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FEATURE ARTICLE

Brownfield sites: a view from the eyes of a developer

Professor G L P Randall

ZENECA Limited Brixham Environmental Laboratory

The first point that a developer will be concerned about is the definition that can be used for a Brownfield Site in the United Kingdom. At present there is no clear definition. There is only one relating to derelict land. The importance of this point is its impact on value. As soon as land is declared as being in any way 'contaminated' the value changes downward dramatically. The other point of definition is that in some circumstances, depending on local arrangements, there may be incentives that a developer can access, depending on the classification of the land.

The next two questions tend to come together, and they are 'What do I want to use it for?' and 'What can I use it for?' These two questions tend to drive very strongly towards the question of standards for particular use and, indeed, standards for the remediation of land. The standards that exist in the UK are the ICRCL ones, which unfortunately lack scientific credibility. Often, Dutch standard values are used, but they may be quite inappropriate because of dramatically different geology and end use scenarios.

Problems faced

The problems that a user of Brownfield Sites will face can be of varying types. They can be physical, in the form of piles in the ground and underground bunkers. They can also be chemical or microbiological and, indeed, there may be radioactivity issues to address. The immediate next enquiry relates to how much it will cost to find out what needs to be done. Often developers will not have the key know-how necessary to select which consultants to use, what type of contract should be appropriate or what they should ask the consultants to look for (should it be a standard suite of determinands or the most likely contaminants of the site based on historical information?) In addition, what parts of the site should they look at and what confidence limits should they set in the analytical determinations.

Costs and standards

Having got this far, the intending developer is faced with a dilemma of how much it will cost to remediate the site, and this throws back to earlier issues such as what use do they want to put it to, what standards and what type of remediation should be adopted? Also, the question 'How long will it take?' becomes crucial at this point where venture financing is involved. The issue of statutory permissions is often a vexed one, with the remediator having to negotiate between a variety of

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regulators who sometimes take a different view about the appropriateness of different types of remediation and the standards that should be adopted.

By this stage the local community, including immediate neighbours to the site, and public interest groups will have been alerted to some of the events. These are sometimes some of the most challenging issues to deal with as the possibilities are unbounded and the level of concern can be very high. Development of Brownfield Sites is often used by local interest groups and politicians to show how caring they are about the local community The unwary developer is often caught in the middle of these very difficult situations.

Here we come to a further interesting dimension. The investors in the project, often banks and the clients for the remediated property, in the absence of clear national standards, are inclined to set their own criteria. They often add 'safety margins' that are not justified in sound science but are to give them a degree of comfort in making difficult investment decisions.

The vexed problem of liability now comes to the fore and it is enhanced by the frequent need for a formal property transfer. This throws light on adequate disclosure of all information, the quality assurance that was applied to the assessments of the remediation and, indeed, whether future legislation may be applied retrospectively. The developer will be aware of the 'deep pockets' approach that has been utilised in the USA to the charges for the remediation of Superfund Sites.

The way forward

If the developer is still involved in the use of a Brownfield Site, he will now have a fairly clear view of a better way ahead if the nation wishes to ensure that Brownfield Sites are used to their maximum capacity. The establishment of robust national standards, together with incentives for the remediation of land, under the umbrella of integrated regulatory teams will help. The integration of regulation itself might not be practical, but for the individual regulators to work together in task forces for particular sites, would be a most efficient way forward. The final point is that the recognition that natural attenuation with appropriate monitoring may in many situations often be the most sustainable way forward for many Brownfield Sites.

■ *Summary of an address to the Parliamentary and Scientific Committee on 18 May 1998.*

Developing brownfield sites: coping with contamination

Professor Jane Plant CBE, British Geological Survey

In this brief presentation I am going to look at what contaminated land is, where it is and how it can be dealt with in a realistic fashion. The official definition of contaminated land is that significant harm or pollution of controlled waters is either being or likely to be caused. The Environmental Protection Act (1996) emphasises the need to demonstrate that actual or potential harm is likely to be caused bearing in mind the likely use to be made of the land and hence its fitness for purpose. It also deploys a risk based approach involving the source-pathway-target concept whereby the probability of contaminants reaching the target is assessed. This is different from the approach of other countries, particularly Holland where legislation is aimed at remediating all land to exceptionally high standards for multipurpose use.

Statistics on the distribution of contaminated land are difficult to obtain and the exact amount of contaminated land is probably unknown. Estimates of the amount of contaminated land by such bodies as the Department of Transport, Environment and the Regions (DETR) suggest that it is of the order of 1 per cent of the UK land surface, but that is probably an underestimate. According to the DETR there are about 100,000 individual contaminated sites of which approximately 50 per cent might be in urban areas. These statistics refer to specific sites of contamination however and agricultural areas contaminated by nitrates or pesticides, for example, or areas near major roads or motorways with lead or platinum contamination, are not included.

Focusing on site specific contamination, typical sources of contamination include old petrochemical works, gas works, landfills, heavy industry, mines (many urban centres in Britain developed in areas of old coal mines), petrol stations, pipelines and sewage works. Recently, the latter have become a source of

The first requirement in dealing with contaminated land is to fully assess the risks, before developing methods of remediation capable of returning the land to a state fit for the purpose for its future use

particular concern because of their discharge of endocrine disruptors and, where they are downstream of major hospitals, concentrations of elements and isotopes used in medical diagnosis.

The sites of old landfills need to be fully documented and the information made available to planners and the public. Typically, in old sites a pollution plume would develop in the soil and the saturated zone beneath the site and so water soluble and water insoluble compounds would reach the water table from where they would migrate through important aquifers and into river courses with the potential to damage human health and wildlife. Airborne pollution plumes, like those in water, tend to be highly directional although there is greater variation in response to climatic conditions. Practice in dealing with landfill has improved dramatically in recent years following media interest, regulation and licensing. Moreover, modern factories and industrial plant tend to operate to higher standards.

Clearly, Britain's industrial heritage suggests that there is likely to be a legacy of contaminated land with potential problems for those working or living there and for the health of animals and crops and the environment generally.

Chemical pollution can in some cases lead to physical problems. For example, damage to foundations can be caused where high levels of sulphate affect concrete buildings or underground services. Direct physical damage can also occur as a result of gas generation. For example, in 1986 a bungalow in Loscoe, Derbyshire exploded as a result of methane leaking from an old landfill site. One of the most important problems of contaminated land is the potential for long term chronic exposure of man, animals and plants to potentially harmful chemical elements and compounds. The British Geological Survey (BGS) is concerned with the problems of contaminated land and is carrying out a programme to map systematically the geochemistry of the UK to international standards, based on the analysis of soil, stream sediment and water samples. Unfortunately, funding is available only for inorganic contaminants, such as arsenic, cadmium, copper, lead and zinc while potentially damaging organic chemicals are not included. The work has formed the basis for a review of potentially harmful elements (PHEs) from natural sources and mining areas and their relevance to planning and development. Many of the areas where high levels of contamination have been found would not have been predicted by looking at their former use: for example, over the northern portion of the Lake District, high levels of some PHEs are almost entirely related to bedrock geology. Other areas affected include old mining areas such as the north Pennines orefields where high levels of PHEs occur related in part to the occurrence of metalliferous mineralisation enhanced by former mineral working, long before proper environmental standards were introduced. The maps also show a halo of heavy metals around urban centres, such as Edinburgh and Glasgow.

The BGS has recently carried out more detailed studies of the geochemistry of urban centres using the Metropolitan Borough of Wolverhampton as a pilot study. Taking lead as an example, levels are high over old industrial sites or where there is a high volume of traffic with concentrations in excess of 500 ppm, compared with the natural background level of 35 ppm. It is important that this information is available especially to planners so that the land can be developed according to the fitness for purpose philosophy implicit in UK legislation on contaminated land. As an example, in one area of Wolverhampton there was a rather old, potentially leaky landfill which has been repackaged, remediated and a leisure complex, which is less likely to be affected by contamination than family dwellings, is being developed. Also in Wolverhampton areas of undermining, where residential homes are susceptible to subsidence, can be mapped in relation to areas where potentially toxic chemical element concentrations are higher and used as a basis for developing planning policy.

Hence the first requirement in dealing with contaminated land is to fully assess the risks, before developing methods of remediation capable of returning the land to a state fit for the purpose for its future use. If the future land use is a bowling alley or a cinema complex, or even a scrapyard, then different standards can be adopted from those required for land being considered for horticulture, agriculture or for family housing. Realistic solutions also depend on understanding that the natural background levels of chemical elements, such as arsenic and cadmium, can be highly variable naturally.

The cost of remediation can involve considerable sums of money. It has been estimated that in 1996 alone £600 million was spent on the remediation of contaminated land and it is estimated that about £900 million will be needed for contaminated land remediation by the year 2000. The 'dig and dump' solution, whereby the soil from contaminated sites is simply removed to a landfill site elsewhere is increasingly recognised as unsustainable. New remediation technologies are urgently needed and in the future these may be based on novel approaches such as electrochemical methods or the use of the micro-organisms capable of recovering metals, or of degrading particular organic species. Dealing with contaminated land requires a multi-disciplinary approach involving town planners, sociologists, economists and certainly scientists. Geology, hydrogeology and geochemistry provide an essential basis for site specific evaluation while regional geochemical surveys provide a sound basis for establishing sensible and realistic remediation targets.

Britain does have a legacy of contaminated land but it is important to understand that high concentration of chemical substances can occur entirely naturally. What is needed are good data in the public domain, so that the problem of contamination can be viewed realistically and in context as a basis for sound planning decisions.

■ *Summary of an address to the Parliamentary and Scientific Committee on 18 May 1998. This, and the preceding article, have been reprinted with the kind permission of the publishers of Science in Parliament.*

Metal bioavailability and regulations for aquatic systems

John C.S. Binns MIEnvSc

Metals are natural components of the biosphere. Even though some metals are essential for life, all metals are toxic at sufficiently high concentrations; for some there is a threshold between what is essential and what is toxic. When discharged into the aquatic environment, a metal partitions between solid and liquid phases. Within each phase, further speciation occurs among specific ligands, determined by ligand concentration and the strength of each metal-ligand association. An organism therefore is never exposed to a metal as a single entity. Exposure occurs in both food (particulate) and solution. Within each phase, the organism is exposed to a variety of different physicochemical forms of each metal, and each form can differ in its accessibility to the organism.

Metal uptake by an organism can occur via ingestion (of food and water) or via transport through a plasma membrane or cell wall. The characteristics of the interface between the environment and organism greatly influence the metal form that is accumulated.[1] A number of environmental processes also affect metal uptake, with the most important of these appearing to be (a) metal concentration in solution; (b) solute speciation of the metal; (c) the influence of other cations; (d) the temperature (for metals which exchange slowly); and (e) pH and redox potential in some situations.[1]

Studies have shown that the concentrations of free metal ions (rather than total metal concentrations) appear to be the most important control on metal uptake from solution of at least Cd, Cu, Fe, Mn and Zn by eukaryotic and prokaryotic algae. invertebrates, and fish.[2] Furthermore, the quantity of metal transported into biological tissues may also be influenced by the physiological state of the organism or by biological factors involved in metal metabolism.[1] Consideration of high availability of free metal ions has helped explain observations of metal behaviour in many natural systems. For example it is known that environments with olgiotrophic waters are more susceptible to trace metal stress in comparison to more eutrophic waters, as organic material is more abundant to complex trace metals (especially Cu), thereby reducing free ion concentrations and metal bioavailability.[3] The free-ion concentration therefore is determined not only by the total dissolved metal concentration, but also the concentration and nature of ligands present in solution.

In the UK the approach to water pollution control of metals is to determine environmental quality objectives (EQOs) based on the use to which the water is put (e.g. potable water). Standards are then placed on individual discharges which will leave a river of the necessary quality defined by the EQO. This approach takes into account the assimilative capacity of a river, therefore it is possible that relatively little expenditure may be required to treat some discharges.[4] This type of standard allows for adequate control of discharges, requiring treatment at a justifiable level, especially where the ecosystem already receives effluent discharges. An alternative approach involves fixed uniform emission standards, which limit all polluting discharges irrespective of existing water quality, dilutions available or future use of a river.

For much of the time water quality regulations have been in operation, speciation and bioavailability effects have been recognised but, as for example in the UK, only enforced through the acceptance of local conditions.[4] Recently there has been a trend towards assessing a more quantitative treatment of speciation and bioavailability within the regulative framework, due to the advancement of chemical and biological test methods and a consequent improvement in the understanding of biogeochemical models. Presently though water quality standards, such as those set by the EU, are mostly framed in terms of total recoverable metal concentrations. Some member nations have brought in standards based directly on bioavailability. The UK WQOs approach, although not directly based on bioavailability, does allows for local conditions and have various categories of water quality based on usage. From 1993, the USEPA recommended the use of dissolved metal concentrations to set and measure compliance with WQS, although states did not uniformly follow this practice.[5]

Chemical or biological techniques can be used to estimate the bioavailability of metals. Chemical techniques include measurement of the total recoverable metal fraction, acid soluble metal concentration, total dissolved metal concentration, total metal measurements, labile dissolved metal concentration and chemical speciation methods.[2] Chemical measurements are only capable of approximately measuring bioavailable species, from which assumption are made concerning toxicity. Chemical measurement is not a direct measure of toxicity as the bioavailable fraction is only operationally defined by chemical analysis rather than by interactions with organisms, and different analyses measure different fractions. Chemical measurements which provide a more accurate estimate of the bioavailable fraction tend to be more difficult and expensive to undertake.

Biological toxicity tests are more accurate as they directly measure the response of an organism to metal, which automatically includes bioavailability effects. Biological testing though tends to be very labour intensive and costly. Difficulties in such tests arise though when they are conducted in solutions differing

substantially from the natural waters of interest or organisms are used that are poor representatives of the constituent species of a water body.[4]

Water effect ratios offer a means to account for the contrast between metal toxicity in laboratory dilution water and its toxicity in the water at the site of interest. A WER is operationally defined as the endpoint value obtained with a toxicity test. They can be expressed in terms of dissolved metal concentrations or total recoverable metal concentrations. WERs are complex and expensive, and are difficult for small dischargers to perform, although they have been used successfully in the US.[5] Whole effluent toxicity (WET) tests use the effluent waters for toxicity tests with sensitive organisms. WET tests take into account synergistic effects between various toxicants, as well as the matrix effect. Recently in the US, there has been a change in emphasis from the use of specific water quality criteria to WET based permits.[5] Individually WETs offer a non-mechanistic approach, and require other toxicity identification measurements to be undertaken in order to be used to advise on how improvements in water quality could be made. To determine this for metals it is necessary to conduct WET tests with the gradual addition of strong chealting agents that decrease the bioavailability of metals, and therefore their toxicity.

As numerous chemical and biological tests are available it is often necessary to combine them to determine if an effluent or water is toxic. However, for some systems simpler tests should be sufficient to determine whether a water is toxic or not, based on previous studies. Consequently a tiered approach, in which simpler tests are initially conducted leading to more sophisticated tests as positive results are obtained for toxicity, can be cost effective. Schemes using this approach have been developed in Australia and New Zealand, and the USA.[5]

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5. MSc Environmental and Ecological Science, Lancaster University, course lecture notes.

IES Information

Forthcoming events, courses and conferences

27 January 1999
Local transport solutions for local air quality management
Novotel, Hammersmith, London.
A conference which aims to disseminate the latest thinking on local traffic solutions for local air quality management.
£130-£180.
Details: The Registration Officer, PTRC, Glenthorne House, Hammersmith Grove, London W6 0LG.
0181 741 1516.

15-16 February 1999
Commercial opportunities in emissions trading
Intercontinental Hotel, Hamburg.
Turning the concept of emissions trading into a workable option.
Details: Conference Dept, DMG Business Media Ltd, Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS.
01737 855380.

16-17 February 1999
Health effects of vehicle emissions
The Royal Society of Medicine, London.
This conference will identify and analyse areas of concern and examine how legislation, government policies and innovations can provide solutions.
£300-£350.
Details: Energy Logistics International Ltd, 70-72 St marks Road, Maidenhead, Berks SL6 6DW.
01628 671717.

24-25 February 1999
Environmental decision making analysis and tools
University of Surrey, Guildford.
A short course which reviews the environmental tools for problem solving and decision making in a complex environment.
Details: Mrs P Savill, Centre for Environmental Strategy, University of Surrey, Guildford, Surrey GU2 5XH.
01483 259047.

3-5 March 1999
Urban air quality, measurement, modelling and management
Technical University of Madrid
International Conference.
Details: Lucy Hamilton, The Institute of Physics, 76 Portland Place, London W1N 3DH.
0171 470 4800.

6-8 September 1999
International conference on emissions monitoring
University of Warwick.
Announcement and call for papers.
Will cover legislation, stack and ambient measurement techniques, calibration, air quality and case studies.
Details: Dave Curtis, Source Testing Association.
Fax 01462 457157.

The Hon. Secretary's news desk...

Season's Greetings

I would like to wish all our members and other readers a happy Christmas and a prosperous New Year as we head towards the millennium. This will inevitably be a time for taking stock, reviewing our past performances, but more importantly for planning ahead. IES Council and Committee members have already commenced the process. Our earlier Three-Year Plan, prepared under the chairmanship of Roy Waller, has run its course and a new business plan to take us into the twenty-first century is to be formulated.

For the past, thanks are due to the voluntary efforts of all those who have given their time and energies to the service of the Institution. It is appropriate also to express our appreciation for the continuing interest and support of our Sponsor Members: Marks & Spencer, Rio Tinto, Unilever and United Utilities.

BUPA membership discounts

This matter is becoming somewhat of a marathon exercise due to the receipt of conflicting information from BUPA themselves. We think that we have finally reached an agreement, however.

The Institution has been registered on the BUPA database of organisations whose members qualify for a BUPA scheme discount. This is a standard arrangement offering an initial discount of 10 per cent on premiums with an additional 5 per cent discount for those individuals agreeing to payment by direct debit.

Application may be made directly to BUPA, Thames House, 140 Battersea Park Road, London SW11 4NB. You should quote membership of the Institution, giving your membership number.

1999 subscriptions and membership database

In the first week of January, members may expect to receive their 1999 subscription invoices. May I enter a plea for prompt payment by *all.* This will be of great assistance with our budgeting and financial management and will obviate the considerable administrative burden of reminders. Please remember to date your cheques '1999' and may I also remind you that receipts are *not* issued unless specifically requested at the time of payment *with a stamped addressed envelope.*

This year we are enclosing an additional form with the invoices which we would ask you to complete and return with your subscription to assist us in updating our membership records.

Due to high printing costs it is not expected that we will be publishing an updated membership directory (which itself goes out of date very rapidly). We are, however, investigating the possibility of making this available on disk at a charge. It is also proposed that the list may be made publicly available for specified purposes, as is the practice nowadays with most professional bodies.

Hungarian delegation

An official delegation from the Institute of Environmental Management in Budapest was in London for a visit at the end of October. The Institute is a government sponsored research body and is seeking partners for joint research co-operation on a number of environmental projects. A representative group from the Institution composed of the Chairman, Hon. Secretary and Dr Lohmann met with the delegation and a policy for continuing co-operation between the two bodies was agreed.

Plantlife

A new environmental action group has come to notice recently, promoted by one of our more prominent members, Professor David Bellamy. The charity seeks to preserve the wild plants of the countryside that are threatened with destruction and, in many cases, extinction. Some of the statistics quoted are upsetting and alarming and the movement is deserving of support.

Further details may be obtained from: Plantlife, The Wild-Plant Conservation Charity, The Natural History Museum, Cromwell Road, London SW7 5BD.

RAF

New members

The IES is pleased to welcome the following to membership of the Institution:

Miss C. A. Bryant	Bank Clerk Lloyds Bank Plc
Mr P. C. Collings	Wood Scientist Hutton & Rostron Environmental Investigations Ltd.
Miss R. Davies	Recent Graduate University of Glamorgan
Ms C. L. Denny	Environmental Consultant Environmental Resources Management
Mrs J. J. Douglass	Recent Graduate Nottingham Trent University
Miss D. S. George	Student, Plymouth
Mr P. Georgiades	Recent Graduate Glamorgan University
Miss G. A. Hines	Recent Graduate University of Sunderland
Miss F. C. Hutson	Recent Graduate Manchester Metropolitan
Mr K. Man	Student
Miss O. A. Ogundipe	Recent M.Sc, University of Hull
Ms A. D. Pickett	Student
Mrs K. S. Tanner	Recent Graduate Lincolnshire & Humberside University
Mr B. L. Taylor	Student

BOOK REVIEW

Air pollution and health

This is No. 10 in the series *Issues in Environmental Science and Technology* published by the Royal Society of Chemistry. The collection of technical papers on this subject complement those on *Air Quality Management* published in an earlier issue (Number 8 in 1997).

Where the earlier papers dealt with the subject of different forms of air pollutants, monitoring and some control methods, this latest collection looks at the effects of air pollution of different kinds on health, methods of assessment and the establishment of levels of acceptability.

Title:	***Air Pollution and Health***
Edited by:	***R. E. Hestor and R. M. Harrison***
Publisher:	***The Royal Society of Chemistry, 1998***
ISBN No:	***0-85404-245-8***
Price:	***Paperback £22.50: 170pp***

The first three papers consider, in detail, the effects of gaseous pollutants (sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone), and causes of lung injury from PM10 and chemical carcinogens (benzene, butadiene, formaldehyde and PAHs).

Subsequent papers deal with the setting of air quality standards including the determination of acceptable levels. A particular study deals with American standards for particulate matter and ozone. A final paper considers the health effects of indoor pollutants.

In common with other books in the series, the papers included represent the latest expert opinion and findings from some of the leading international figures in the field. The context is technically expert and comprehensive in nature, providing an excellent overview of the subject. It is recommended reading for environmental practitioners in both the public and private sectors and for post-graduate students.

Dr R.A. Fuller

ENVIRONMENTAL EDUCATION

This section of the Journal is in response to the growth of news, information and activities which underpin the Education Committee of the IES.

Special prominence is given to student activities and projects, national and international initiatives, campus developments and research in order to capture the diversity, wealth and vitality of modern environmental education.

Readers are invited to send articles and letters to:

- ***Derek Blair, School of the Environment, University of Sunderland. Benedict Building, Sunderland SR2 7BW.***
- ***Tel: 0191 515 2737.***
- ***Fax: 0191 515 2741.***
- ***E-mail: derek.blair@sunderland.ac.uk***

Education in the 21st century: vision and challenge for young people

Paris

Between 5 and 9 October 1998 the UNESCO World Conference on Higher Education took place in Paris to create a 'Vision of HE in the 21st century'. Of the 4,000 delegates, 250 were students. Late changes to the structure of the plenary sessions gave more platform time to formal, prepared and political statements reducing the opportunities for student voices to be heard.

Nevertheless, the students present claimed to have made important contributions to the World Declaration on HE (one of the conference's planned outcomes) and, of special interest to ES readers, to the way in which sustainable development can be extended and reinforced in the future.

The main agenda of the UNESCO conference was dominated by topics familiar to us in the UK:

1. The relevance of HE
2. Quality in HE
3. Management and financing
4. International co-operation

However, in addition to the formal sessions, live thematic debates on HE and Development took place which allowed students much more scope for interaction and comment. The debates included *Sustainable human development,* (contributing to national and regional development, world of work, etc), *New trends and innovations in HE* (student vision, new technologies, research, educational system), *Higher education, culture and society* (women, peace, social responsibility and academic freedom), and *HE and the educational system as a whole.*

The UK delegation was led by Baroness Blackstone from the DfEE but included Mr Foulkes of the Department of International Development, Tony Clark, Director HE, CVCP and NUS student representatives. No known environmental education expert or professional environmental institution attended.

An active lobby of national and international student and NGO interests included:

IUS (International Union of Students,
AEGEE (Association des Etats Generaux des Etudiants de l'Europe),
ESIB (National Unions of Students in Europe),
AIESEC (Association Internationale des Etudiants en Science Economiques et Commerciales),
IPSF (International Pharmaceutical Students Federation),
BEST (Board of European Students of Technology),
IMSMO (Intersectoral Meeting of International Students Organisations),
ELSA (European Law Students Association),
EMSA (European Medical Student Association),
IAAS (International Association of Agricultural Students),
IFSA (International Forestry Students Association).

As with the UK delegation, most of these did not have sustainable development as a primary concern, but a few like IPSF, BEST and ESIB expressed their interests in trying to integrate it into their differing interests.

No specific student environmental organisations were represented formally, although GOSEA (Global Organisation of Students for Environmental Action) attended unofficially.

GOSEA featured in the IES Journal Vol 6 No 5 Sept/Oct 1997. Roos Wemmenhove, a Dutch member of GOSEA, attended the conference unofficially and expressed ambivalent views about the process and practice of ensuring that the value of environmental education is embraced in future strategies and visions for HE. She felt, 'sustainable development in the full sense was seen as a rather hard-to-grasp idea, too vague and hardly apparent during the plenary sessions'.

In the thematic debate, however, the importance of sustainable development in and for HE was more directly acknowledged. Participants expressed views that were germane to the modern environmental position and accord with the underpinning principles of environmentalism, e.g. that sustainable development should be a driving force of HE; that values and ethics are important components, that interdisciplinarity is essential in teaching a holistic view, that it should be developed locally with students being important stakeholders, contributors and actors. Sentiments that have been long on the IES agenda.

But, sustainable development is still too vague and peripheral to those in control according to Ms Wemmenhove and many environmentalists. Education for sustainability is an ideal that many could subscribe to if it was communicated more clearly. It makes sense. Some interests appear threatened by its implications – perhaps not surprisingly. Developing countries were an important fraction of the 150 countries represented in Paris and have a lot to say about sustainable development, often different from the developed countries.

In the end, the UNESCO Conference agreed generally on the concept of a 'University Platform for a Sustainable Future' and will seek to establish a 'Sustainability Future Award Scheme', contributing towards the implementation of Local Agenda 21. And as happens at conferences of this magnitude and type a whole range of new initiatives were optimistically generated such as a special fund for 'direct mutual transfer of knowledge', a 'future audit system' and 'feasibility study of LA 21.' Dhr H van Ginkel of the UN University will start working on these plans. Another colleague, Dr van't Land, will start an electronic network to accumulate an up to date overview on everything there is on sustainable development in HE. A massive agenda!

Hard questions can be directed at the generality and even blandness of the fine words of the Conference Declaration and Action Plan: Article 1 of the World Declaration affirms, for example, that the 'core missions and values of HE, in particular the mission to contribute to the sustainable development and improvement of society as a whole, should be preserved, reinforced and further expanded…' How will these ideals be realised? Will they ever be implemented? How does it relate to what is being done now? Will UK students respond to this agenda in any new way?

London

Meanwhile, the Government has launched a UK Children's Parliament on the Environment – a joint initiative of the DETR and DfEE – launched by Deputy Prime Minister John Prescott and Education Secretary David Blunkett on 4 November 1998. It targets Year 6 pupils (10-11 year old children) – potential students of HE in about the year 2009 and stakeholders in the future of the planet – in the belief, according to Mr Prescott, that 'it's only right that they should have their say'. The initiative will take the form of a national competition by essay and debate around the theme of Sustainable Development culminating in a national Children's Parliament in May 1999 for regional winners. The debating competition will be judged first at local authority level and then regionally. From the regional event two schools (four children) will take part in the national Parliament combining with winning essayists to form a 54 strong Parliament.

Three years ago the first ever International Children's Conference on the Environment was staged... attracting 800 children from 83 countries, who discussed waste recycling, wildlife, and sustainable development

The Children's Parliament is described as an extension of the Government's 'Are you doing your bit?' publicity campaign which aims to demonstrate to consumers that they can take simple actions which will help fight both local pollution and global warming. Whilst Mr Prescott applauds children's passionate care for the environment and invites them to make a difference to the world they live in, Mr Blunkett stresses the value of involvement to 'practise active citizenship'. If the purpose of the exercise is to develop the interest that young people have in the environment and to stimulate them to think about what can be done and in particular what they can do themselves to secure a healthy future for everyone, then one might ask why the importance of environmental education has been recently devalued in the National Curriculum.

Perhaps both Ministers are responding, albeit belatedly, to Chapter 25.12 of Agenda 21 which addressed the environmental agendas of children (9-13) stating that 'the specific interests of children need to be taken fully into account in the participatory process on environment and development in order to safe-

guard the future sustainability and to improve the environment'. UNEP supported the production of the children's edition of Agenda 21 in those early years. Then, three years ago the first ever International Children's Conference on the Environment (ICC) was staged in Eastbourne attracting 800 children from 83 countries who discussed waste recycling, wildlife, and sustainable development and set up a Leave it to Us (LITU) network of children groups and a Junior Advisory Board of 12 children (11-13 years).

Are the present initiatives on sustainable development for children linked to these previous activities? Does UNEP/UNESCO talk to our Government and *vice versa* on the environmental agenda? Will the child ambassadors of yesteryear advise the new breed of child parliamentarians of today? Will the students of the new millennium – future MEPs and decision makers – benefit from the Parisian Declaration and debates on sustainable development? Or will the vision for the 21st century remain in words only, another restatement of the same old ideals? There are less than 400 days now to the next century – enough time for responses which this column is interested in publicising.

Further information

HE – A Vision for the 21st Century – http://www.education.unesco.org/educprog/wche/index.html

Children's Parliament on the Environment, Project Coordinator, School of Education, Cardiff University, PO Box 922, 21 Scenghennydd Rd, Cardiff CF2 4YG. Tel 01222 874997.

Derek Blair

ENVIRONMENTAL NEWS

Air Quality Management workshop: the consultation process

A workshop for air quality managers held at the The Air Quality Management Resource Centre, based at the University of the West of England, Bristol

Best practice in respect of air quality management consultation was the subject of a workshop, organised by the West of England Air Quality Management Resource Centre, Bristol, which took place on 15 October. The event attracted representatives from 17 local authorities, mainly from the South West region and South Wales.

Presentations from local authorities and the Environment Agency provided an excellent insight into how other statutory consultation processes are effectively undertaken, to include the Bristol City Council Local Plan, Local Agenda 21 in Bristol and the Environment Agency's Local Environment Agency Plans (LEAPs). Tim Williamson from the National Society for Clean Air and Environmental Protection (NSCA) also spoke of the recent NSCA paper on *Consultation for local air quality management.*

A number of important points were clarified. The development of partnerships between stakeholders is of paramount importance, and effective consultation must be a two-way, interactive and participatory process. The use of local skills, knowledge, experience and resources provides for a more meaningful consultation process, enhanced through innovative techniques for getting the relevant messages and information across in an understandable and simple manner.

Delegates clearly envisaged a variety of potential problems with the consultation process. Consultees were considered too numerous, with implication for authority resources, and the question arose as to whether officers undertaking the air quality management work were best equipped to manage the consultation process effectively. Public ignorance of the issue and the unlikely acceptance of potential actions to be taken to combat air quality problems were raised. Different political and working agendas of consultees, and the potential for feedback received to represent extreme views were also clear concerns.

The workshop concluded with participants working in groups to identify perceived difficulties in air quality management consultation, and to consider a model consultation strategy. All groups identified a staged approach to the consultation, seeing the need for a structured process using a variety of techniques for getting the information across, to include local meetings, exhibitions, events, use of the Internet, audiovisuals and leaflets.There were however, differences in, for instance, the target groups identified, and the stages at which the various groups are to be consulted. One group proposed consulting with the general public at a third stage of the process, recognising the important role that councillors, resident groups and focus groups have to play.

Copies of the follow-up report to the workshop are available from Nicky Woodfield on 0117 976 2716 (or email nicky.woodfield@uwe.ac.uk)

Diary dates

20 January 1999 – Air Quality modelling techniques workshop (Screening techniques and more advanced techniques)

23 February 1999 – Air Quality Management Review and Assessment Workshop: Stage 2

Nicky Woodfield

■ *Nicky Woodfield is Co-ordinator of the Air Quality Management Resource Centre, University of the West of England.*

Environmental policy making for the new millennium: a new approach?

In its 21st report, *Setting environmental standards,* published in October, the Royal Commission on Environmental Pollution calls for a new approach to deciding environmental policies. A key feature of this approach is the need for sensitivity to people's values alongside rigorous and dispassionate analysis.

The report indicates that protecting the environment has become a need to prevent damage which may be global in scale and occurring some way into the future. It emphasises that commitment to sustainable development means that pursuing material well-being and enhancing social equity have to be reconciled with protection of the environment. The report's 85 key conclusions are summarised as follows:

Decisions about environmental policies must be based on the scientific evidence and an analysis of appropriate options, taking into account risks and costs, and informed by people's social and environmental values. Better ways need to be developed to articulate and take into account such values from the earliest stages of decision making. The limitations and uncertainties in any estimates of risk must always be made clear in ways which are meaningful to people without particular specialist knowledge.

The Department of the Environment, Transport and the Regions, in consultation with other government departments, should consider how new methods such as citizens' juries or consensus conferences should be incorporated into the procedures for considering environmental issues and setting environmental standards, including the framing of questions to be addressed in analysis and communicating the results of scientific assessments in a comprehensible form. It should also collate the experience gained, and draw up a code of practice for use of the new methods, designed both to maximise their effectiveness and preserve their integrity.

Environmental standards should be set for the smallest area for which it is sensible and effective to do so. Bodies setting environmental standards must operate in an open and transparent way. Limitations and uncertainties associated with data at each stage of scientific assessment should be recognised. Such bodies should draw an explicit distinction between scientific statements and recommendations it wishes to make after considering a scientific assessment in conjunction with other factors. Such factors should be clearly identified.

When environmental policies or standards are adopted, it should always be made clear in an explicit statement whether they are designed to protect the natural environment, human health, or both, and the degree and nature of protection they are intended to afford. Where a standard is set at European or international level, it should be set in a form that allows as much discretion about the methods of implementing it as is feasible without undermining its effectiveness.

To prevent development of new understanding being restricted by established regulatory procedures, vested interests or small closed communities of experts, publicly funded programmes of environmental research should include provision for independent investigation and inquiry.

To ensure that the full ranges of options and repercussions are considered, assessments of technological options carried out as inputs to decisions on environmental policies or standards should be on a life cycle basis. Broadly based assessments of such options should not be used as an excuse for avoiding or delaying significant improvements available at particular stages in the cycle.

Use of direct regulation, economic instruments and self-regulation in combination is the best way to promote adoption of clean technology, while not putting at risk compliance with standards to protect the human and natural environment from specific hazards.

■ *Setting environmental standards,* published on 7 October 1998, is the Royal Commission's 21st Report. It has been laid before Parliament and is available from the Stationery Office (Cm 4053, ISBN 0 10 140532 4), price £21.40.

Derek Hall

Application of the natural step to water management

Dr Mark Everard

Introduction

Many initiatives seeking to contribute towards sustainability lack focused definitions of sustainable development relevant to their intended purpose. This can too frequently lead to results that are merely 'greening' – peripheral 'end-of-pipe', 'end-of-field' process optimisation, mitigation, or reputation-building measures – or, worse still, seek as an adequate end-point compliance with basic obligations.

The distinction is more than semantic. Sustainable development demands deeper re- evaluation of policy and practice, addressing wise use of the environment that sustains human health, wellbeing, and economic interests. Whether in industry, the public sector or elsewhere, it necessarily involves internalising all economic, ecological and social costs, as well as accounting fully for the benefits accruing from intact ecosystems and stable societies. A commitment to sustainable development is therefore wise for more than altruistic reasons, since a more sustainable business or activity will be less disrupted by resource scarcities, reduced environ-

mental 'headroom', adverse public opinion, more stringent environmental and social regulations, etc, in a future world in which population is set to increase and environmental resources to diminish.

Since sustainable development touches all aspects of human life, it necessarily entails a cross-society response to environmental problems, and to meeting human needs in less harmful ways. This societal context means that sustainable development can not be achieved by a business, local government organisation or other enterprise in isolation. Since the application of sustainable development therefore pervades all sectors of society, a set of high-level principles are therefore required to offer a generic, yet robust and science-based, framework for the development of a shared vision, and for shared decision-making, across society.

Sustainable development and the water environment

The water cycle, together with the aquatic ecosystems that it supports, demonstrates sustainability: the capacity for indefinite continuance. Current human exploitation of the water cycle falls far short of sustainability, and indeed it is widely predicted that the availability of clean fresh water – essential to all aspects of human wellbeing and economic activity – will be a limiting factor to development globally in the next millennium (Ramsar, 1996). Indeed, it is currently so even in regions of developed countries such as the UK, the USA and Australia.

Historic approaches to protection of aquatic resources have all too often been undertaken as a 'greening' exercise, comprising merely 'sustaining' isolated aquatic habitats by addressing local water quality or hydrological problems on an *ad hoc* basis. Although necessary in some cases to protect our most critically endangered species of plants and animals, this fragmented approach fails to consider the aquatic resources within their geographic contexts, and tends to externalise the environmental costs of the technical fixes (for example, additional energy consumed by pumping and treatment processes, habitat loss due to new plant, etc). This situation is frequently compounded by an inflexible investment infrastructure and 'ring-fenced' budgets tied to essentially non-integrated solutions. Reactive 'spatial' approaches to protection of aquatic resources is not true sustainable development; not only does it externalise many environmental costs, it also isolates the resources from the living landscape in which they are a part (Everard, 1998).

Models for sustainable development

Essential resources, such as water, touch all human activities and are influenced by decisions from all sectors of society. Since it is unreasonable to expect decision-makers across all social sectors to consult with aquatic experts on every decision that might impact on hydrology, water chemistry or aquatic habitat in some direct or indirect manner (i.e. potentially all decisions), generic yet scientifically robust frameworks are therefore necessary to support wise decision-making. Robert *et al* (1997) recognise eight essential criteria for such frameworks, including a scientific basis, applicability at different scales, consistency with actions based on self-interest, simplicity of understanding, etc.

Systems thinking is a helpful technique for understanding, and making wise and strategic decisions about, complex systems. The systems thinking approach starts by identifying holistic dynamic systems, and then seeking the first-order principles governing them. It therefore offers a helpful means to conceptualise a sustainable society. Biospheric cycles offer a natural and relevant systems thinking context for tackling the challenge of sustainable development.

The Natural Step (TNS) is a systems thinking approach founded on the cycling of matter and energy in the planet's biosphere, from which first-order 'system conditions' are derived as generic principles to guide decisions across and between social sectors. The scientific starting point of The Natural Step is a recognition that this planet is virtually closed to matter, yet open to energy. Nature – which as we have observed is inherently sustainable – has evolved to produce no net waste, recycling matter sustainably through complex ecosystems containing diverse pathways for efficient and adaptive processing, powered by inputs of solar energy. By contrast, developed society relies substantially upon linear (mine-use-dispose) resource flows. Linear resource flows inevitably cause problems, being alien to nature's cyclic flows of matter, since wastes inevitably build up in the biosphere (or living parts of the planet). A good example of adverse impacts deriving from linear resource flows is the heavy reliance of developed society on cheap and abundant energy unlocked from fossil fuels, whose wastes accumulate due to their production at rates exceeding nature's reintegration rates, threatening climatic stability at the global scale. The TNS model is based on nature's sustainable cycle, and the four system conditions define how a sustainable society must act 'ecocyclically'.

The scientific understanding of sustainability that underpins The Natural Step provides a robust basis, giving the system both credibility and generic applicability. It is also easily understood and communicated, and furthermore enables environmental and social issues to be conceived as not merely essential to continued survival and health, but also to longer-term economic performance and social wellbeing since all human activities ultimately depend upon resources provided by nature's solar-powered cycles. As such, the TNS model is consistent with decisions based on enlightened self-interest, providing a powerful incentive for business to treat sustainable development as a business priority. TNS thereby integrates economy, ecology and society in a pragmatic yet scientifically-robust manner relevant to decision-makers, fulfilling the criteria identified by Robert *et al* (1997).

The basic model upon which The Natural Step is based is illustrated in Figure 1, which indicates that a sustainable society is one in conformance with the 'rules' of nature. An unsustainable society is one that offends these 'rules', and which will inevitably contribute towards the breakdown of the support systems upon which it ultimately relies. The Natural Step identifies four such first-order principles, referred to as the 'system conditions', which are indicated in Figure 2 and described below.

System condition 1 – *Substances from the Earth's crust must not systematically increase in nature* – relates to those substances immobilised in the lithosphere (the 'rocky' and largely inert parts

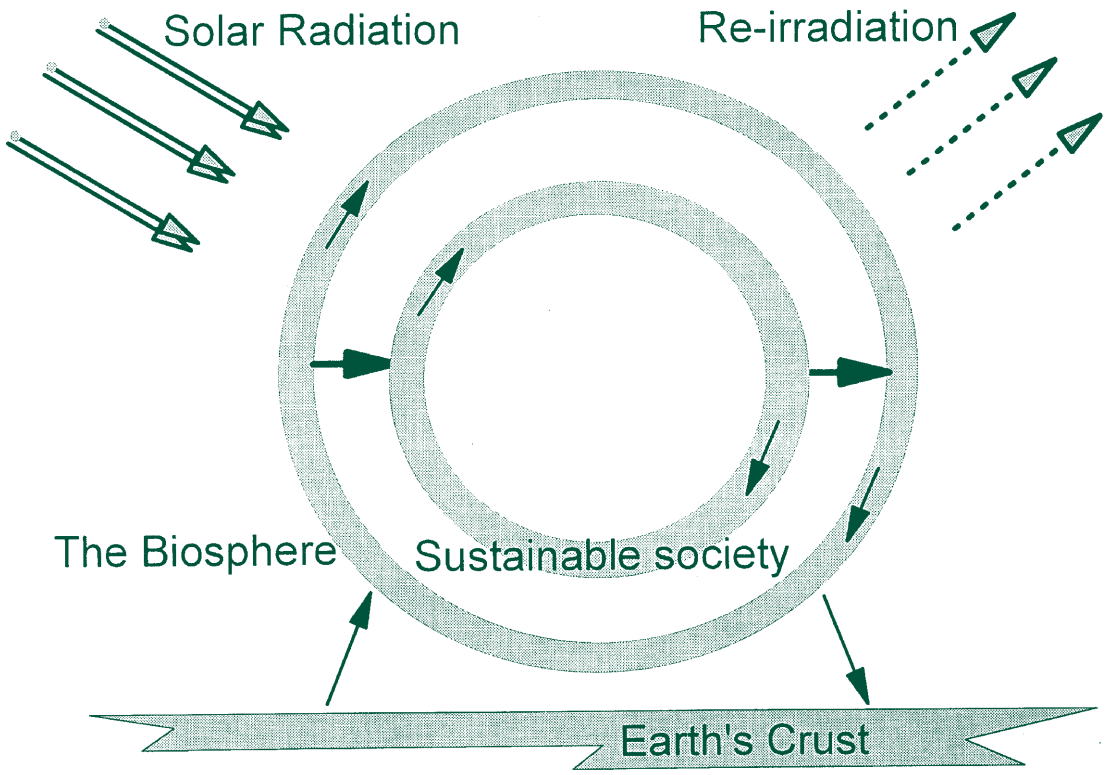

Figure 1

of the planet) by billions of years of slow sedimentation and biomineralisation in the biosphere. As noted above, linear resource usage by industry and agriculture tend to reintroduce heavy metals, nutrients, radioactive substances and fossil fuel wastes into the biosphere at rates substantially exceeding nature's reintegration or redeposition rates. Consequently, these wastes tend to rise systematically in concentration, giving rise to potentially adverse and unpredictable impacts upon climate, ecology and economic values deriving from them.

System condition 2 – *Substances produced by society must not systematically increase in nature* – relates to man-made substances. Substances new to nature are processed inefficiently, if at all, by biochemical systems that have evolved over 4.5 billion years in their absence. Breakdown and reintegration of the estimated 100,000 such substances currently in production is therefore slow, leading to systematic accumulations in the biosphere. Therefore, predicting tolerable limits, and particularly in the light of the complexity of ecosystems, the diversity of substances, and our largely incomplete knowledge. The relatively recent discovery of endocrine disruption is an example of an unforeseen, poorly understood yet potentially widespread problem arising from the ubiquitous and incautious utilisation of synthetic substances. It is for these reasons that the Swedish government is considering phasing out persistent bioaccumulative substances, regardless of toxicological data, since 'new, unexpected forms of toxicity may be uncovered in the future' (ENDS, 1997).

System condition 3 – *The physical basis for the productivity and diversity of nature must not be systematically diminished* – addresses the quantity of productive surfaces. The extent of green surfaces, and their biological diversity, are the 'engine' of biospheric processing equipped throughout millennia of evolution with diverse ecosystems providing adaptable and efficient pathways. The natural life support 'services' provided collectively by earth's ecosystems are generally overlooked in development planning and business decisions, yet are clearly of fundamental importance to society, and of potentially massive economic value. Aquatic ecosystem services, and particularly those derived from wetland systems, are known to be of particularly high value through the hydrological, physico-chemical and ecological processes they perform, and the social values accruing from them.

System condition 4 – *There needs to be far more efficient use of resources with respect to meeting human needs* – highlights the social considerations permitting compliance with sustainable resource use. Primarily it addresses issues of resource efficiency and equity. Whilst the need for improved (Factor 4, Factor 10, etc) resource efficiency is already well recognised, society is less adept at responding to the international dimension of environmental problems, and the contribution of injustices and inequities to social instability. Specific to the water environment, there is a pressing need to develop more water-efficient technologies and sustainable wastewater systems, make these available to the developing world where water scarcity presents particular problems, and develop appropriate tariffs for equitable provision of essential water services.

TNS is designed as a generic tool to support more sustainable decision-making on a society-wide basis, and as such is applicable across a range of scales. It is helpful in conceiving innovative ways of managing the water environment (Everard, in press), since water is one of the fundamental cycles upon which ecosystems and human interests ultimately depend.

Conclusions

The Natural Step is based on a comprehensive, science-based and generic

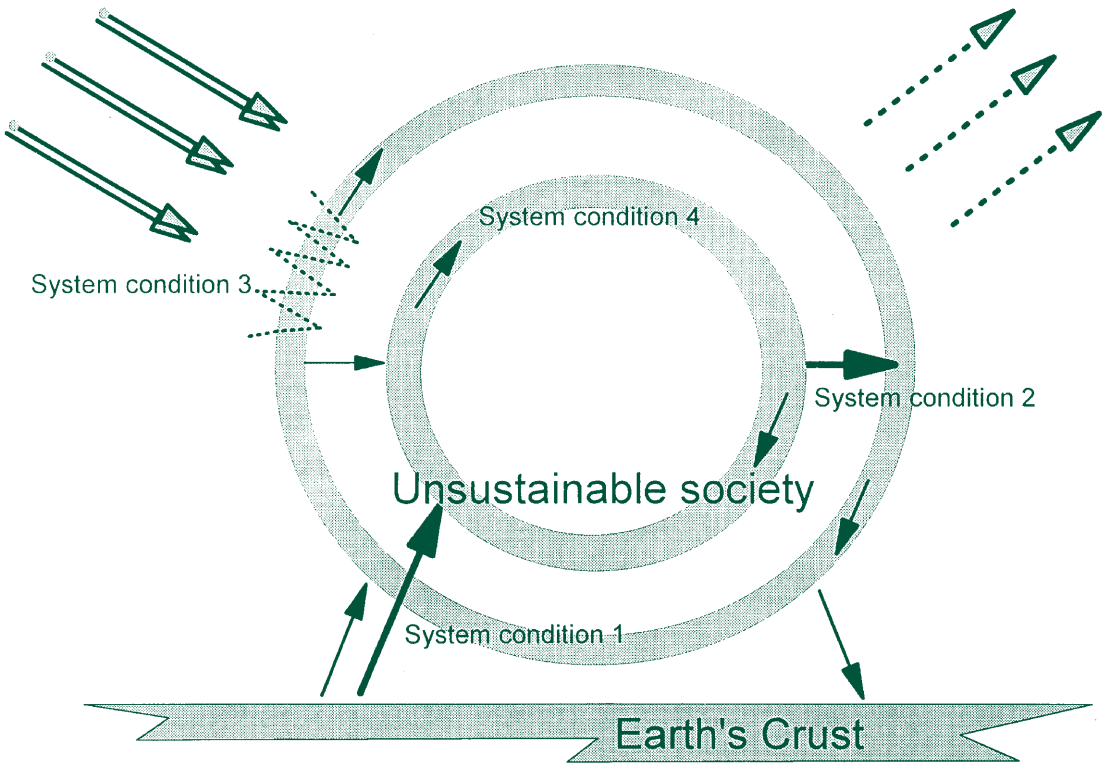

Figure 2

model of sustainability. The readily-understood model is helpful in promoting dialogue and consensus about complex environmental issues, offering the added incentive of demonstrating that a commitment to sustainable development is of direct value to decision-makers in business, government and other social sectors. The four system conditions of TNS define a sustainable world which, though not achievable immediately, enable enterprises to 'navigate' increasingly towards sustainability through incremental decisions. Above all, TNS makes sustainable development tractable and is supportive of immediate decision-making, averting the procrastination that stems from preoccupation with contentious detail. It also offers a context to address apparently isolated decisions which, though apparently inconsequential in isolation, may have substantial consequences in aggregate.

Water touches all aspects of humanity, and is accordingly affected by all sectors of society. There is therefore a pressing need to develop generic decision-support tools usable by decision-makers across society, and who are unlikely to possess specialist aquatic expertise nor perhaps even to be aware that their decisions affect aquatic resources. The goal of a sustainable water cycle is therefore challenging, and particularly so to linear industrial and commercial procedures. However, TNS provides not only a conceptual model to begin to work towards it, but also a scientifically-neutral framework against which to negotiate in the light of obstacles such as historic water and land use rights, etc.

Increasing population and decreasing environmental 'headroom' will inevitably enforce more sustainable behaviours in the future. TNS provides a mechanism to pre-empt these pressures, and for an enterprise to decide in advance how it will address them. Clearly, the challenge will require further research by ecologists, economists, social scientists, and those communicating science to decision-makers. The 'systems thinking' approach used in TNS has a politically neutral scientific basis, and thereby provides and comprehensive and generic framework to focus debate, stimulate innovation, and identify opportunity. In the context of the water environment, some of the privatised water service companies in England realise that a sustainable water cycle is essential to underpin their core business, and have committed to sustainable development to the advantage of their own profitability and long-term security, in addition to their concerns for the wellbeing of future generations.

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■ *Dr Mark Everard is Director of Science at the Natural Steps UK, 9 Imperial Square, Cheltenham, Gloucestershire GL50 1QB. This article formed part of a presentation to the SIL conference in Dublin, August 1998.*

Latest climate predictions

The latest climate predictions, which were presented to a world audience of scientists and politicians at the Buenos Aires climate change conference in November suggest that, by 2050, vegetation will lose its ability to absorb CO_2, thereby accelerating the build-up of CO_2 in the atmosphere.

Commenting on the prediction, Environment Minister Michael Meacher said:

'Globally we expect to see a temperature rise of 3°C by the end of the next century, but it won't be an even warming – the land will warm faster than the sea. This may not sound much, but by 2050 millions of additional people will face shortages of food and water, an increase in the incidence of malaria and disruption due to coastal flooding.

'These results identify the problem facing everyone on the planet – this is a threat we cannot afford to ignore.

'The UK is committed to leading the fight against global warming. As well as working hard with other nations to deliver a programme to meet the Kyoto targets, the UK will be presenting these findings in Buenos Aires. This will maintain the momentum begun in Kyoto and help keep the pressure on the international negotiation process.'

The latest findings from the Hadley Centre show:

- Average global temperature in 1998 likely to exceed 1997 – the hottest on record;
- 1997-79 El Niño was the most extreme on record;
- Man-made greenhouse gas emissions have made a substantial contribution to increase global temperatures in the last 50 years;
- A further 3°C warming in the next 100 years – the land warming faster than the sea; and
- A slowing down of the North Atlantic Circulation of about 20 per cent by the middle of the next century – although Europe still warms.

This will mean that by the 2050s we could see:

- Tropical forests die off in parts of northern Brazil;
- Tropical grasslands transformed to desert or temperate grassland;
- 20 per cent more people at risk of hunger in Africa;
- 20 million extra people at risk of flooding due to sea level rise of 21 cms;
- 170 million extra people living in countries with extreme water stress; and
- Increased exposure to malaria.

The UK is taking a leading role in addressing the threat of climate change. In Kyoto Last year the EU agreed to a legally binding emission reduction target of 8 per cent below 1990 levels for the period 2008 to 2012. Under the UK Presidency an agreement was brokered to share out the target between member states, the UK share being a reduction of 12.5 per cent. In addition, the UK has a domestic aim to cut emissions of CO_2 by 20 per cent by 2010. The Kyoto reductions are just a first step and more will need to be done.

The Protocol agreed at Kyoto in December 1997 was an historic turning point, with developed countries taking on legally binding greenhouse gas emission reduction targets for the first time. The forthcoming meeting to the UN Framework Convention on Climate Change was held in Buenos Aires (2-13 November 1998) and it looked at the practicalities associated with meeting these targets.

Specifically, it addressed the details on the implementation of the flexible mechanisms, for example the rules for the operation of emissions trading, and aim to put in place a programme of work to complete all outstanding matters from Kyoto to enable the Protocol to enter into force.

The results from the latest global climate model run from the Hadley Centre at the Meteorological Office and a first view of its global implications were presented at the Convention meeting.

The model has been improved in a number of ways. Until now, the Hadley Centre's climate model, like most others, relied upon corrections called 'flux adjustments' at the ocean atmosphere interface in order to prevent an unrealistic drift in temperatures. The latest version of the Hadley Centre model, however, represents a great step forward in that these are no longer needed. Being able to operate without flux adjustments increases our confidence in the model's predictions. The model also includes a high resolution ocean improved treatment of land surface processes and better representations of sulphate aerosols and individual greenhouse gases.

Using IPCC-projected increases in greenhouse gases over the next century, the model predicts that globally we will see a temperature rise of about 3°C by 2100, and the rises over land (where of course the most important impacts will be experienced) will be almost twice as great as those over the sea. Because total global sulphur emissions are not expected to change substantially over the next century, the global warming is still close to 3°C when the effects of sulphur are included in the model.

The model not only predicts the future – it helps us understand the recent climate. Temperature records over the past 140 years show that the world has warmed by 0.6°C. We need to know if this is due to human activities, but distinguishing a human-made signal from background natural climate variability is a challenge. To do this, advanced statistical techniques are used to compare the patterns of observed temperature change, both at the earth's surface and throughout the atmosphere, with those simulated by the model. The results of this work support the IPCC 95 statement that the balance of evidence suggests a discernible climate change due to climate activities.

The Government has put in place a

'This may not sound much, but by 2050 millions of additional people will face shortages of food and water, an increase in the incidence of malaria and disruption due to coastal flooding...'

series of linked global assessments to provide a first view of the latest results of the Hadley Centre's global climate model in terms of its impacts. These assessments look at possible effects on natural vegetation, water resources, food supply, coastal communities and human health. Preliminary work on the impacts for the 2050s is presented in the brochure *Climate change and its impacts*. This suggests that tropical forests will die back in many areas of northern Brazil. In other areas of the world tropical grasslands will be transformed to deserts or temperate grassland. Vegetation will absorb CO_2 at the rate of some 2-3 GtC per year in the first half of the next century; this compares to current human-made emissions of about 7GtC per year. After 2050, and as a result of vegetation dieback, this will become a source of about 2GtC per year, thereby enhancing CO_2 build up in the atmosphere.

Water resource stress in many of the poorest countries, already expected to increase, will be exacerbated by climate change. Due to climate change alone, some 66 million extra people will live in countries with water stress, and some 170 million people will live in countries which are extremely stressed.

Under this climate change scenario crop yields will increase in high and mid-latitude countries such as Canada and Europe, but decrease in lower latitudes. Africa will be worst affected with some 20 per cent additional people at risk of hunger due to climate change alone by the 2050s.

Global mean sea level rise by the 2050s is predicted to be 21cm. If coastal protection evolves as in the past, then each year, over 20 million extra people will be at risk of flooding due to sea-level rise. South and south-east Asia are most vulnerable. While growth in population will itself increase the number of people at risk from malaria, climate change will increase the proportion of the world population at risk, particularly in areas where the disease is currently not endemic.

The work on the different sectors has been undertaken by:

Natural vegetation: Andrew White, Andrew Friend and Melvin Cannell, Institute of Terrestrial Ecology, Edinburgh;

Water resources: Nigel Arnell, Southampton University;

World food supply: Martin Parry and Mathew Livermore, Jackson Environment Institute, University College London, Cynthia Rosenzeig, Goddard Institute for Space Studies, Anna Iglesias, Ciudad Universitaria, Spain, Gunter Fischer, International Institute for Applied Systems Analysis, Austria;

Coastal communities: Robert Nicholls, Middlesex University;

Human health: Pim Martens, the Netherlands, Antony McMichael and Sari Kovats, London School of Hygiene and Tropical Medicine, Mathew Livermore, JEI, UCL.

■ Copies of the brochure: *Climate change and its impacts* are available from Dr Geoff Jenkins, The Hadley Centre for Climate Prediction and Research, The Meteorological Office, London Road, Bracknell, Berks, RG12 2SY.

Email: gjenkins@meto.gov.uk

Website: www.meto.gov.uk/sec5/sec5pg1.html

Reference: DETR News Release 917: 2.11.98.

Diary dates 1999

18 January	GP Committee	13.00
8 March	Education Committee	10.30
8 March	AGM followed by Council	13.30
8 March	Burntwood Lecture	18.30
19 April	GP Committee	13.00
16 June	Education Committee	10.30
16 June	Council	13.30
6 September	GP Committee	13.00
6 October	Education Committee	10.30
6 October	Council	13.00

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IES ties

IES ties are available in either dark blue or dark green with a gold IES logo. They can be obtained from the Secretary, price £6.00 inluding post and packing (£7.00 overseas).

Burntwood Lecture

The Burntwood Memorial Lecture will now take place on Monday 8 March 1999.

The speaker will be the Rt Hon John Gummer MP and the title:

'HOW JUST IS THE DEMAND FOR SUSTAINABLE DEVELOPMENT?'

The lecture, at 6.30pm in the Scientific Societies Lecture Theatre, New Burlington Place, London W1, will be followed by a reception.

- ***Admission is by ticket only, available free on application to the IES at PO Box 16, Bourne, PE10 9FB. Please send a stamped addressed envelope (DL size: 220 x 110mm).***

Contributors

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