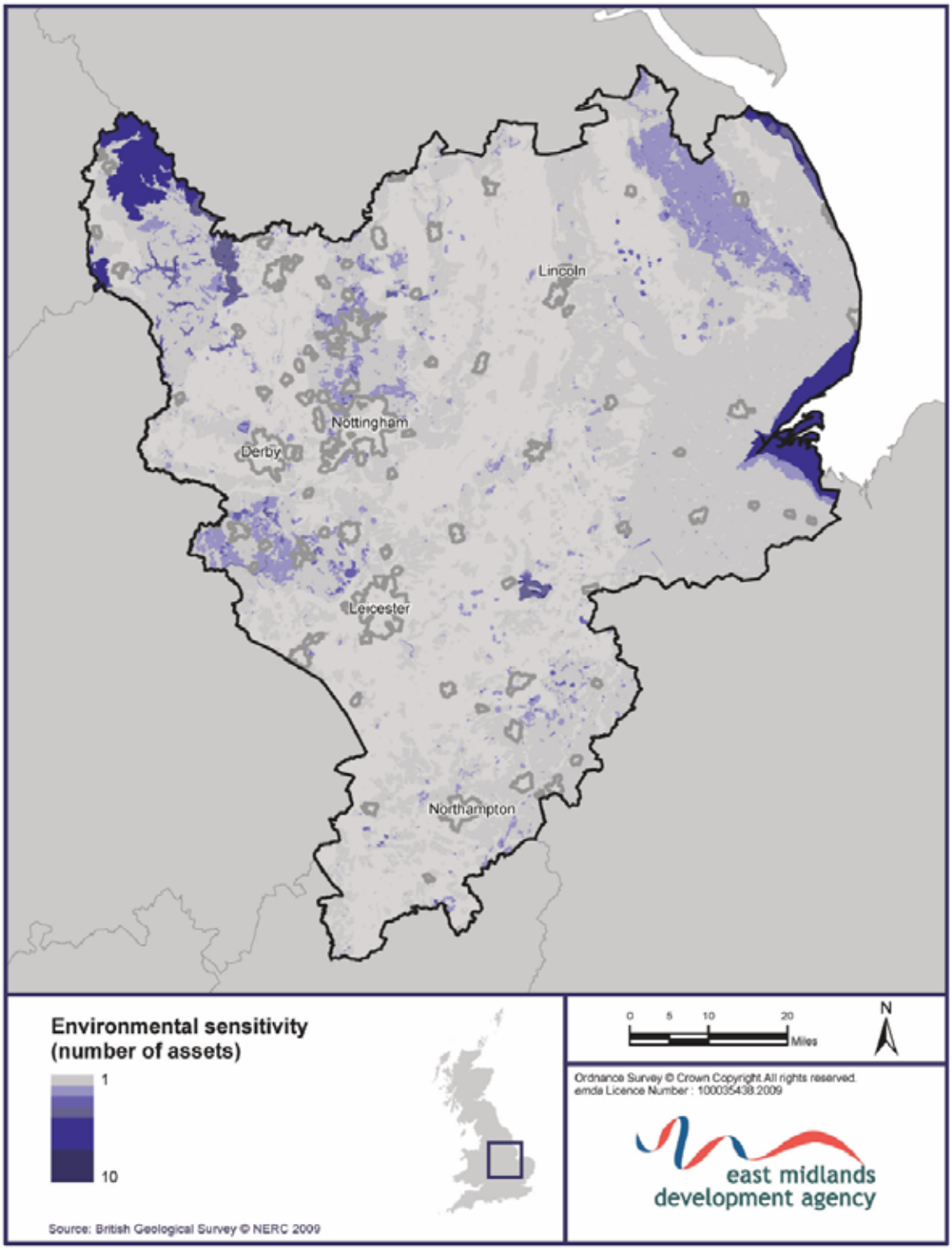
[130] Environmental asset density mapping (which can also be referred to as environmental sensitivity mapping) is a technique developed by the British Geological Survey to provide a strategic overview of the environmental and cultural assets in a region. See strategic environmental assessment and future aggregates extraction in the East Midlands region, BGS Commissioned Report CR/04/003N, available for download at http://www.bgs.ac.uk/mineralsuk/free_downloads/downloads.html
The map was created in a Geographical Information System (GIS) using a one hectare grid to generalise the original data and enable analysis in the GIS. A listing of the environmental and cultural assets used to create this map can be accessed online at http://www.bgs.ac.uk/mineralsuk/envsens/whatare.html

Map 16: Environmental asset density of the East Midlands region



7.9 Land use, agriculture and soil geochemistry

7.9.1 Land use and agriculture

The East Midlands is a very productive area for agriculture, containing a significant percentage of the total national resource of the best and most versatile agricultural land. The proportion of agricultural land in the East Midlands of the most versatile grades (Grades 1, 2 and 3a) is 47% compared to 39% across all of England. The region also has a significant percentage (34%) of the total national resource of Grade 1 land. This enables a wide range of crops to be grown, adding robustness to the local economy and helping to support a wide range of complementary and ancillary rural businesses and services. Over 1.2 million hectares of land are in agricultural use, employing over 39,000 people across some 18,500 farms in the region. As a result, arable farmland dominates the landscape, reflecting the national trend towards arable farming being more dominant in the east and permanent grassland dominating in the west:

- The East Midlands has the second largest proportion of arable land of any English region (behind the East of England), representing almost half the total land area of the region;

- The most common farm types in the East Midlands are cereals and grazing (livestock lowland) accounting for 19% and 13% of total holdings respectively, compared to 11% and 16% in England;

- The East Midlands accounts for 18% of total cereal holdings and 17% of all general cropping holdings in England;

- In terms of farm size the East Midlands is not dissimilar to the England average. Forty three percent of holdings in the East Midlands are <5 hectares (45% in England), 18% are 5<20 hectares (19% in England). The region does however have a slightly higher percentage of holdings greater than 100ha, at 16%, than the England average (of 13%);

- Wheat is the primary crop in both the East Midlands and England accounting for 31% and 28% of all arable crops respectively (measured by total hectares). Wheat production in the East Midlands accounts for 20% of total wheat produced in England;

- Oilseed rape is produced on 12% of farmland in the East Midlands compared to 9% in England;

- There are 519,000 cattle in the East Midlands, accounting for 9% of total cattle in England;

- The East Midlands accounts for 11% of pigs produced in England (418,000);

- The East Midlands produces 20% of all poultry in England; and

- Between 2006 and 2007 there was a 10% increase in output from crop enterprises as measured by £ per farm. In the same period there was an overall reduction in output from livestock enterprises, of 2%. Data for England suggests that output from crop enterprises increased by 16% whilst output from livestock enterprises increased by 13% over the same period.[131]

Good quality soil is generally located in the east of the region. The fenlands along the eastern borders of the East Midlands are Britain's largest area of peat soils. Soil is a valuable resource within the region and is under pressure. In March 2005 the Environment Agency identified 74 contaminated land sites in the East Midlands. These sites are generally small with 59 having an area of less than five hectares.[132]

7.9.2 Regional geochemistry

For many years the British Geological Survey has been carrying out a detailed regional scale survey of the geochemistry of the UK using stream sediments, soils and stream waters as the principal materials. This analyses up to 50 chemical elements (such as calcium, copper and lead) and parameters such as the acidity (pH) of soils and stream waters, in both rural and selected urban areas.

Key elements of interest include lead and arsenic in both soils and stream sediments, as both elements are commonly known to be toxic. However, it should be noted that such 'trace elements' occur naturally at low levels in almost all geological materials, and that toxicity is a complex issue involving not just the concentration of the element, but also its chemical form, its host minerals, and the conditions in which it is found. The typical natural background levels of such trace elements in soils might be a few tens of parts per million by weight (milligrammes per kilogram).

Lead levels over much of the region are typically less than about 40 mg/kg in soils and stream sediment (median value), but very high lead levels are present over the eastern part of the Peak District, where lead ores were extensively mined and smelted in the 18th and 19th centuries. Concentrations of greater than 1000 mg/kg lead are locally present, but the mainly limestone bedrock gives rise to alkaline soils and stream waters which strongly limit the solubility of lead and therefore minimise its toxicity. Moderately high concentrations are present around the industrial centres of the Nottinghamshire Coalfield and are also associated with urban centres such as Derby and Nottingham. A prominent line of moderately high lead values follows the Dove-Derwent-Trent Valley system downstream as far as Gainsborough and is related to lead minerals from the mineral deposits and

[131] Defra, 'Agricultural and Horticultural Survey', June 2007.
[132] Environment Agency, 2005.

mining activities of the Peak District being redistributed into the river alluvium (sand and gravel deposits).

The natural background levels of arsenic over much of the region are typically less than 15 mg/kg in soils stream sediment (median value), but the most prominent features on the maps are the high arsenic levels which run in two lines. The first runs approximately south then south west from Scunthorpe to Northampton and the second south eastwards through Lincolnshire to The Wash. Arsenic is a natural component of these sedimentary ironstones, and can be present at relatively high concentrations of up to a few hundred mg/kg. Other areas with raised arsenic values include south Derbyshire (where an outcrop of black shale is naturally high in arsenic) and parts of the Nottinghamshire Coalfield.

Although at the present time, even those areas with the highest levels of arsenic and lead are at a minimal risk from any environmental toxic effects from these elements, a change to a warmer climate could increase the rate of weathering and release more geochemically active forms, especially if soil bacterial activity increases. There is too great a level of uncertainty to allow forecasting on what effects this might have.

Climate change may also affect the rates of weathering and mobilisation for many other elements, such as the agriculturally important major nutrients potassium, calcium, magnesium and phosphorus and trace elements such as cobalt and molybdenum.

Key Points: Biodiversity, heritage, landscape, soil and landuse

- Sites of Special Scientific Interest (SSSIs) cover 10% of the East Midlands (although this figure includes several large cross-boundary sites). The Wash, which is the largest SSSI in England, accounts for 40% of the East Midlands area designated as an SSSI.
- The East Midlands currently has the highest proportion of SSSIs assessed as being in 'favourable' or 'recovering' condition of the English regions, at 96.2% in March 2010. This means that the region has exceeded the PSA target of 95% by 2010. Of the region's SSSIs, 100% of coastal habitats were assessed as 'favourable' or 'recovering', whilst only 66% of SSSIs in urban areas were assessed as 'favourable' or 'recovering' in the East Midlands compared to 76% in England.
- As a wider indicator of biodiversity in the region, the population of woodland bird species has increased in the region by 7% between 1994 and 2006. However, the population of farmland bird species had decreased by 1%.
- The region has identified 31 Landscape Character Types, and 55% of the region's National Character Areas have been assessed as either maintained or enhanced, although this means that the remainder is either neglected or diverging.
- The East Midlands has the lowest proportion of land covered by woodland of all regions other than London, at 4.7% compared to 8% in England overall. Furthermore, public accessibility to woodland is low compared to regions in the north of England, with 48% of woodland accessible to the public in the East Midlands compared to 93% in the North West.
- The East Midlands has the lowest proportion of its land area designated as an Area of Outstanding Natural Beauty (AONB) of the English regions (at 3% compared to 15% in England). The Lincolnshire Wolds is the only AONB in the region.
- Visitors to National Nature Reserves in the East Midlands accounted for 10% of all visits in England in 2005-2006 and the Peak District National Park is the second most visited National Park in the world.
- The East Midlands has a number of important heritage sites, containing 10.7% of Grade I listed buildings and 11.6% of registered battlefields in England.
- However, a comparatively high proportion of listed buildings in the East Midlands were at risk in 2009, at 4.6% of all Grade I and Grade II listed buildings, compared to 3.1% in England overall.
- The East Midlands is a productive area for agriculture, accounting for the second largest proportion of arable land in England. The region accounts for 18% of cereal holdings and 17% of general crop holdings in England.
- Soil is generally of good geochemical quality, with relatively low levels of lead and arsenic.

7.10 Conclusions

Global and national evidence presents a compelling case for the contribution of economic activity to climate change. The Stern Review suggests that even if current rates of emissions are stabilised, the world is still likely to experience a temperature increase of at least 2°C by 2050. Recent projections suggest that climate change outcomes in the East Midlands will be quite close to the national average. Mean summer temperatures in the East Midlands are projected to increase by 1.4°C and winter temperatures to increase by 1.3°C by the 2020s. By the 2050s, summer temperatures are projected to increase by 2.5°C and winter temperatures by 2.2°C in the region. Winter precipitation could increase by 5%, whilst summer precipitation could decrease by -6%. Projections of sea level rises are more modest than previous estimates, but the East Midlands coastline could still experience a rise of 9.7cm on 1990 levels in the 2020s. This could lead to increased chances of coastal flooding in Lincolnshire, which is not only a consideration that could constrain development planning, but is also a threat to the region's coastal SSSI and areas of high quality agricultural land. The likely scale of future population increase (detailed in the chapter on Demography) and associated increase in demand for housing could present further challenges in areas of increased flood risk.

Greenhouse gas emissions in the East Midlands have decreased over the long-term, but there has been a short term upward trend since 1999. This is due to two reasons. Firstly the East Midlands is a major producer and exporter of energy, with fuel and power production accounting for 87.2% of all greenhouse gas emissions in the region in 2007. The impacts of improvements in technology in the early 1990s accounts for the long-term decrease in emissions from fuel and power production, but since 1999 further improvements have had a more limited impact, which explains why emissions have stabilised and then increased after that date. However, end users have also contributed to this increase, principally through emissions attributed to road transport. Latest figures show that the East Midlands had one of the highest volumes of emissions attributed to road transport, and this has demonstrated little sign of decreasing despite significant improvements in car engine design. This can be linked to the East Midlands' relatively dispersed spatial pattern of development, with no single dominant centre and significant inter and intra-regional flows of commuters and goods.

Other trends reflecting the impact of human activity on the environment have been more positive in the East Midlands. With the exception of nitrogen oxide, technological improvements have significantly reduced emissions in the major air pollutants in the region, such as sulphur oxide.

The East Midlands has experienced the greatest improvements of any region in the proportion of its rivers assessed as 'good' in terms of both biological and chemical quality. Pollution incidents that have had a 'major' impact on water quality have also fallen in recent years, although the Water and Waste

industries have consistently been responsible for the largest number of incidents.

The region also has the highest proportions of municipal waste recycled or composted in England. However, the region still has to achieve significant improvements in order to manage waste more sustainably. An above average proportion of all waste continues to be disposed of in landfill sites and a relatively small amount of waste has been subject to energy recovery. In terms of resource efficiency – measured by the amount of waste generated for every unit of economic output – the East Midlands remains relatively inefficient, and this represents a key challenge for regional policy.

The threat of coastal floods not withstanding, recent assessments of site-specific biodiversity in the East Midlands are very positive, with the region recording the highest proportion of SSSIs that are either in a 'favourable' or 'recovering' position of any English region. However, the region has a fairly low proportion of its land area designated for protection, and has the second lowest proportion of woodland, behind London, and the lowest proportion of land designated as Areas of Outstanding Natural Beauty of all nine regions. Looking just at 'biological' SSSIs, the picture is less positive, with only 2% of county areas, with the exception of Derbyshire, designated as such. Past assessments have suggested that the region has fewer functional habitat networks than other regions, making them more vulnerable. Other wider indicators of biodiversity are also less positive. On the indicator of wild bird populations, although the East Midlands has experienced a decline in farmland bird species, there has been an increase in woodland birds.

It is important to view the environment in terms of assets and opportunities as well as constraints. The Stern Review estimated that markets for low carbon energy products could be worth at least $500 billion per year by 2050. The energy resources provided by the East Midlands coal mining past reviewed in this chapter, such as the extraction of Coal Mine Methane (CMM), are examples of an opportunity for innovation and enterprise that the region can build on. However, recent statistics on renewable fuels suggest that the East Midlands, as a significant energy producer, continues to contribute a relatively small share of the national renewable energy capacity.

The East Midlands is geologically rich, and is England's principal producer and exporter of aggregates and other minerals. It is also the country's principal manufacturer of concrete. In addition to this significant asset, the region also has a relatively benign geology, with limited risks of earthquakes or other geological hazards (such as radon), although shrink-swell clay poses a risk for development in some parts of the region. However, it also has to be noted that much of the extraction that makes the East Midlands England's most important region for aggregate production takes place in areas of natural beauty, such as the Peak District National Park.

Recent evidence on heritage suggests that East Midlands residents have a greater level of interaction with their historic environment than elsewhere, with above average visits to heritage sites for both men and women and for all age

bands. However, a relatively high proportion of listed buildings are at risk, and this has not reduced significantly over time.

The East Midlands has strong environmental assets in terms of the improving quality of its water bodies, reductions in air pollutants, and has made significant achievements in improving the condition of its sites of importance in terms of biodiversity and heritage. However, the region's important status as an energy producer means that it remains responsible for a significant level of greenhouse gas emissions. To an extent, emissions from power generation in the East Midlands are therefore affected by demand and consumption from other regions. However, current estimates suggest that the region is currently generating a smaller share of national renewable energy capacity compared to its overall share of total energy production. The other significant challenge for the region is reducing the contribution of road transport to overall emissions. As other chapters in demonstrate (e.g. the Demography, Labour Market, and Spatial Economy chapters), the region has a relatively high level of commuting, and its central location means that it has an important place in national transport routes and logistics. Reducing emissions whilst maintaining these strengths will presents a key challenge for the region's sustainable economic growth aspirations.