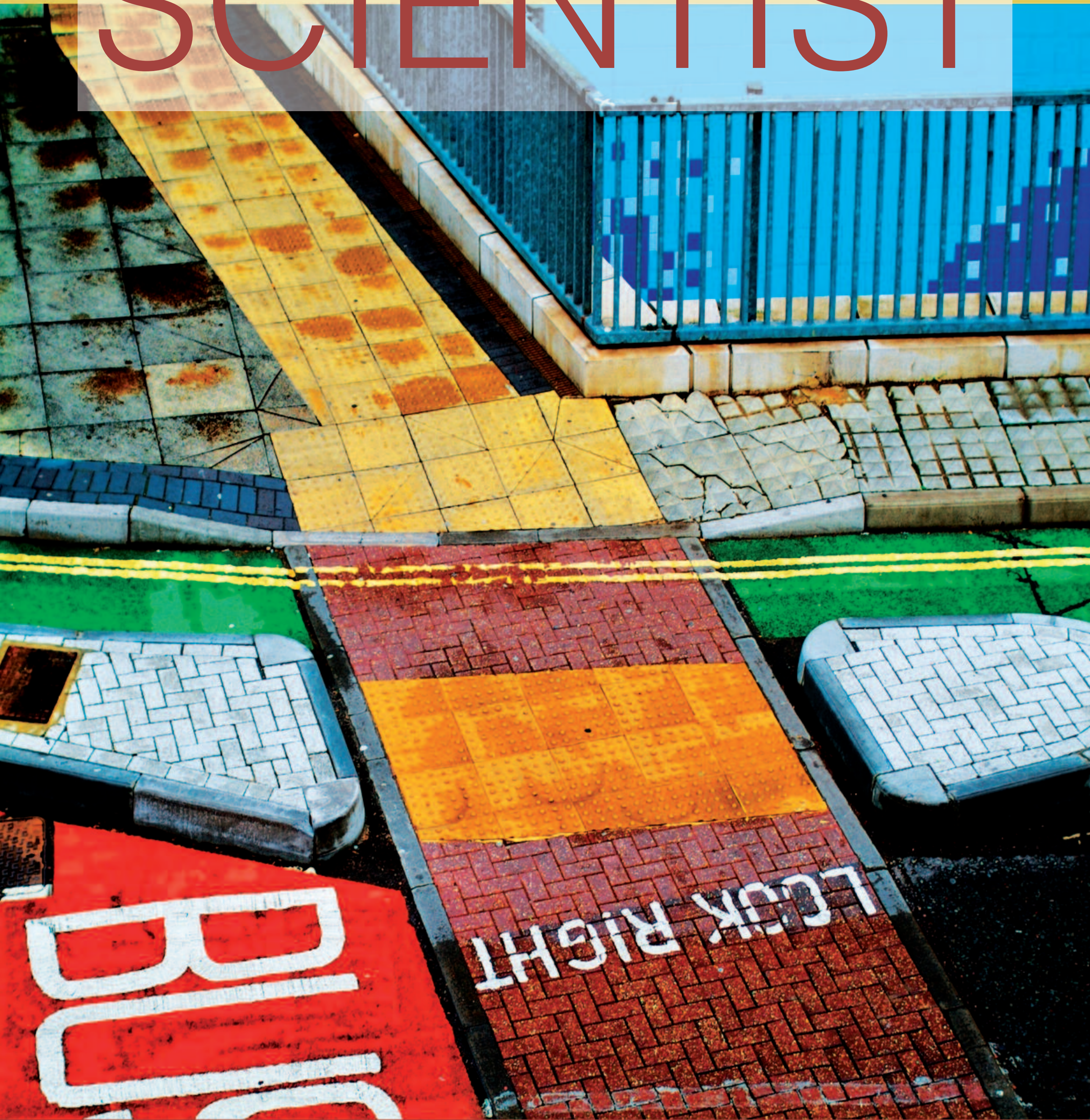
environmental SCIENTIST



January/February 2008

THE URBAN ENVIRONMENT: 1

Journal of the Institution of Environmental Sciences

environmental SCIENTIST

Journal of the Institution of Environmental Sciences

ISSN: 0966 8411
Vol 17 No 1
Established 1971

The Environmental Scientist provides a forum for members' contributions, views, interests, activities and news, as well as topical feature articles. Articles should be submitted to the Editor, Environmental Scientist, Suite 7, 38 Ebury Street, London SW1W 0LU or emailed to *enquiries@ies-uk.org.uk*.

Views expressed in the journal are those of the authors and do not necessarily reflect IES views or policy.

Guest Editor: Noel Nelson
Editorial Advisers:
Adam Donnan & Jimi Irwin

Published by The Institution of Environmental Sciences, Suite 7, 38 Ebury Street, London SW1W 0LU.
Tel: 020 7730 5516
Fax: 020 7730 5519
Email: *enquiries@ies-uk.org.uk*
Web site: *www.ies-uk.org.uk*

Design and origination by Davies Communications, London NW5 1LX.
Tel: 020 7482 8844
Web site: *www.daviescomms.com*

Printed by Uniprint Ltd, London SW12 8SG, using recycled paper and inks based on renewable raw materials that contain no mineral oil.

THE URBAN ENVIRONMENT

An important role of any institution is to disseminate specialist knowledge to the general public and its members. To fulfil this objective effectively the IES has decided to chose a theme for the year around which to base its activities. In selecting this theme we were mindful of the wide spectrum of disciplines that collectively form the environmental sciences. The broad topics of air, land and water quality themselves encompass a wide range of specialists all contributing to the wider goal of environmental protection.

After some consideration we agreed on the topic of the 'urban environment'. There were several reasons for this choice: first of all, the problems associated with the urban environment are numerous and require some, if not all, of the range of environmental expertise to bring about improvements. Problems such as poor air quality, contamination of land, river and watercourses, protection of vulnerable fauna and flora, collectively make full use of the complete range of environmental expertise represented by the members of our Institution. Secondly, last year for the first time in human history, more than half the world's population resided in urban rather than rural areas.

In the UK, as much as 80% of our population are already living in urban areas. Although our towns and cities can act as vibrant, exciting places to live and offer a potential for significant environmental advantages, many of our environmental concerns seem to be exacerbated within our urban areas. Finally, as part of the government's Regional Spatial Strategies, plans were announced for significant urban expansion and regeneration – the intention is for three million homes to be built in England by 2020. This will clearly have an important impact on the way our towns and cities will look in the future. We now have a rare and exciting opportunity to shape the way our future towns and cities will look and operate. To do this effectively we will need the multi-disciplinary efforts of our environmental scientists working in close harmony with those responsible for town and city planning.

Sustainable cities

It is possible to chart the notable progress in the standard of living and quality of life in our cities over the past 150 years. Nevertheless, running side-by-side with our improvements has been the 'inevitable' backward step as individual aspects of our urban life experiences a knock-back. This may and has occurred in any one of the spheres of existence that comprise our experience of the urban environment. Whether we consider the social, financial or environmental aspects of our urban existence, we can point to a degree of degradation. This has led many to consider the concept of a sustainable city in

> 'The inevitable increased demand for more roads and parking will result in additional impermeable surfaces over which increased volumes of rain run-off will eventually lead to flash floods'

This year the Institution of Environmental Sciences is turning the spotlight on the problems facing the urban evironment. **NOEL NELSON** explains why.

which we develop an environment where major changes to the way we live are first examined in the light of the impact those changes may have on the financial, social and environmental quality of our lives. This has been a very difficult concept to achieve in practice and is perhaps not so surprising when one considers the complex and interactive nature of our urban environment.

In their report on *The Urban Environment*[1] the Royal Commission on Environmental Pollution refers to the complex nature of urban environmental management as a 'wicked problem'. The term refers to the extreme complexity of the urban system which consists of a myriad of inter-related aspects, each with their own problem that can be in some way connected to other aspects of urban life. This is illustrated in the report by showing the 'web of connections'[2] associated with increased car ownership in urban areas. One such outcome path shows how increased car ownership can result in increased localised flash flooding and property damage. The inevitable increased demand for more roads and parking will result in additional impermeable surfaces over which increased volumes of rain run-off will eventually lead to flash floods. This is only one of many consequences that can occur; others involving congestion, noise, closure of local shops and the formation of food deserts all result from an increase in car ownership.

In part this explains why when solutions to individual urban environmental problems are designed in isolation, they often result in unexpected detrimental consequences in other areas of our urban environment. It is important therefore that future solutions to our urban problems be designed in a more holistic fashion; it is unreasonable (for example) to expect citizens to leave their car at home in order to assist in the improvements to air quality if public transport is expensive, uncomfortable and (at times) dangerous.

This edition

In this edition of the journal (the first of two parts) we have collected several articles which, individually, explain an aspect of urban environmental degradation but collectively illustrate the extent and interconnectivity of environmental problems faced in the urban locality. Topics such as sustainable drainage systems, air quality, environmental inequalities, urban rivers and the influences of property and carbon emissions in our cities are explored. Through this journal and the May/June edition we intend to give you an insight into some of the challenges facing the urban environment.

What is interesting is that when solutions are designed holistically they can demonstrate improvements outside their immediate area of concern (as is the case for sustainable drainage systems). What is also apparent is the extent to which the level of support and organisation required must come from a variety of stakeholders: central and local government as well as, in some cases, local businesses and residents.

Throughout the year this journal will return to the topic of the urban environment to highlight other issues that we feel illustrate the spectrum of environmental expertise required to bring about real environmental change in our towns and cities.

They will also highlight the need to plan the future of our urban environment in a holistic fashion.

1 The Royal Commission on Environmental Pollution (2007). The Urban Environment, TSO.

2 The Royal Commission on Environmental Pollution (2007). Figure 1.1 The Urban Environment, TSO.

CAN WE ELIMINATE URBAN AIR POLLUTION?

BERNARD FISHER looks at the history of air pollution in UK cities and considers the best approach for the future

LONDON. Implacable November weather. Smoke lowering down from chimney-pots, making a soft black drizzle, with flakes of soot in it as big as full-grown snow-flakes – gone into mourning, one might imagine, for the death of the sun. Fog everywhere. Fog up the river, where it flows among green aits and meadows; fog down the river, where it rolls defiled among the tiers of shipping, and the waterside pollutions of a great (and dirty) city. Fog on the Essex marshes, fog on the Kentish heights. Fog in the eyes and throats of ancient Greenwich pensioners, wheezing by the firesides of their wards…

(From the first page of *Bleak House*, Charles Dickens, 1852)

The original growth of cities was, in part, so that man could protect himself against the undesirable elements of his environment, such as the weather, and to enhance his economic well-being. The growth of urban living is mainly a 19th and 20th century phenomenon as man conquered his environment, though cities are seen as a measure of success of earlier civilisations. Air pollution has been recognised as a visible, undesirable consequence of urban life from the 19th century onwards and since then there have been significant efforts to reduce the impacts of air pollution.

Then, as now, city life is a balance (see Figure 1) between advantages, such as economic or greater cultural opportunities, and disadvantages, such as crowded living in an unnatural environment. In developed countries the aim has been to solve the problems of urban living and to achieve the goal of a sustainable city. In terms of urban air pollution which used to be much greater than rural air pollution, great strides have been made. The most significant step in Britain followed the winter smog event in London in December 1952. This prompted the introduction of clean air legislation which was regarded as a major advance in improving urban air pollution. The legislation was directed towards smoke, defined as 'particles' resulting from incomplete combustion, usually with a size less than several microns in diameter, and involved the introduction of smokeless zones. In 'smoke control areas' only authorised smokeless fuels could be burnt, with the cost of converting heating appliances shared between the government, the local authority and the householder. The declaration of a smokeless zone was a local authority responsibility, illustrating how legislation alone does not necessarily solve problems and that measures require partnerships, in this case between local and central government and the individual householder.

The other main air pollutant of concern in urban areas was the gas sulphur dioxide arising from the burning of domestic coal, which contained a small percentage of sulphur. Sulphur dioxide was not part of the clean air legislation, but nevertheless emissions from domestic sources decreased by 50% between 1950 and 1972, because of the changes in domestic fuel use. It had been recommended that only fuels with a low sulphur content should be burnt in smokeless areas, while high sulphur fuels should be burnt in power stations. In power stations combustion is efficient and pollution could be dispersed through tall chimneys, so ground-level concentrations would be low. The policy was carried through by the completion and operation of a number of large oil and coal-fired major power stations located in rural areas. The recognition that this could lead to acid rain on a regional scale led to curbs on power station emissions in the 1990s.

Another factor which led to major reductions in air pollution in urban areas was the switch to more convenient fuels, like electricity, oil and especially gas. Indeed it has been argued that the benefits of legislation have been overstated and that the 1956 Clean Air Act was merely 'swimming along with the social, economic and technological tide' (see Elsom, 1987).

The explanation of high concentrations of pollution in an urban area is straightforward, although the details may be very complex. Indeed our understanding of the meteorological influences on urban air pollution is incomplete (Fisher *et al* 2005). This is partly because of the complexity and variability of urban areas (see Fig. 2). The air above a city may be regarded as a box with pollution entering from below, from numerous near-ground level sources, the lid of the box (an atmospheric inversion) constrains the pollution to within the lowest couple of hundred metres of air above the ground and the wind carries pollution away through one side of the box. In light wind stagnant conditions pollution will leave the box slowly and inevitably concentrations will be high. In the London smog of 5 to 8 December 1952, when smoke and sulphur dioxide from domestic chimneys was discharged into stationary fog, later analysis of health records showed an extra 4,000 deaths compared with normal mortality figures. A major factor is therefore the occurrence of adverse weather conditions. Adverse weather conditions may not occur every year (indeed London smogs seem to follow a ten-year cycle), but one needs to plan for their possible occurrence.

Having apparently solved one problem, smogs returned to London in the late 1980s and continue until the present

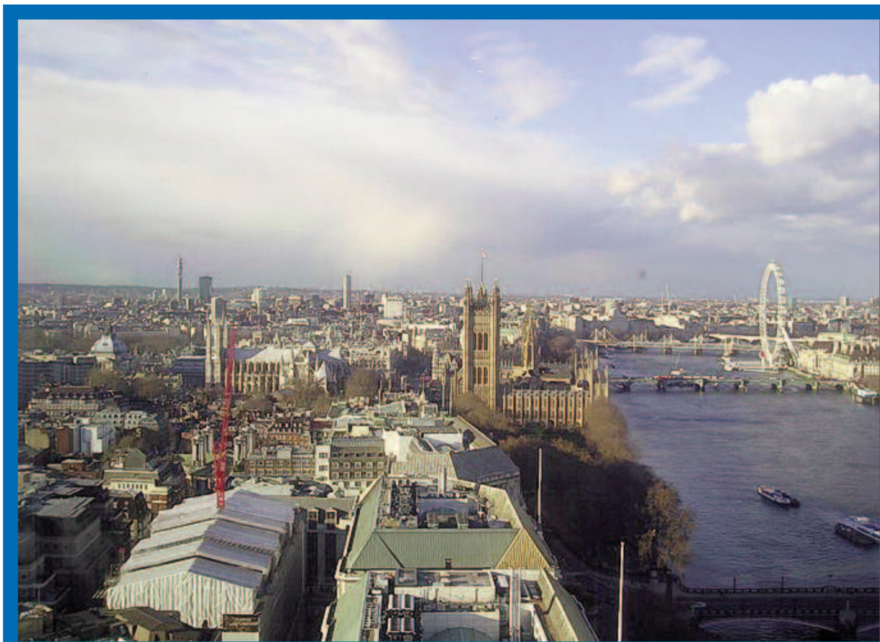


Figure 1: London atmospheric on a clear day without a pollution episode

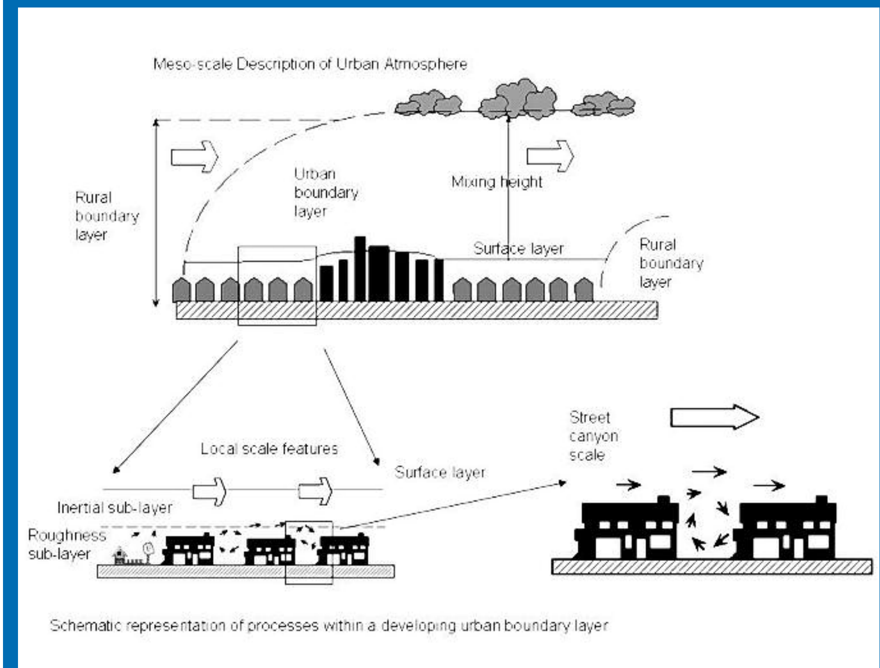


Figure 2: Diagram illustrating the meteorological processes within the urban atmosphere and their complexity

day (Elsom, 1996). In December 1991 nitrogen dioxide concentrations (mainly attributed to motor vehicle exhaust emissions) reached very high concentrations. The cause this time was the enormous growth in road transport emissions in London and elsewhere, since the 1950s. This air pollution episode was a return to a winter smog, albeit with different pollutants. The other main change since the fifties is the occurrence nowadays of summer photochemical smogs. These are caused by the emission of a mixture of gases, nitrogen oxides and organic compounds from combustion sources, the chemical reactions between them and limited dilution in the atmosphere, as in winter smogs, but with a new factor, solar radiation, causing the photochemical formation of ozone in the atmosphere. The increasingly tight controls on all kinds of atmospheric emissions from motor vehicles to industry in the intervening years means that such events have declined in severity, but still occur given suitable atmospheric conditions.

The main health effect in both the 1950 and 1990 winter smogs is thought to be caused by particles. The smoke in 1952 consisted of particles from domestic coal burning, a different source from today. The other main change in understanding has been the recognition of the chronic long-term effects from air pollution, in addition to the short-term acute effects on mortality brought about by episodes of high pollution. In the 1950s particulate was measured in terms of back smoke. Another difference is the development of accurate automatic monitoring equipment. By the 1990s the mass of particulate matter in a cubic metre of air could be measured reliably, at hourly intervals, by setting up extensive ground-level monitoring networks, the results from which are available in real time on the web. For London, see for example *www.londonair.org.uk*.

Particles may be in solid or liquid form and in modern terminology, because of their size, they are referred to as PM_{10}. PM_{10} measurements are made by collectors which preferentially collect small particles, collecting 50% of particles with an aerodynamic diameter of 10 microns. More recently attention has focused on particles in the smaller range below 2.5 microns. Generally these particles are small enough to be breathed in. Measurements of PM_{10} include all $PM_{2.5}$ particles. The consensus of available epidemiological studies of PM_{10} is that every 10µg/m^3 (1µg = 1.10^{-6}g) increase in concentration during an air pollution episode is associated with a 1% increase in deaths and this is broadly consistent with the extra deaths in the 1952 London episode and other pollution episodes in cities. Since most of the population live in urban areas, and the highest concentrations occur in towns and cities, this directs attention to urban areas where the greatest harm occurs.

The other important result to arise from health studies in polluted cities around the world is the recognition that there is a risk arising in the long-term from exposure to particulate concentrations. The risk is more complicated than that from exposure in the short-term, because it is necessary to take into account the age range of the exposed members of the public, the duration of the exposure and the lag between exposure and the effect. The most recently recommended estimate of the effect is that the impact of exposure in the long-term to $PM_{2.5}$ should be quantified using a percentage change in hazard rate of 6%, that is a 6% increase in the baseline mortality rates at each age for an 10μg/m³ increase in $PM_{2.5}$ concentrations. It is uncertain how long the effects lag behind the $PM_{2.5}$ exposure: the greatest weight is usually given to the zero lag results. If the number of deaths in a year is increased by this extra hazard then the extra deaths can be expressed in terms of potential life years lost, the details depending on the age distribution at the time and the projected life expectancy under normal conditions. A factor in the calculation is the size of the population exposed and this is highest in urban areas.

The relationship is assumed to have no threshold, so even the much reduced levels of particulate matter in urban areas will have an effect on mortality. Concentrations in London which lie in the range 20 to 40μg/m³, according to location, would be regarded as being at very low levels in a historical context, but still have an effect on mortality in the capital. The relationship translates into the single, largest hazard from any environmental influence in this country (see Table 1 from the RCEP(2007)).

Though people thought the problem of urban smoke pollution was well on the way to being solved in the 1960s and 70s, there is no practical way to totally eliminate the effects of particulate pollution, as this requires one to reduce particulate concentrations to trivial levels, which is not possible. A new EU ambient air quality directive is expected to come into force by May 2008. The new directive will set for the first time a framework for the control of fine particles, $PM_{2.5}$.

A feature of urban pollution today is that it is becoming increasingly difficult to justify cost-effective measures to further reduce pollution emissions. This is why the directive obligations for particular matter are in two parts. The key element is a limit value of 25μg/m³ to be met everywhere by 2015 (with a target date of 2010), with a second stage 'indicative' limit value of 20μg/m³ to be met by 2020. These are intended as 'backstops' to provide minimum protection for all. The driver for reductions is intended to be an exposure reduction target for urban background areas, to be achieved by 2020. This target is based on an assessment of the exposure of the population as a whole, to $PM_{2.5}$ particles. Based on measurements in urban background sites (these are sites which are neither near the roadside nor in rural areas) the objective is that between 2010 and 2020 the exposure of the UK population to ambient levels of $PM_{2.5}$ should reduce by 15%.

Some flexibility in complying with other air quality limit values has been introduced. For PM_{10} the limit value will come into force in 2011 and for nitrogen dioxide in 2015, subject to the UK putting forward detailed plans

Table 1: Aspects of urban environment that affect health (from RCEP, 2007)

Air pollution		24,000 premature deaths in Great Britain in 1995/6, reduced average life expectancy by around eight months in 2005.
Climate	Winter:	25,700 extra deaths in December to March 2005/6 in the UK (compared with the death rate for other months of the year).
	Summer:	At least 2,000 excess deaths in the UK in the summer heat wave 2003.
Mental health		Association between urban residence and prevalence of psychiatric disorders, which persists after adjusting for confounding factors.
Infectious diseases		Some disease transmission rates are higher in urban areas; this could also be the case for pandemic influenza or exotic infectious diseases.
Obesity		34,000 premature deaths and about 16 million attributable days of certified incapacity in England per year.
Traffic accidents		3,300 deaths and 29,000 serious injuries in Great Britain in 2005.

setting out how the limit values will be achieved in the extended time frames. Subject to public consultation, the UK expects to submit such plans for PM_{10} and NO_2 . It is thought that the UK will need to demonstrate action beyond that agreed in the recently published UK Air Quality Strategy if it is to achieve full compliance with EU limit values. (See Fisher and Muir (2006) for a discussion of some of issues raised by the Air Quality Strategy.)

It is because achieving some of the limit values is predicted to be challenging that the obligations of the directive are formulated in this flexible way. It is worth illustrating this in detail for particulate matter. For example, in recent years the traffic contribution has dominated at roadside locations within urban areas (AQEG, 2005). However for all monitoring sites, urban and rural, there is also a substantial contribution from the regional background, including the secondary particulate matter component. This regional component is derived from sulphur and nitrogen oxides, emitted from both far and near the urban area of interest, which are converted in the atmosphere to particulate sulphate and nitrate as the gases travel downwind from their sources. As a consequence of measures to tackle acid rain, sulphur sources and to a lesser extent nitrogen sources have been reduced on a European scale, but they still contribute significantly to rural particulate concentrations.

There is also a ‘residual’ component from wind blown, re-suspended dust (partly traffic related, from tyre and brake wear, but not related to combustion in the vehicle engine) which also makes a significant contribution to the total particulate in an urban area. The residual component is difficult to eliminate and depends in part on sensible local measures to avoid dust production. Measures discussed in the Air Quality Strategy and in Europe to control emissions suggest that the traffic component will be substantially reduced in future, to less than half of its current contribution. This still leaves the residual component and the secondary components which would remain major factors. The difference between urban and rural particulate levels will therefore diminish.

Management of future regional particulate matter background levels appears to be an attractive policy option for the control of future exceedences of particulate matter limit values, because it would operate city-wide and would not require detailed understanding of the spatial distribution of particulate matter exceedences. However a further possible twist to the story is that as sulphur dioxide emissions have been falling dramatically, both in the UK and in the rest of Europe, significantly faster than ammonia emissions, sulphate particulate has decreased. This has had the result that, with the increased availability of ammonia, there may be an increase in the formation of ammonium nitrate particulate. This is suggested by AQEG (2005) as the reason why particulate *nitrate* has taken over from particulate *sulphate* as the most important PM component of particulate matter in the regional particulate matter background concentration. This illustrates how all the main air pollutants may become inter-related because of chemical processes in the atmosphere.

The interactions can affect both urban and rural areas. For example ammonia emissions occur mainly in rural areas, while the reduction in emissions of urban nitrogen oxide has led to an increase in ozone.

The difficulty in specifying effective measures for reducing particulate matter, and the recognition that pollutants are linked through their chemistry, the meteorology that determines their dilution in the atmosphere and the implementation of integrated pollution control, led AQEG (2005) to recommend a broader strategy for emission control. It recommended that consideration is given to a more flexible and holistic approach to urban air quality management and to the control of acid rain, eutrophication and ground-level ozone. Such a combined approach to all types of pollution, in rural and urban areas, might deliver a more cost-effective solution to future urban air quality than one based on urban particulate matter alone. This suggestion is valid for all types of urban pollution. It implies that although air pollution is a well understood aspect of urban living and conventional urban pollution has decreased, further progress towards sustainable urban living is only possible if other aspects of urban life, described in this and the next journal editions, are taken into account and treated together.

References

Air Quality Expert Group (AQEG), 2005. *Particulate matter in the United Kingdom*, Defra, London.

Brimblecombe P and Maynard R L, 2001. *The Urban Atmosphere and its Effects* (Air Pollution Reviews) Imperial College Press London

Elsom D, 1987. *Atmospheric Pollution, Causes, Effects and Control Policies.* Blackwell, Oxford.

Elsom D, 1996. *Smog Alert Managing Urban Air Quality*, Earthscan Publications Ltd, London.

Fisher B and Muir D, 2006. *Air Quality Improvement: is continuous improvement sustainable?*

Fisher B, Joffre S, Kukkonen J, Piringer M, Rotach M and Schatzmann M (editors), 2005. *Meteorology applied to Urban Air Pollution Problems*, Final Report COST Action 715, Demetra Ltd Publishers, ISBN 954-9526-30-5, 270pp.

Royal Commission on Environmental Pollution (RCEP), 2007. *The Urban Environment*, Cm 7009, HMSO.

■ The views expressed in this paper are those of the author and are not necessarily those of the organisation for which he works.

SUSTAINABLE DRAINAGE SYSTEMS (SUDS)

The massive disruption and huge costs caused by recent large-scale flooding are bound to increase the appeal of Sustainable Drainage Systems, say **ABHISHEK SHARMA** and **EDWARD MALTBY**

Over recent years, there has been increasing media coverage of climate change, unpredictable weather patterns and related flooding incidents. These changes in our weather, coupled with urban development that often disregards the implications for surface water run-off, means that major flooding events like those which occurred in summer 2007 are likely to become more frequent in the UK. Much of the flood damage ensuing during summer 2007 came not from what we would regard as 'traditional flooding' (i.e. from rivers or the sea) but as a result of what is described as pluvial flooding – excessive volumes of water running off over land and simply overwhelming urban surface water drainage systems.

Rapid urbanisation leads to increased local and regional flood risk. The aftermath of urban flooding can be severe, entailing human distress, high costs of drainage reconstruction, social impacts of residents forced into temporary accommodation, and very large insurance payouts. The latter were estimated at £3 billion for the UK's summer 2007 floods (Association of British Insurers (ABI), 2007). Impaired water quality of rivers, streams and lakes is also of significant concern as receiving water bodies are impacted by large volumes of polluted urban run-off that recurs on a more frequent basis, and is referred to as urban diffuse pollution.

Recently, the UK government announced that 3 million new homes are to be built over the next 13 years with a significant number of houses planned for land prone to flooding (Department for Communities and Local Government (DCLG), 2007). As this rapid urbanisation gathers pace, more impervious hard surfaces are created resulting in more rainfall being converted to run-off with which traditional 'end of pipe' urban drainage systems are increasingly unable to cope. Indeed, the summer 2007 floods demonstrated that infrastructure dependent upon extensive piped systems for dealing with urban run-off reached crisis conditions and proved to be technically, financially and environmentally problematic.

In the light of such scenarios, the need for a more sustainable approach to urban surface water management has never been more pressing. Furthermore, the advent of the Water Framework Directive (WFD), which aims to achieve 'good ecological status' (including chemical conditions appropriate for ecosystems) for all European surface waters by 2015 has necessitated that the key urban catchment stakeholders in the UK (including local authorities, developers and the Environment Agency) pay more attention to dealing with urban diffuse pollution as well as impacts on ecohydrology. Implementing surface water drainage methods that consider water quantity, quality and environmental amenity – collectively referred to as Sustainable Drainage Systems (SUDS) – on a catchment-scale is now recognised as essential for achieving this aim. The SUDS approach is particularly valuable in urban areas where high density development and impermeable surfaces mean surface run-off can easily cause flooding, either directly or in conjunction with Combined

Problems with traditional drainage systems

Storm water run-off from urbanised areas is generated from a number of sources including residential areas, commercial and industrial areas, roads, highways and bridges with predominantly impervious surfaces. These convert rainwater directly into surface run-off rather than facilitating infiltration into the soil and helping groundwater recharge.

The traditional means of managing such storm water run-offs as quickly and efficiently as possible has been to construct a network of piped drainage systems, gullies, oil interceptors and underground storage tanks. Ever-bigger pipework has become de facto 'best practice'. Most of the time, this infrastructure is adequate for the job. However, during high rainfall events, volumes of run-off may be so high as to overwhelm piped drainage systems contributing both to localised flooding as well as raising flood risk from receiving water bodies. Where they are still in operation, floodwater can also overwhelm older combined foul sewerage and surface water drains, resulting in discharge of their contaminated contents to surface waters through Combined Sewers Overflows (CSOs).

In addition, road, car park and driveway surfaces collect sediments and pollutants such as soil debris, hydroflurocarbons, metals and nitrous oxide (N_2O), a highly potent greenhouse gas (EPA, 1999) – from car exhausts, tyre wear, oil leaks, etc – which are washed off when it rains, causing serious water quality problems and hazards to wildlife in rivers and streams.

Increasing proportions of hard surfaces through widespread urbanisation and development further exacerbate such problems, as large volumes of rainwater are converted directly into surface run-off rather than infiltrating into the soil and helping groundwater recharge.

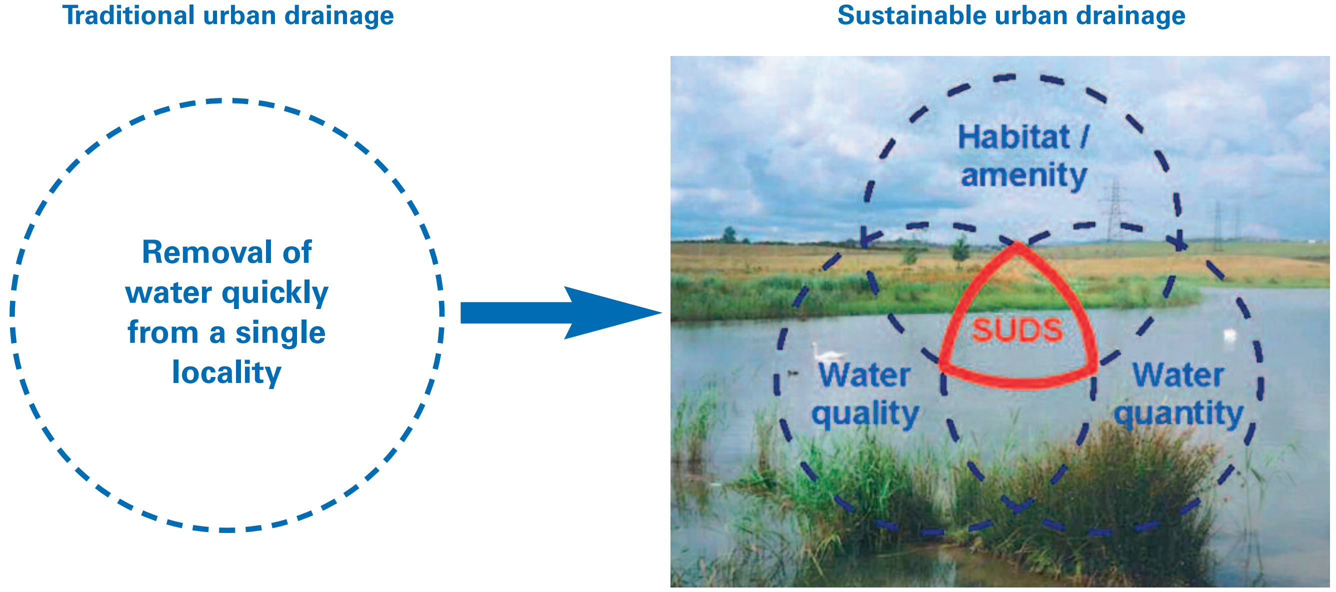


Figure 1: Illustration of the ongoing transition towards sustainable drainage *Source: Stahre, 2006*

Sewers Overflows (CSOs) (see box on previous page).

Although the benefits of SUDS are well-documented, there are challenges in achieving their wider uptake and acceptance. Lack of awareness about SUDS is one such key obstacle in the UK. A significant hurdle is also posed by issues related to the eventual ownership of SUDS systems and, in particular, who will maintain and repair them. Public acceptance and safety concerns related to the SUDS techniques have also been identified as key barriers to their successful implementation. Developers remain unwilling to incorporate these systems into buildings if ongoing maintenance/repair responsibilities are uncertain and protracted. Most local authorities and water companies in the UK have been reticent about agreeing to adopt and maintain individual SUDS primarily due to concerns regarding risks and liability associated with such systems.

However, following the flooding in Yorkshire and the Thames and Severn catchments in summer 2007, there has been a renewed interest in the benefits of SUDS approaches to drainage.

Sustainable Drainage Systems: an overview

SUDS are defined as '…a sequence of management practices and control structures designed to drain surface water in a sustainable way' (CIRIA, 2004). The SUDS approach is to manage rainfall as close to the source as possible by mimicking natural movement of water from a development site (commercial and non-commercial) and treating surface run-offs to remove pollutants. In doing so, the impact that a development has on urban flooding and pollution of rivers, streams and other water bodies is minimised as much as possible.

SUDS represent a more sustainable approach than conventional urban drainage methods because they take a holistic view by helping maintain surface water quality, enhancing percolation to groundwater, treating soluble and suspended pollutants before they can accumulate in 'dirty' flows downstream, reducing flood risk and creating high quality public open space features that not only support biodiversity but may also have significant amenity value. A comparison of traditional urban drainage with that of the sustainable drainage approach is illustrated in Figure 1.

SUDS include a portfolio of approaches; they are not a 'one-size fits all' solution. Techniques that come under the SUDS umbrella vary enormously but are usually categorised into 'Source Control', 'Site Control' and 'Regional Control' that take the rainwater from an urban area, provide treatment and release it slowly into the environment – either to streams, rivers or to groundwater.

For a particular development site, SUDS operate in a staged approach, referred to as a management train (Figure 2a, 2b). The management train employs a collection of SUDS techniques (as detailed in Table 1) in a series to control the flow and volume, as close to where the raindrop falls as feasible, and improve the quality of run-off as it passes through the system.

The key idea is to control the flow of surface run-off or stormwater as close to the source as possible. This is intended to achieve progressive reduction of pollutant concentration so that the water that percolates to groundwater, or else leaves the catchment and drains into the receiving water body, is of acceptable quality or standard. The final stage (Regional Control) in the train ensures that opportunities for wildlife and biodiversity and landscape/amenity benefits are maximised by employing techniques such as ponds and wetlands.

SUDS techniques involve the physical construction of a

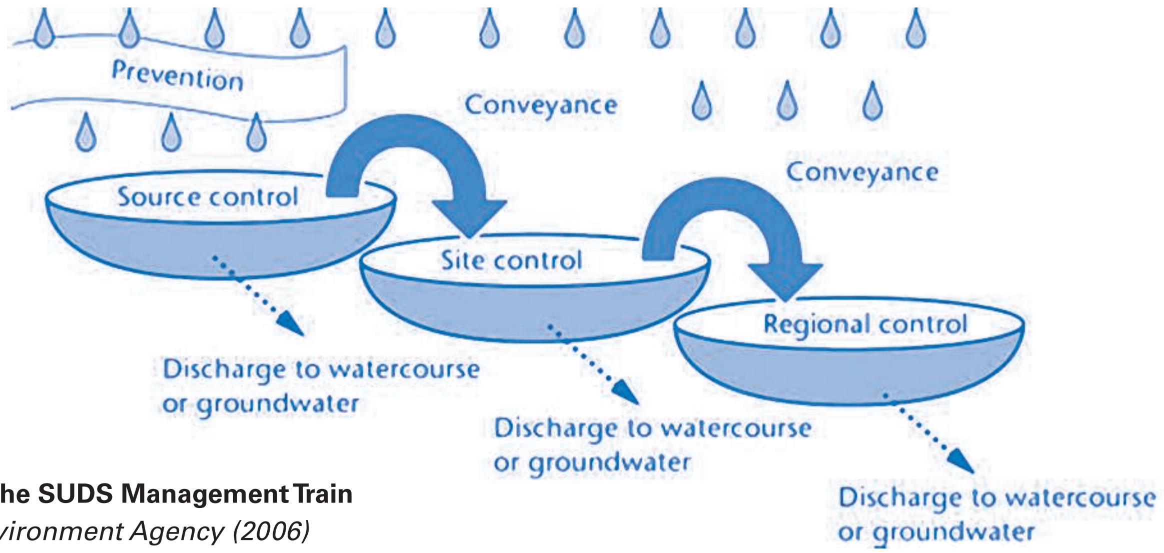


Figure 2a: The SUDS Management Train
Source: Environment Agency (2006)

system for urban stormwater management. Table 1 describes some of the typical structural SUDS techniques that could possibly be employed, depending upon the nature of the development in the catchment.

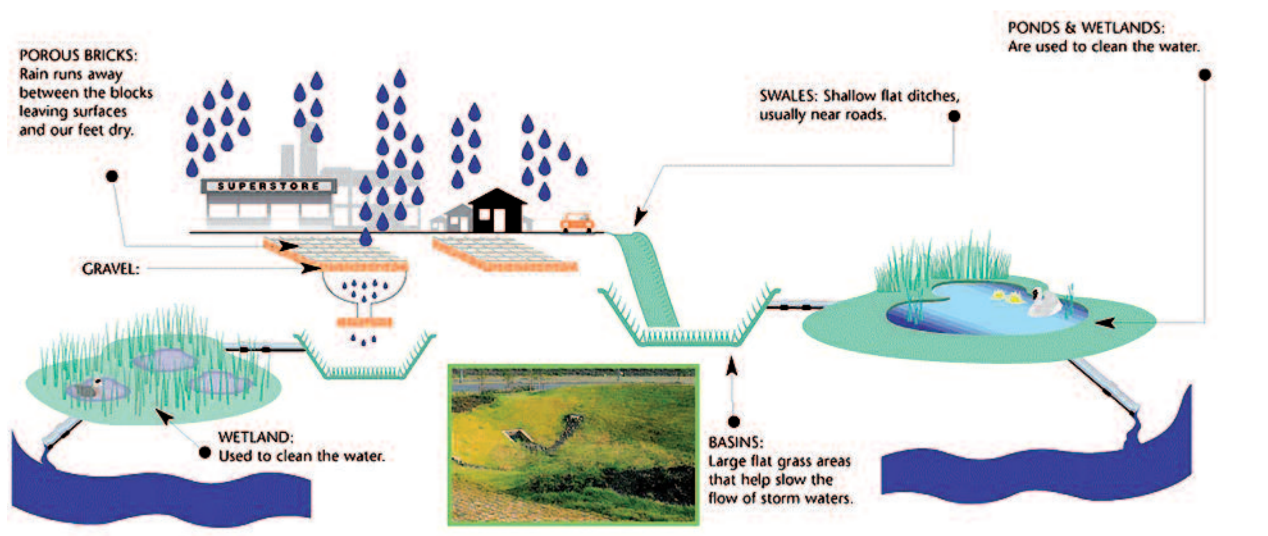
Environmental and amenity benefits of SUDS

Unlike conventional drainage, opportunities for SUDS to provide amenity and other associated environmental benefits are significant. SUDS techniques such as swales, ponds and wetlands are likely to form part of public open spaces and could be used as part of maintaining traditional urban landscapes. This promotes interaction between communities and their local environment as they can be used as amenity sites for quiet enjoyment in an urban setting. Areas set aside for floodwater storage or as 'detention basins' in times of heavy rainfall may also be suitable for other multiple uses (i.e. sports pitches or recreational areas) during dry periods. This may substantially enhance the public and planning acceptability of the drainage scheme, as well as enhancing its value to local communities. It is consistent also with the drive towards implementation of the ecosystem approach by DEFRA (DEFRA, 2007).

Wetlands in parks and public open spaces can support an array of native plants with high ecological significance which can also act as biological filters, trapping silt and helping to process the dispersed chemical pollution that runs off car parks, roofs and roads. Such SUDS components are now recognised as 'green infrastructure', designed and managed to emulate natural processes.

The implementation of such SUDS techniques in new developments (where possible) are being championed by many organisations including the Environment Agency, DEFRA and SEPA and a number of local authorities as a more sustainable alternative to traditional drainage

Figure 2b: Individual SUDS techniques in the Management Train *Source: SEPA (2005)*



SUDS processes

Source control	Controlling run-off at or as near to the source as possible
Site control	Managing water from several sub-catchments
Regional control	Managing run-offs from several sites
Prevention	Using good site-management to prevent run-off and pollution
Attenuation	Slowing down the rate of flow, with a consequent increase in the duration of the flow

SUDS techniques	Category	Structure and mechanics	Benefits (water quantity, quality, amenity)
Soakaways	Site control; source control	Sub-surface structures that infiltrate run-off	Control of run-off at or very near its source; filtration, adsorption, and biodegradation of pollutants
Pervious pavements	Site control	Car parks (and potentially minor roads) and other paved surfaces which provide infiltration and storage of rainwater in the underlying construction	Stormwater attenuation at source; filtration, adsorption and biodegradation of pollutants
Infiltration trenches	Source control	Sub-surface structures that promote the infiltration of surface water to ground	Management of water from several sub-catchments
Swales	Regional control	Shallow vegetated channels that collect overland flows from an adjacent site	Source control; facilitates water conduction, retention and infiltration. The vegetation filters particulate matters (and pollutants)
Detention basins	Regional control	Vegetated depressions designed to store water to meet specific attenuation requirements	Pollution attenuation, adsorption and biodegradation
Ponds	Regional control	Areas of permanent water used for storing and treating run-off. They have a permanent pool and usually some aquatic vegetation	Conveyance, attenuation, filtration, adsorption and biodegradation of pollutants
Wetlands	Regional control	Similar to ponds, but the run-off flows slowly and continuously through aquatic vegetation	Stormwater attenuation; sedimentation, adsorption and biodegradation of pollutants; a significant ecological resource
Green roofs	Source control	Vegetated systems designed to protect roofs from the rain, the sun and the wind	Stormwater attenuation at source; enhance wildlife; visual aesthetic; key component of urban regeneration

Table 1: Individual SUDS techniques

schemes. SUDS are now widely recognised and accepted as the most sustainable environmental infrastructure due to their ability not only to control flooding and pollution of watercourses from stormwater run-off but also due to their contribution to groundwater recharge in often impermeable landscapes. They can also improve the environmental quality of a development by delivering landscape, wildlife, ecology and aesthetic benefits to the local community.

Delivering SUDS on the ground: challenges and opportunities

Following the flooding in Yorkshire and the Thames and Severn catchments last summer, there has been a renewed interest in the benefits of a sustainable approach to drainage. SUDS may not have prevented the flooding in all such extreme circumstances, as they too can be overwhelmed by extreme rainfall, but using the SUDS approach will definitely help. For example, although the county of Oxfordshire experienced extensive overland flooding in July 2007, none of the existing sites at which SUDS were installed had flooded (West, 2007).

Despite notable benefits for the urban environment and catchments, SUDS have not been implemented as widely as they potentially could be in England and Wales. In England, although Planning Policy Statement (PPS) 1 and Building Regulations state that regional planning bodies and local authorities should promote the use of SUDS, in practice there is still much resistance to their use. This is mainly due to uncertainties over adoption (formal agreements as to ownership and ongoing maintenance and management responsibilities), particularly where there is no single identified owner or operator of SUDS systems.

Currently, the responsibility for urban stormwater management in the UK is fragmented across a range of stakeholders including the Environment Agency, sewerage authorities (duties usually vested in other private or public bodies), local authorities, drainage interests in the highways authority, riparian owners and private owners of land beneath which drains and sewers may run. Hence, the remit for implementing SUDS spans a multitude of such stakeholders, which has raised one of the bigger challenges in achieving their wider uptake and acceptance. Who will maintain and take responsibility for the new systems once they are commissioned? It is not automatically the responsibility of the water companies, with SUDS not classified as sewers and therefore not falling under water company Asset Management Plans (AMPs).

Another key factor in the high level of reticence among the concerned stakeholders towards implementing SUDS has been the implicit assumption that maintenance and management of traditional systems, together with their associated risks and costs, are minimal and acceptable. In reality, well-designed SUDS eliminate or minimise requirements for much hard engineering infrastructure. Life-cycle studies by H.R. Wallingford and Coventry University demonstrate that SUDS can reduce the often substantial costs of both construction and planned maintenance as the requirements for oil and grit interception, an extensive pipe network and underground storage structures may be minimised or eliminated altogether (Everard, 2002).

There are, however, successful examples of SUDS schemes where the adoption issue has been effectively addressed by considering these challenges early in the design process. Agreements based on Section 106 of the Town and Country Planning Act (1990) and Section 38 of the Highways Act (1980) can provide a flexible mechanism for allocating responsibilities for the long-term maintenance of SUDS by taking into account the type of SUDS system, its location, and the recipients of any associated benefits. Either of these legislative approaches allows for the use of a 'commuted sum' which a local authority collects from the developer, ring-fenced and placed in an interest-bearing account to cover maintenance for a specific timeframe. This approach has been progressed over recent years by, among others, Oxfordshire County Council.

A developer might see safety concerns as a key risk along with the potential liability issue of using ponds and wetlands at a new development site, thus potentially deterring their use. This might be due to poor public understanding of SUDS and their wider benefits, which could potentially be overcome if a developer were to work with the appropriate local authority to introduce natural barriers around the ponds and wetlands as well as providing benches and creating walkways to increase local amenity value. Additionally, local authorities could potentially maintain wetlands, ponds and detention basins – with their associated ecological and amenity benefits – as part of their wider remit for managing public open space. Often this entails only minor, sometimes even cost-reduced, adjustments to existing grounds maintenance activities such as amended mowing regimes. Figure 3 illustrates a permeable car park scheme which has been successfully adopted in Worcestershire.

Figure 3: A permeable car park scheme *(Courtesy of Robert Bray Associates)*

Notwithstanding the many potential benefits of SUDS, adoption issues remain a major challenge in achieving successful implementation of SUDS in the UK. They will continue to remain so unless there are step changes in primary legislation, or greater clarity in government guidance, concerned with urban drainage. The Pitt Review (Pitt 2007) on the UK's summer 2007 flooding has given SUDS renewed prominence, recommending that the Government, as part of its water strategy, should resolve the issue of which organisations should be responsible for ownership and maintenance of sustainable drainage systems. Recent Government initiatives, such as the DEFRA-led but cross-Government strategy 'Making Space for Water', intended to shape the way in which flood and coastal erosion risk in England are managed, have given detailed consideration to the issues of adoption and funding of sustainable drainage in a joined-up manner. Key UK planning policies such as the Planning Policy Statement 25 (PPS25) have reinforced the role of SUDS as a means of reducing flood risk from new developments.

The UK's exceptional and devastating summer 2007 floods have given SUDS an unprecedented profile. The effects of this extreme flooding on individuals, families, communities and businesses – effects which are still being felt today – have exposed the vulnerability of urban drainage infrastructure, much of which in our larger cities is still of Victorian heritage. Even drainage systems implemented more recently seem not to have been designed to cope with extreme events. Climate change is now also accepted as a reality that should shape policy, and the increased likelihood of extreme weather events makes flood risk management a topic of major concern. Indeed, the Stern Report on climate change (Stern, 2006) makes reference to stormwater management by stating that water should be allowed to infiltrate into the ground as close to source as possible.

With such high-profile news items on flooding and realisation of their associated costs, coupled with government-level initiatives and drivers including the Water Framework Directive and the additional sustainability considerations being brought to bear upon new developments, the importance of implementing SUDS in the 21st century environmental planning context, with their ability to deliver water quantity, quality, wildlife and amenity benefits on a catchment-scale in an integrated manner, is only likely to grow. There is therefore an urgent need for all concerned stakeholders to work in a more 'joined-up' way to make a convincing case for implementing SUDS across the board.

Effort is being directed to help achieve this in the context of the SuRCaSE project (Sustainable River Catchments in SE England), a collaborative EU LIFE project including the SE England Development Agency (as beneficiary) contributing partners (Environment Agency, Natural England, South East Water and Southern Water, Westcountry Rivers Trust) and implemented by the Institute for SWIMMER at the University of Liverpool, *www.liv.ac.uk/swimmer*.

More information is available on the SuRCaSE website: *www.liv.ac.uk/swimmer/surcase*

Acknowledgments

The writing of this paper was made possible by the support of the SuRCaSE project. Abhishek Sharma works for the Institute for Sustainable Water, Integrated Management and Ecosystem Research (SWIMMER) as a SUDS Advisor based at the University of Liverpool, which is the main technical partner in the project. Edward Maltby is Director of SWIMMER.

References

Association of British Insurers (2007): Insurers call for 25-year flood management strategy. Available from *www.abi.org.uk/Newsreleases/viewNewsRelease.asp?nrid=15477* [Accessed 20 December 2007].

Construction Industry Research and Information Association (CIRIA) (2004): *Interim Code of Practice for Sustainable Drainage Systems: National SUDS Working Group*. CIRIA.

DEFRA (2007) Securing a healthy natural environment. *An Action Plan for embedding an ecosystem approach*. Available from *www.defra.gov.uk/wildlife-countryside/natres/eco-actionp.htm* [Accessed 30th January 2008].

Environment Agency (2005) *Sustainable Drainage Systems (SUDS): A guide for developers*. Environment Agency.

Environment Protection Agency (EPA) (1999) *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-1997*. US Environment Protection Agency Office of Policy

Everard, Mark (2002) *Putting Sustainable Drainage Systems (SUDS) into Practice*. The Natural Step.

Grice, Andrew (12th July 2007) *Brown plans three million new homes*. Independent. Available from *news.independent.co.uk/uk/politics/article2758828.ece* [Accessed 20 December 2007].

Pitt, Michael (2007) *Learning lessons from the 2007 floods: An independent review by Sir Michael Pritt*. Cabinet Office.

Scottish Environment Protection Agency (2005) SUDS Guidance. SEPA. Available from *www.sepa.org.uk/pdf/dpi/resources/dpi_reports/dpi_010.pdf* [Accessed 2 October 2007].

Stahre, Peter (2005) *Sustainability in Urban Storm Drainage: Planning and Examples*. Svenskt Vatten.

Stern, Nicholas (2006) *Stern Review on the economics of climate change*. Cambridge University Press.

West, Barry (2007) *Delivering SUDS*. In Landform: Delivering sustainable drainage on the ground. 20 September 2007. CIRIA.

THE CITY WILD: URBAN NATURE IN 21ST CENTURY BRITAIN

MATHEW FRITH ponders the delights of our city wildernesses and concludes that the natural environment's role in urban areas is critical

Leaving Tate Modern on a damp Friday night in January, and making my way through the crepuscular promenading along Bankside, I noted a young male fox trotting casually towards the Globe, seemingly oblivious to the passing crowds. Nothing unusual in that – I commonly see them in this part of town, and they always bring a smile to my face – but seeing a fox in central London never extinguishes my genuine wonder at nature's ability to adapt and survive. A London without foxes, or for that matter without the daily sight or sound of wild animals or plants, would be a depressing place in which to live.

Thousands of wild species share our towns and cities with us in Britain; from microbes and tiny invertebrates, through to many fungi, plants, and larger animals. Although most people equate 'urban nature' with pigeons, house sparrows, foxes and grey squirrels, the diversity of wildlife associated with our conurbations is often surprising, and constantly changing. It is the moorhen in the canal, the veteran beech tree at the road junction, and the hoverfly on the Michaelmas-daisy in the garden. It is the old woodland surrounded by housing, the scrubby verge alongside the railway, and the splutter of weeds along the top of a wall. Some of this wildlife is almost exclusively associated with urban environments, others have found 'success' here, many more tolerate it, and there are also those that are 'clinging on' on the peripheries. In Dundee you can still find red squirrel, otter have returned to the Tyne in Newcastle, while London is home to the largest national populations of greater yellow-rattle.

While our urban areas may seem at first hand inhospitable, polluted, noisy, car-ridden and dominated by bricks and mortar (as well as people), they can provide many advantages for wildlife. They are generally warmer throughout the year; the centre of very large cities may be up to 5°C warmer than the surrounding countryside in summer. Large conurbations have fewer frosts during winter. City centres are also drier in summer, with more rain often being deposited on the suburbs. Drainage systems ensure that water is not held within the urban infrastructure (except on natural and porous surfaces) and it evaporates quickly, causing low atmospheric moisture content. However, in summer extreme high temperatures may exacerbate evapo-transpiration from urban woodlands and gardens, and increase humidity levels significantly. Cities are abundant in food (for some species), and also offer niches to be exploited. The current success of magpie and crow can partly be explained by the amount of food we leave around and the maturity of the post-war tree-planting programmes.

As foci of human activity (e.g. cooking, industry, trading, building, horticulture), towns and cities are also usually the first points for the introduction of species from elsewhere. Rabbit, black and brown rats, Chinese mitten-crab, German cockroach, Himalayan balsam, Sumatran fleabane, Oxford ragwort and London rocket are but a tiny sample of those that first took foot in this country in our towns. The inter-relationship between each town and its nature over time has led to significant differences in the ecology of our conurbations.

Wildlife is found across our urban environment, which in ecological terms can be broadly split into the following typologies:

- relict habitats and features – e.g. ancient woodland, chalk downland
- altered and manipulated habitats – e.g. parks, gardens
- new natural habitats – e.g. wasteland habitats
- artificial habitats – e.g. newly created sites
- built structures – e.g. buildings, roadways.

Due to their continuity to the past relict habitats are usually the most valuable in traditional nature conservation terms, as they are likely to support rare or threatened communities and species that require specialist management. Many will have survived through historical patronage, public protest, or simply luck, and will form the key nodes of a network of sites of wildlife interest across the nation's conurbations. Whilst most of these are located in suburban and urban-fringe locations (e.g. Richmond Park), some of these habitats survive in more surprising situations, for example churchyards, cemeteries and the borders of old water-works. Most urban wildlife is within parks, gardens, transport corridors, etc; the manipulated green spaces that have simply changed from a more natural past through use and management. These – individually – usually support a less diverse biodiversity, but with 15 million or so private gardens across the country their accumulative biomass makes these critically important at a landscape scale.[1]

We often think of the wildlife of urban areas as unnatural, but it is here that we find some of the country's most natural habitats, those where we have let nature 'do her own thing' without our intervention. The colonisation of post-industrial land from the 1950-80s by a wide range of

1 Gaston K J, Warren P H, Thompson K and Smith, R M (2005), Urban domestic gardens (IV): the extent of the resource and its associated features. *Biodiversity and Conservation* 14: 3327-3349.

plants and animals – often with high proportions of species originally from outside Britain – was, arguably, a re-wilding (there was little guiding hand from us apart from preparing the canvas). They are in some respects wildernesses – are the remaining sparse prairies of evening-primrose on the wastelands of south Liverpool any more manipulated than the machair of the Scottish isles? Astutely championed by Richard Mabey, for seeing what nature was doing when we took our hand off the tiller, these places and processes took time for most conservationists to recognise, let alone accept, most probably because they involved species and places that didn't – and possibly still don't – fit in with what is believed to be truly natural. As Mabey remarked, 'no amount of human planning could have produced… the remarkable orchid colonies that [grew] up on the lime-rich chemical tips near the old soda factories of Manchester.'[2]

Many of these wastelands and other post-industrial wildernesses – our 'unofficial countryside' now conveniently tarred as 'brownfields' – have subsequently disappeared, are due to be built on, or be landscaped into 'new' duller green spaces.[3] In the rush to destroy them there has been action recently to recognise their biodiversity value, as many support regionally and nationally important populations of otherwise rare species, such as various bumblebees, moths and beetles.[4] Critically, we are likely to see whether effective mitigation can be developed in the face of the Government's 'brownfields first' agenda.

The wildlife found within and on our buildings is generally that most adapted to human environments, with many species largely dependent on us, most of which we view as competitors and/or pests. Nevertheless, the role of built structures providing roosting and nesting sites for many birds, bats and some insects (e.g. mason bees), can be critical to their survival in our towns. As technology has improved, however, the construction and refurbishment of buildings is effectively excluding wildlife from them; this appears to have had an impact on species such as house martin, swallow, swift and house sparrow, as well as several species of bats. Modern buildings are designed to be air and water tight, and it is only by specifically designing for biodiversity that these opportunities can be maximised.[5]

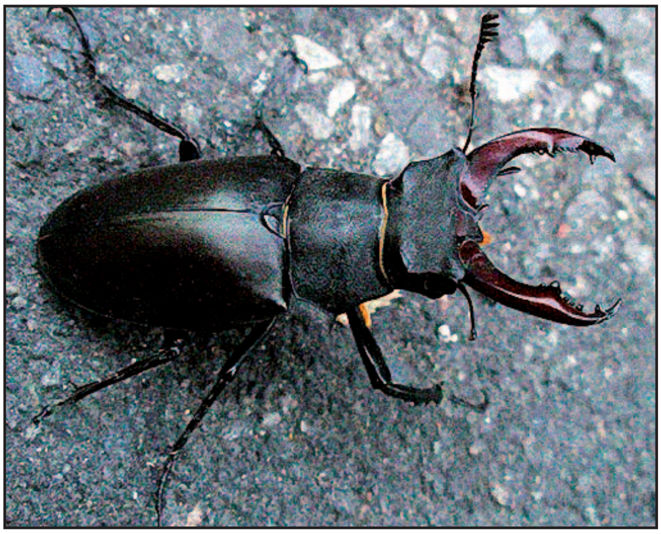
Notwithstanding the continuing developmental pressure upon green spaces and the inevitable impacts of society (persecution, traffic, pets, diffuse pollution, etc), there have, arguably, been advances for the natural environment within our towns and cities over the past 30 years. The birth of a grass-roots urban nature conservation 'movement' in the mid-1970s has subsequently led to the creation of hundreds of urban nature reserves and Community Forests, enhancement in the management of public green space and waterways for biodiversity, growth in gardening for wildlife, and the creation of new habitats, such as Camley Street Natural Park in King's Cross (on

2 Mabey, R. (1980), *The Common Ground: A place for nature in Britain's future*, Hutchinson and Nature Conservancy Council, London.

3 It is no irony that the developers of the Greenwich Peninsula in preparing the site for the Millennium Dome exclaimed their pride in 'transforming over 300ha of wilderness less than three miles from the City' in a report of 2000.

4 Anon. (2006), *Brownfields*, Buglife, Peterborough.

5 Frith, M. and Sargent, G. (2004), Buildings, *Habitats Volume 1*, CIWEM.



old coal sidings in 1984) and the Wetlands Centre in Barnes (on old reservoirs in 2000).

The improved understanding (if not performance) of developers, engineers and planners in recognising and providing for biodiversity through the development process has also contributed.

This has been reinforced by a steady proliferation and strength in legislation and statutory guidance, most recently in the Natural Environment and Rural Communities Act 2006, which imposes a duty on public bodies to have regard to conserving biodiversity.[6] In urban areas local authorities are critical to the conservation of wildlife through the planning process, land and building management, and their engagement with local communities.

The actions to improve urban areas for biodiversity are continuing to evolve to meet the demands of early 21st century Britain, through the promotion and adoption of green infrastructure, sustainable drainage systems, green roofs, appropriate greenspace management, sympathetic development practices, and the direct engagement with people increasingly disconnected from the natural world.[7] Programmes to aid and support planners and developers such as *Building for Nature* and *Design for Biodiversity*[8], as well as guidance published by TCPA[9] and CIRIA[10], have indicated a willingness to engage with an industry that was not so long ago perceived as the enemy. And while there will undoubtedly be continued loss of biodiversity through regeneration, there is also recognition that there are technologies and processes to minimise this loss and maximise opportunities. Good practice is beginning to show the art of the possible. This ranges from bio-diverse green roofs being installed on skyscrapers and schools[11], through naturalising the culverts of rivers in public parks[12] and installing reed-bed SUDS in business parks, to the incorporation of bespoke swift-boxes on office blocks[13] and transforming the green deserts of housing estates to wildflower prairies.[14]

Despite the increasing dominance of glass, steel and concrete in the centres of our towns and cities, and an approach to public space which appears to favour clean-lined squares and fountain-filled piazzas (but not necessarily demanded by the public), the wilding of our towns and cities can be further encouraged. The key drivers for adopting greening practices are currently twofold: adaptation to and mitigation of climate change and, albeit more tenuously, health and well-being. Multi-functional greenspace, first articulated in the 1990s,[15] is becoming embedded in the jargon and slowly worming its way into policy and guidance. There are undoubted and significant merits in implementing the green infrastructure approach to the design and management of our urban areas, that can also provide benefits for wildlife.[16]

6 DEFRA (2007) *Guide for Public Authorities on Implementing the Biodiversity Duty*, DEFRA. *www.defra.gov.uk/wildlife-countryside/pdfs/biodiversity/pa-guid-english.pdf*

7 Massini, P., Cook, R. and Robertshaw, E. (2004), *London's Natural Values*, English Nature and London Wildlife Trust, London.

8 *www.d4b.org.uk*

9 *www.tcpa.org.uk/biodiversitybydesign.htm*

10 *www.ciria.org/buildinggreener*

11 *www.livingroofs.org/livingpages/casebarclaysbank.html*

12 Environment Agency (2002) *River Restoration; A Stepping Stone to Urban Regeneration: Highlighting the Opportunities in South London*, English Nature, Greater London Authority, and Environment Agency, Reading.

13 *www.londons-swifts.org.uk*

14 Riley, J., Frith, M., Massini, P., Kimpton, B. and Newton, J. (2007) *A natural estate*, Neighbourhoods Green, Peabody Trust and Notting Hill Housing Group, London.

15 Barker, G. (1995), *Nature is good for you*, English Nature, Peterborough.

16 For example the draft SPG East London Green Grid Framework, see *www.london.gov.uk/mayor/strategies/sds/docs/spg-east-lon-green-grid.pdf*

Ironically, the challenges of climate change perhaps provide significant opportunities; 'it reward[s] imaginative lateral thinking [and an] awareness of the importance of giving nature room for manoeuvre.'[17] With the need to green our cities in order to make them more comfortable and to alleviate the impacts of extreme weather events, biodiverse greenery and even wilderness has a role to play if we are willing to take a gamble. Why could we not see large herbivores and the odd, fleeting, parry from a big predator amongst a backdrop of windblown trees, and scrubby out-of-town wilds, to bring back a bit of excitement on our fringes? In the Wigan Flashes, Don Valley north of Rotherham, the Wakefield coalfields, the Potteries, Tees Estuary, the Mersey Basin, and even the Thames Gateway, putting a bit of the wild into the mix might make a difference.[18] Not so far fetched, when one considers the advances made less than 30km from the centre of Amsterdam at Oostvaarderplassen.[19]

Are towns and cities good for wildlife? We cannot ignore their external adverse impact on the natural environment, whether land-take, resources, energy, water, and the consumption of materials – often thousands of kilometres away (the current controversy over bio-fuels being just one example). In reducing these impacts, we must not forget that our conurbations have a role to play in maximising opportunities for wildlife throughout, as this can have direct intrinsic benefits to the conservation of many species, as well as providing us with that direct contact with nature which I believe we need if we are to make urban living worthwhile.

Nature it seems has a remarkable way of ignoring the strictures of human endeavour and ecological romanticism; that 'there is no true wildlife any more, only urban and suburban wildlife, adapting to yet another human-warped landscape with terrible patience' is a notion that is gaining some resonance.[20] While these 'rebounds' in no way compensate for the damage we have dealt to natural environment, they demonstrate the selective resilience of nature. And maybe we can benefit from rediscovering the 'wild heart' through promoting and encouraging a sense of wild(er)ness in the places where most of us live and work?

Last year, the Royal Commission on Environmental Pollution provided an eloquent snapshot of the current philosophy and practice advocated by many of those active in the field.[21] Much reads like echoed mantras that have fallen repeatedly on deaf governmental ears in the past – the functional value of the natural environment is 'under-recognised by government policy and practice.'[22] Little is new. Most is familiar to what a number of practitioners have been implementing where they can over the past 30 years, but are still exceptions to the rule, whether the relationship of people's well-being to access to natural greenspace, sustainable drainage systems, or green roofs: 'Many of the challenges and problems have been diagnosed repeatedly by specialists in the fields and that a broadly similar range of solutions have been proposed by experts over decades.' And because it is informed by other urban environmental concerns, it both expands upon the limited picture captured in, say, the England Biodiversity Strategy, and provides a convincing rationale for advancing a pluralistic approach. The natural environment's role in urban areas – the report states – is critical, and it 'should be at the heart of urban design and management', a phrase notably absent from Towards the Urban Renaissance.

17 Adams, W. M. (2003), *Future Nature; a vision for conservation*, Revised Edition, Earthscan, London.

18 Frith, M. and Massini, P. (2007), The wolf at the door, *Ecos*, 28, 1, BANC, Cheltenham.

19 *www.staatsbosbeheer.nl/pagina.asp?id={487C2A48-BF7C-4531-A2EB-553C1EBE8432}*

20 Matthews, A. (2001), *Wild nights; the nature of New York City*, North Point Press, New York.

21 For example Goode, D. (2006), *Green Infrastructure*, Report commissioned by the Royal Commission on Environmental Pollution.

22 Royal Commission on Environmental Pollution (2007), Twenty-sixth Report, *The Urban Environment*, The Stationery Office.

THE CARBON CONSEQUENCES OF UK CITIES AND THE ROLE OF PROPERTY

How much does property contribute to a city's carbon footprint? **JIM WHELAN** looked at ten major UK cities and compared the cabon dioxide output of housing, business and transport

By 2050 the Government aims to have reduced carbon dioxide (CO_2) emissions by 60% compared to 2000 levels. This is a major challenge for all, both the business community and householders. Profound changes will be required in order to deliver such a target, both in how people and businesses operate, as well as in terms of the development of the built environment.

The major cities in the UK will have a significant role to play if this target is to be achieved, not least given their importance as engines for economic growth. This paper provides a brief examination of the major commercial centres outside London to see what their contribution to emission levels is currently, and how it would need to change in the future to secure the national CO_2 reduction sought by government.

The cities examined are Birmingham, Bristol, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Newcastle and Sheffield. The combined population of these cities is, at approximately 7 million, as great as that of London. If change can be achieved in these cities given their complex internal dynamics, then the potential for achieving improvements elsewhere in the UK is good.

A particular focus in this paper is upon the role of property in achieving a reduction in the 'carbon footprint' in each of these cities. This requires an understanding of the current environmental impacts of property, as well as examining the measures being developed and implemented by each of the cities to tackle their environmental consequences.

The paper is not a formal academic report, but rather a thought-piece on how cities can tackle the consequences of their actions. The paper does not, for example, provide a standard carbon footprint assessment of each city. The focus is, instead, upon a number of the key drivers or contributors to carbon emissions in each of the cities, and an overview assessment of their relative impacts. The purpose is to provide a guide to debate rather than a definitive picture on each city. The data and results must therefore be recognised as both tentative and evolving, but that should not stop an exploration of their possible meanings and implications.

Approach

A wide variety of data have been examined in order to develop a composite and balanced picture for each city. The data sources range from government agencies, such as the Office for National Statistics and DEFRA, through to independent bodies and organisations, such as the Carbon Trust and the Building Research Establishment.

From examining these data sources the various forms of 'carbon consequences' of each city were identified. Given the state of development of this field, these results are best viewed as indicative, but are still a reasonable indicator of performance. The factors examined include:

- CO_2 levels – domestic, business and transport emission levels.
- Waste generation and recycling rates
- Brownfield development levels
- Environmental quality of development schemes
- Intensity of space use
- Selected response policies and measures.

Summary findings

Figure 1 indicates the amount of CO_2 emissions produced by each of the ten cities examined. This shows that Birmingham, Leeds and Sheffield produce the largest absolute amounts of emissions. In fact, these three cities generate 45% of the carbon emissions of all ten cities. Newcastle, Bristol and Cardiff, meanwhile, have the lowest emission levels.

City	Total CO_2 Tonne
Birmingham	6,586,090
Leeds	5,614,534
Sheffield	4,453,795
Glasgow	4,118,108
Manchester	3,230,697
Edinburgh	3,168,861
Liverpool	2,678,629
Cardiff	2,370,940
Bristol	2,339,170
Newcastle	1,908,469
Total:	**36,469,295**

Figure 1: Total carbon output from cities

Figure 2: CO_2 levels in major cities.

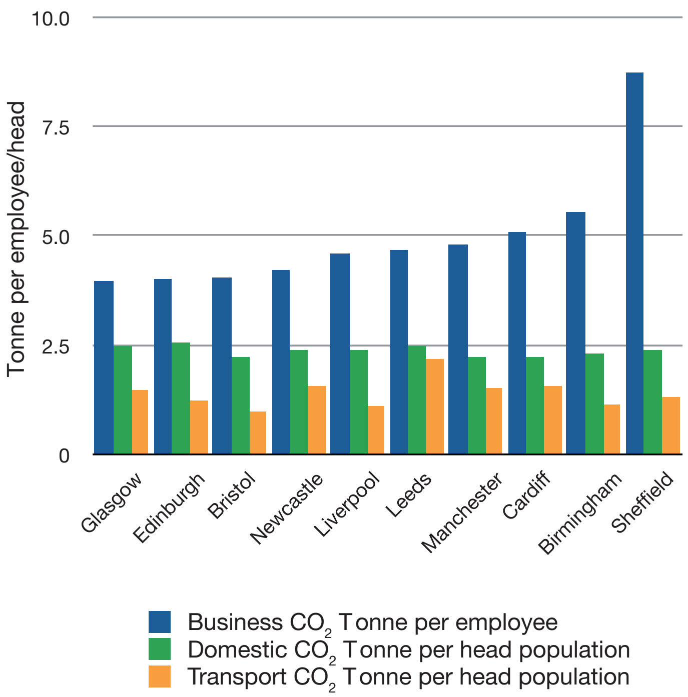


Figure 3: Waste per city

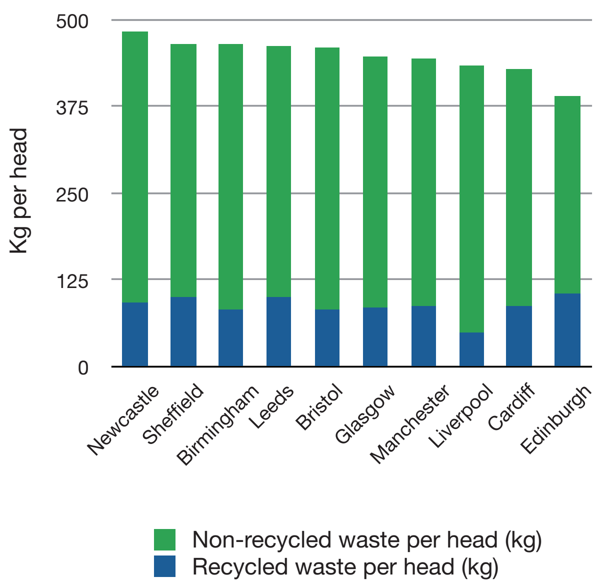


Figure 4: Business CO_2 tonnes per sq m commercial floorspace

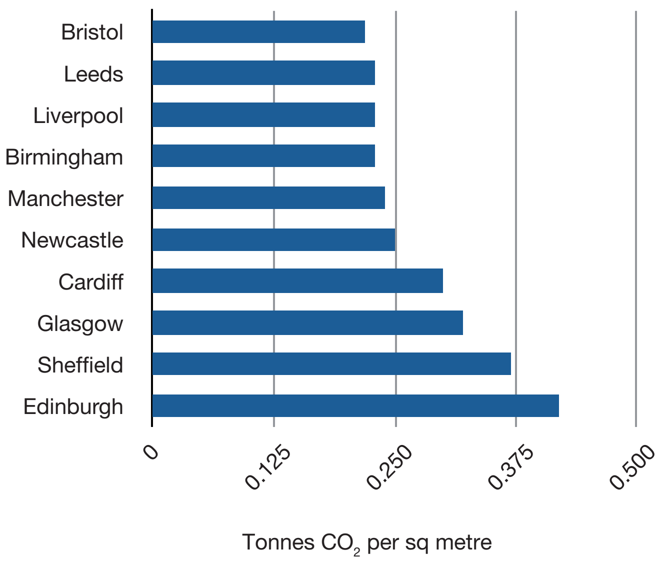
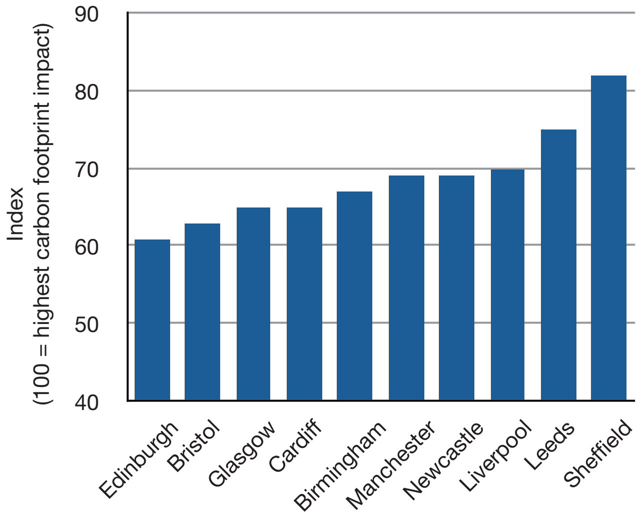


Figure 5: Overall carbon footprint impact



However, this is only part of the picture, as the amount produced per capita is likely to be a better indicator for target setting purposes, as this shows how 'efficient' the cities are in environmental sustainability terms. The results for this are summarised for business, domestic and transport uses in Figure 2, which reveal an interesting contrast to the absolute figures.

In terms of business CO_2 levels, Sheffield has by far the highest emission per employee. Part of the reason for this is the industrial make-up of the city, which still retains a significant proportion of traditional manufacturing enterprises that have a disproportionate influence upon carbon emission levels. These businesses are still vital aspects for the UK economy though.

Whilst Glasgow and Edinburgh have the lowest business CO_2 emission levels per employee, their domestic CO_2 emission levels per head of population are amongst the highest of all the cities. For Edinburgh the high domestic emissions are partly a reflection of the relatively low population density in these cities. For Glasgow – which has one of the highest population densities – the reason is more complex and is likely to be associated with the nature and quality of existing housing stock.

> 'The ten cities recycle on average less than a fifth of waste… recycling rates need to at least double by 2020, when the government expects 50% of waste to be recycled… Recycling rates need to increase by just under 20% per annum to reach this target'

Bristol has the lowest transport CO_2 emission levels, as well as relatively low emissions from businesses and households. Cardiff, Manchester and Birmingham also have relatively low transport related CO_2 emission levels, although their business related CO_2 emission levels are towards the high end of the scale. Edinburgh, Leeds and Glasgow have the highest transport CO_2 emission levels.

The above pattern between business, domestic and transport emissions demonstrates, if this was necessary, the complex internal operations of cities. Factors such as geography, economic structure, transport arrangements, condition of property and climate all play a part in determining the carbon footprint of each city. Some of these factors can be actively tackled by cities, others can only be mitigated against.

Carbon emission levels are only part of the picture in understanding the carbon footprint of cities, however. Another key factor is waste, both in terms of how much is produced and the degree of recycling that goes on in each city.

Figure 3 summarises the total amount of waste produced per head in each city, and how much is recycled. From this it can be seen that the highest waste levels are in Newcastle, Sheffield, Birmingham and Leeds, which produce over 460kg waste per person. Edinburgh, Cardiff and Liverpool produce the least waste per person, at less than 435kg.

Irrespective of the variation between cities, these levels of waste are a long way from the national target set by government, which is broadly equivalent to 225kg per person in each city by 2020. This is a major challenge, and is equivalent to a 3.3% reduction in waste per annum across the ten cities. Simplistically, everyone needs to stop throwing away the equivalent of seven bags of sugar each year.

A compounding issue on waste relates to recycling. At the moment, the ten cities recycle on average less than a fifth of waste. The best performing city is Edinburgh at 26%, followed by Sheffield and Leeds (21%). At the bottom end of the recycling table are Liverpool, Birmingham and Bristol. The key point though is that recycling rates need to at least double by 2020, when the government expects 50% of waste to be recycled. In broad terms this means recycling rates need to increase by just under 20% per annum to reach this target, assuming the absolute levels of waste per head do not reduce.

The complicating factor, however, is that this recycling rate is expected to be against a lower overall amount of waste. Thus, the broad aim is for 50% of the 225kg of waste produced per head in 2020 to be recycled. On this basis then recycling rates would need to increase by just under 10% per annum. This is still a demanding target, but not impossible.

Property has an important role to play in the reduction of CO_2 emission. Good quality, well designed buildings can help lower overall carbon emission levels, with a number of current developments aiming at zero-carbon impact. This is aside from productivity gains and other wider economic and social benefits such developments help deliver.

However, the relationship between property and business activities is complex. Thus, while property can be a cause of CO_2 emissions as a result of poor insulation or construction-related impacts, separating out the impact of property from the activities being undertaken within the property is difficult. Current best indicators suggest that property may contribute almost half of CO_2 emissions.

Even so, it is revealing to look at the relationship between CO_2 emission levels and total commercial floorspace. This is summarised in Figure 4. It is important to stress that this does not show CO_2 emissions resulting from property, but rather how CO_2 emissions are spread across commercial property. This, in turn, helps illustrate the extent to which changes in property – be that new stock, refurbishment or a more intensive use of property – can help in reducing carbon impacts.

> Separating out the impact of property from the activities being undertaken within the property is difficult. Current best indicators suggest that property may contribute almost half of CO_2 emissions.

Care is needed in interpreting the figures, as they mask a complex position, not least the variation within cities and how space is actually used. In simplistic terms, however, the higher the figure in Figure 4 the greater the significance of property to carbon emission levels. Thus, in the case of Sheffield, the high carbon emission levels per unit of floorspace are in line with the relatively high amount of carbon emission per employee indicated in Figure 2. In other words, improving or reducing commercial floorspace in Sheffield could have an important impact on achieving a reduction in carbon emission levels.

However, some further comment is required on the results in Figure 4. In the case of Edinburgh, Glasgow and, to a lesser extent, Cardiff, the carbon emission levels per unit of space may be unduly influenced by how intensively they are using space relative to the other cities. In other words, as they notionally have less space per employee than other cities (i.e. they are using the space more intensively), their high carbon emission output may appear more influenced by floorspace than it is in practice. Thus, these cities may have less potential for reducing carbon emission levels through a reduction in commercial property than other cities.

Birmingham, Liverpool and Leeds, meanwhile, have relatively high notional employment density figures – i.e. they have more space per employee on average than most other cities. This means that their carbon emission levels per unit of floospace may appear lower than they are in practice. In other words, there may be more opportunity for reducing carbon emission levels through change in commercial property – be that the development of better stock and/or a reduction in the amount of overall stock – than the figures indicate.

The various factors considered as part of the analysis, a selection of which have been summarised above, were combined in order to provide an overall ranking of cities in terms of carbon impacts. This involved developing a relatively simple weighting system which was applied to each of these factors, reflecting their potential significance, although the emphasis was towards property-related impacts.

While this weighting was developed in as consistent and realistic a manner as possible, it should be recognised that there were matters of judgment involved in the process. Accordingly, sensitivity analysis was carried out on the results. Although this resulted in some changes in the range and scale of impacts, there was no profound change in the order of cities.

Figure 5 summarises the carbon impact index results for each city. From this it will be seen that Sheffield has the highest overall index score. However, this reflects the industrial make-up of the city as, unlike the other cities, the total amount of CO_2 emissions from the business sector is greater than that of the domestic and transport sector, reflecting the significance of industry in the Sheffield economy. Retention of this nationally valuable economic activity comes with an environmental cost, which, it could be argued, is a UK plc environmental impact.

> Property has an important role to play in the reduction of CO_2 emission. Good quality, well designed buildings can help lower overall carbon emission levels, with a number of current developments aiming at zero-carbon impact.

At the other extreme, Bristol and Edinburgh appear to perform best in carbon impact terms. However, this should not necessarily be seen as quality rating of these cities in environmental terms; it is more the case that they are having less of a carbon impact that the other cities. In all cases major reductions in CO_2 emission levels are required. This will require substantial changes in behaviour and practices, which will include the property sector – both commercial and residential.

■ A summary of the relative performance of each of the ten cities, along with the full report is available at *http://tiny.cc/JENP6*.

ENEP
European Network of Environmental Professionals





www.environmentalprofessionals.eu

ENEP is the European electronic Network of Environmental Professionals. It is a web portal set up by EFAEP (European Federation of Associations of Environmental Professionals), where its members can record their contact and professional details and where both members of EFAEP and non-members can search for environmental professionals.

The two main aims of ENEP are:
1. to facilitate active communication and exchange of knowledge between EFAEP members, and
2. to provide access to the expertise and experience of environmental professionals at the European level.

This will also give the environmental professionals of Europe a platform where they can present their professional profiles, where they can get in touch with each other, and where clients and service providers can meet.

EFAEP is an association of environmental professionals from all over Europe and was founded in 2002 in response to the increasingly important and diverse role of environmental professionals. The restoration, protection and enhancement of the environment is no longer a secondary phenomenon but has penetrated all areas of life. In response to the growing sensitivity of society to environmental issues, the activities of environmental professionals have been steadily growing over the past decades and have become an unquestionable necessity.

EFAEP brings together professionals who are working in the field of the environment all over Europe and gives them an opportunity to exchange their experiences from their home countries, to find common solutions and to learn from successes and failures made in the current and future member countries of the European Union.

ENEP is the unique web tool EFAEP uses to connect its more than 15,000 members. It is currently the only internet site in Europe letting environmental professionals thoroughly describe their own experience and capabilities, effectively classify their skills, and quote their papers and projects in order to build a really complete profile.


EFAEP
European Federation of Associations of Environmental Professionals





EFAEP
31, rue du Commerce
1000 Brussels
Belgium
Tel: +32 2 500 57 87
Fax: +32 2 511 33 67
E-mail: office@efaep.org
Web: www.efaep.org

MAPPING THE ENVIRONMENTAL SCIENCE LANDSCAPE

This is a summary of **Mapping the environmental science landscape: an investigation into the state of the subject in higher education** which will be published in spring 2008. If you would like a copy of the full report, please contact the IES office

Formal environmental science (ES) education in higher education institutions (HEIs) in the UK has been developing over 40 years. The aim of this two phased project is to try and map this complex landscape over time by investigating recent provision from a number of perspectives and to make recommendations as to future directions and work. The complex landscape was illustrated in the Venn diagram in the recent revised Subject Benchmark Statement for Earth Sciences, Environmental Sciences and Environmental Studies (ES3) (*www.qaa.ac.uk*).

Phase 1 of the report identifies issues with using JACS (Joint Academic Coding System) which, due to multiple changes in the way ES has been coded, makes detailed longitudinal studies very problematic. To try and address this problem undergraduate single honours programmes calling themselves Environmental Science were drawn from the plethora of JACS groups and used as an indicator to reveal 5 year trends. Additionally, subject groups were joined together as the 'ES contingent' (JACS F850/851/890/900/990).

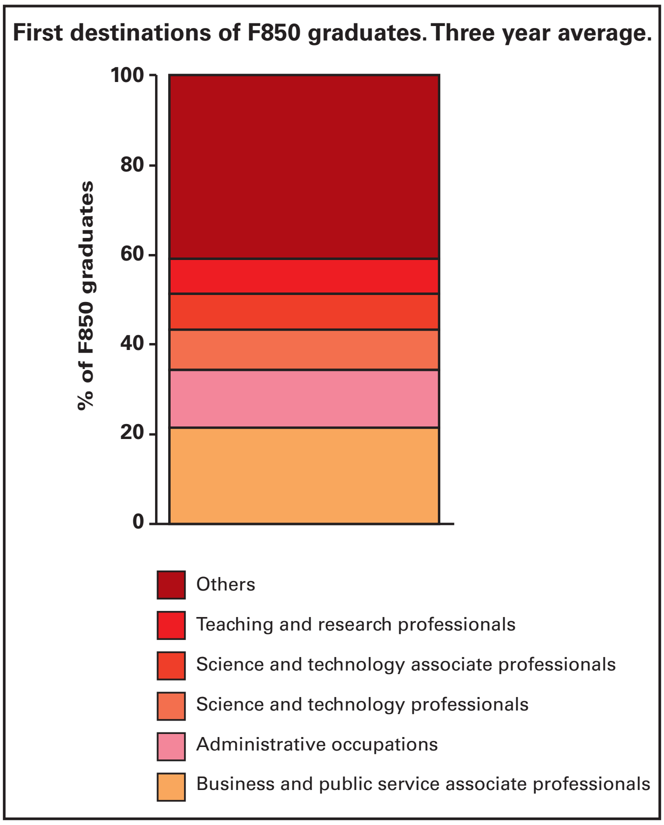
Not only was the statistical data interrogated but surveys were also undertaken with ES in HEIs, providers (lecturers and programme leaders) and ES professionals. Use was also made of a recent report on the current agenda of sustainability in the higher education curriculum.

Findings from the investigation were reported under the following headings:

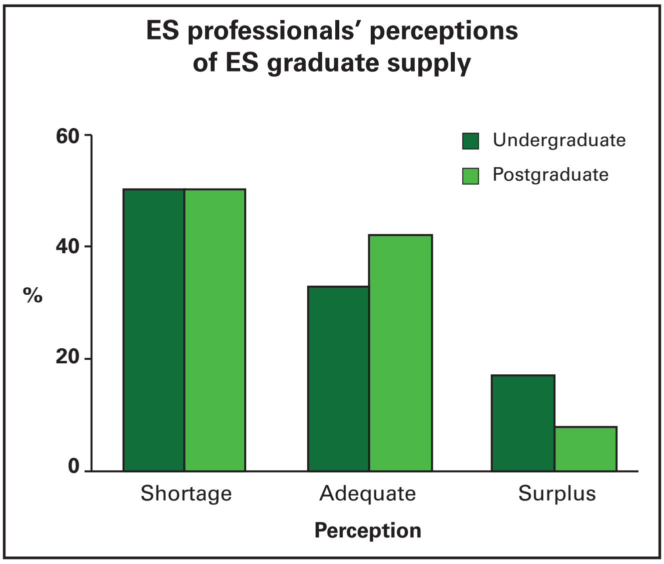
- Recruitment
- Changing structures
- Skills and Employment
- Future Provision
- Education for sustainability

The main findings of the project include:

- applications and enrolments have seen a very minor decrease against an overall increase in recruitment to HE



- there has been a reduction in the number of institutions offering ES (currently 45), overall there has been a growing 'core' and shrinking 'periphery'
- at present there are approximately 18,000 students studying ES and closely aligned subjects which includes approximately 2,200 students studying ES as a named single honours programme (within the codings)
- postgraduate provision has increased dramatically with approximately 4,800 students studying in ES and aligned subjects in 2005
- academic structures have been undergoing change to ➢



IES: NEW MEMBERS

The Institution of Environmental Sciences is pleased to welcome the following new members and regrades:

Miss Jane Akerman	Environmental Scientist	(A)
Miss Jenny Aldred	Environmental Scientist	(A)
Miss Hannah Beswick	Graduate Air Quality Consultant	(A)
Dr Euan Burford	Principal Environment Consultant	(M)
Miss Louise Carman	Project Engineer	(M)
Mr Timothy Cawood	Senior Environmental Consultant	(M)
Mr Martin Chan	Senior Environmental Scientist	(M)
Miss Michelle Cox	Senior Environmental Scientist	(M)
Mr Peter Crome	Student	(Af)
Mr Stephen Foster	Assistant Environmental Engineer	(M)
Mr Kin Ha	Student	(Af)
Mr Nathan Handley	Laboratory Assistant	(Af)
Mr Jeremy Head	Senior Consultant	(M)
Miss Suzanne Hodgson	Graduate Air Quality Scientist	(A)
Mr Nicholas Howard	Senior Environmental Scientist	(M)
Mr Darren Hurst	Scientific Officer	(M)
Mr Darren McGrath	Associate	(A)
Miss Shona McMillan	Senior Finance Assistant	(A)
Miss Lucy Millard	Environmental Co-ordinator	(A)
Ms Helen Millier	Post-Graduate Researcher	(A)
Mr Elvis Oben	Graduate	(A)
Mr James Owen	Student	(Af)
Miss Nicolette Parham	Project Consultant	(A)
Mr Torosay Peebles	Environmental Monitoring	(A)
Mr Ben Pizii	Environmental Consultant	(M)
Ms Jane Saul	Senior Environmental Engineer	(M)
Mr Alan Shepherd	Environmental Consultant	(M)
Dr Michael Steele	Associate Regional Environmental Leader	(M)
Prof. Paul Stephenson	Senior Air Quality Specialist	(M)
Mr Chi Tam	Environmental Engineer	(M)
Miss Marzhan Tleubayeva	Environmental Compliance Specialist	(A)
Miss Nicola Trought	Senior Air Quality Scientist	(M)
Miss Lisa Watt	Environmental Consultant	(A)
Miss Katharina Weigert	Environmental Scientist	(M)
Dr Martin Williams	Head AEQ Division	(F)
Mr Richard Williams	Environmental Manager	(M)
Mr Richard Woolley	Senior Environmental Consultant	(M)

KEY:

F = Fellow **M = Member** **A = Associate** **Af = Affiliate**

MAPPING THE ENVIRONMENTAL SCIENCE LANDSCAPE

➢ continued from page 23

cope with pressures such as student numbers, staff resources and new agendas,
- providers felt concerned or uncertain about future provision though no dramatic change was thought to be on the horizon
- many ES providers saw the popularity of environmental issues in the media as a method of increasing recruitment
- many employers felt that whilst students had broad knowledge they were lacking in specialised skills relevant to the workplace
- there is not a surplus of graduates and employers are still recruiting
- employers would like more input into the higher education curriculum.

Overall the ES landscape was found not to be in dramatic decline or rapid expansion and there is scope and a platform for reigniting interest.

As one respondent stated, there is 'the chance to make a real difference'.

Phase 2 will involve a panel of ES higher education providers interrogating the findings in order to examine trends and issues, make recommendations for the direction of the discipline and further study. This work is being led by the Committee for the Heads of Environmental Sciences (CHES) and supported by the Higher Education Academy Subject Centre Geography, Earth and Environmental Sciences (GEES) and the Institution of Environmental Sciences (IES).

Jennifer Blumhof & Phil Holmes