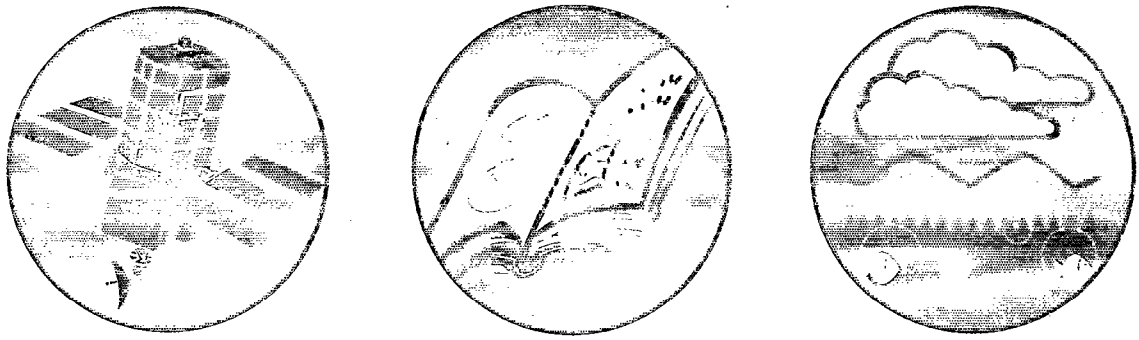
Scoping Study for Collaborative R&D Projects between the Environment Agency and L'Agence de L'Eau Seine-Normandie



Research and Development

Technical Report
W79

ENVIRONMENT AGENCY

Scoping Study for Collaborative R&D Projects between the Environment Agency and L'Agence de L'Eau Seine-Normandie

Technical Report W79

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Statement of use
This scoping study investigates the extent of water management-related R&D interest between the Environment Agency and the Agence de l'Eau Seine-Normandie (AESN), one of six French Water Agencies. The Context is a Common emphasis on intergrated environmental management based on river catchments and the commitment by both British and French governments to the achievement of sustainable development. The report identifies three key common themes for future collaborative R&D, prioitises them and proposes specific R&D Projects within each identified theme.

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Amendments
Any corrections or proposed amendments to this manual should be made through the regional Agency representative on the Water Resources National Abstraction Licensing Group.

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EXECUTIVE SUMMARY

The Scoping Study was initiated to investigate some of the approaches relating to catchment water management with particular reference to Local Agenda 21 and sustainability.

There are obvious advantages in collaborative R&D projects which endeavour to provide for the sustainable management of the water environment and which facilitate review strategies and implementation and promotion of international scientific research co-operation on water issues for both SAGEs and LEAPs. The establishment of partnerships, exchange of expertise and exploration of long-term R&D is central to the identification of best current practice and in developing best preferred practice applicable at the national level.

The promotion of such R&D projects at the national level would ensure some degree of national symmetry in adopted policies. Key features of the scoping study focus on urban conurbations, rural catchment issues and the implementation of Thames 21 and SDAGE. The ideas for future research will be reported to the French Inter-Agence Research Committee and to Board of the UK Environment Agency.

The management of freshwater has been highlighted as being one of the major European environmental issues. The European Environment Agency have stated 'Pollution trends are constraining potential water use but total water demand is increasing - such trends are not sustainable' (EEA, 1995a). Education has a vital role to play in raising awareness of this and other environmental issues in the community.

Three themes and projects have been identified for R&D consideration:

(I) Wetlands for Water Quality Improvement
(ii) Sustainable Management of Urban Runoff
(iii) Environmental Education and Information

Theme (I) has been prioritised by applying criteria which include the anticipated demand of local authorities and the regional and national levels of the Environment Agency for the adoption of constructed wetlands as a sustainable method of runoff management for pollution control. The Role of natural wetlands in the treatment of non-agricultural runoff is a priority theme for L'Agence de L'Eau Seine Normandie and the Inter-Agence Programme Nationale de Recherche sur les Zones Humides.

Key words: Agenda 21, best practice, education, runoff, sustainability, water management, wetlands

1. INTRODUCTION

1.1 Background to the Scoping Study

Earlier discussions between L'Agence de L'Eau Seine-Normandie (AESN) and the Environment Agency (the Agency) within the framework of the French Ministry of the Environment and the former UK Department of the Environment (DoE - now merged into the Department of the Environment, Transport and the Regions - DETR) Bilaterals and the IVth inter-Agence Research Programme, highlighted the advantages of international collaboration on R&D at both the regional and national levels. Many of the themes within the inter-Agence Programme were directly comparable to those within the Agency's R&D Programme. AESN is responsible for 40% of the Inter-Agence budget.

In particular, similarities between AESN's Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) and Schema d'Aménagement et de Gestion des Eaux (SAGE) initiatives and the Agency's 'Thames 21' strategy and individual Local Environment Agency Plans (LEAPs), formerly Catchment Management Plans(CMPs) were identified. The principal objective for both is to ensure a totally integrated approach to water management and to strengthen links with statutory land use planning. The commitment of French and UK governments to Sustainable Development and to broad public involvement through local Agenda 21 initiatives provides a secure foundation for the implementation of both SAGEs and LEAPs. This Anglo-French scoping study was thus established to investigate some of the approaches relating to catchment surface water management.

The partnership also involves the research groups of the Urban Pollution Research Centre within Middlesex University and Centre d'Enseignement et de Recherche pour la Gestion des Ressources Naturelles et de l'Environnement (CERGRENE) within the Ecole Nationale des Ponts et Chaussées. Both groups are evolving at the forefront of scientific research into urban pollution management.

1.2 Objectives of the Scoping Study

The principal aim of this scoping study is to select topics for future joint Research and Development (R&D) projects important to both the Environment Agency for England and Wales and AESN within the context of the SDAGE and LEAPs initiatives. See Appendix I for Terms of Reference.

Topics were prioritised based upon the following criteria:-

(I) The role of environmental management in the context of Local Agenda 21 and sustainability.

(ii) The identification of areas of R&D expertise in which the Thames Region of the Agency/AESN are keen to develop initiatives at the regional level, with application at the national level.

(iii) The provision of an exchange of expertise, information, techniques, staff and researchers, between AESN and the Agency.

(iv) The potential to lead to recommendations that will be straightforward in application, relevant to environmental managers and understandable by the public-at-large.

(v) The initiation of a partnership that will produce high-quality scientific research, development and training.

1.3 Overview

1.3.1 The river catchments of the Seine and Thames

Many European cities have developed around important water bodies such as rivers, lakes, estuaries and coastal waters. In all cities water is a vital economic resource and surface water is important as a habitat for wildlife and for its influence on the urban climate. The major anthropogenic activities affecting the river system are supra-catchment effects (acid deposition, inter-basin transfers); catchment land-use change (afforestation and deforestation, urbanisation, agricultural development, land drainage, flood protection); corridor engineering (removal of riparian vegetation); flow regulation (dams, channelization); dredging and mining; instream impacts (organic and inorganic pollution) thermal pollution, abstraction, navigation, exploitation of natural species, introduction of alien species) (European Environment Agency (EEA), 1995a).

The Seine has a catchment area of 79,000km^2 and drains 14% of the area of France and the Thames has a catchment area of 15,000km^2 and drains 6% of the area of England (EEA, 1995a). These catchments are densely populated - Paris has an estimated population of 17.3 million people and one of the highest recorded population densities in Europe (>20,000 inhabitants/km^2, EEA, 1995a) whilst London has a resident population approaching 12 million (NRA, 1994a). The pollution sources within the catchments range from urban to agricultural and inherent processes range from microbial degradation (heterotrophic activity) to eutrophication (autotrophic activity). As a consequence, the rivers are significant sources of contaminants and nutrients flowing into the North Sea.

Both river catchments have been modified since the industrial revolution. For many years these rivers have been open channels for waste dilution and transport, a source of danger with regard to flooding and poor sanitation. The rivers were used as a water resource and as a sewer. Continued development in the catchments resulted in a decrease in water quality, whilst building on the flood plain led to an increased risk of flooding in adjacent urban areas. Oxygen depletion downstream of Paris, due to wastewater discharges has been monitored in the Seine since 1874. Currently, the Seine, downstream of Paris is ranked as being one of the poorest quality rivers in France.

Both the Seine and the Thames flow through the historical cores of Paris and London and the constraints of dense urban development and a system of combined sewerage dating back to Victorian times limit the opportunities for fundamental improvements in wastewater infrastructure. The full separation of foul and surface water sewerage is unlikely to ever be financially viable, although sewage treatment processes will continue to be refined.

The River Thames itself has benefitted from greatly improved water quality over the last 30 years, as a result of major investment in sewage treatment processes, a reduction of industry along its shores, and increased emphasis on enforcement. With the additional investment in Thames Water

Utilities' "Thames Bubbler", which is deployed to overcome the "oxygen sag" that occurs when the combined sewers overflow into the Thames, the Thames is now the cleanest metropolitan river in the world.

1.3.2 The integrated approach to water pollution control

'Water management should be linked to catchments ....and consideration given to basin-wide, upstream-downstream and riparian interdependencies in the development, use and protection of the waters, their basins and ecosystems (EEA, 1995a).

Much of the earlier legislation on water pollution [Appendix II] was created to deal with specific nuisance problems as they occurred, resulting in a piecemeal approach to water pollution control. The increased demand for potable water and safeguarding public health was an important factor, whilst enhancement of the environmental water quality was perceived as a benefit. Greater public demand for a cleaner environment has resulted in recent trends whereby legislation has adopted a more comprehensive approach to pollution prevention and control. The legislation is now formulated so that it addresses the source and nature of pollution, the environment to which it is discharged and the resultant impact upon the environment.

1.3.3 Water Quality

Water quality is the term which expresses the suitability of water to sustain both various human and ecological uses. Therefore an optimal water quality could be defined as being the quality which enables native species to occur in stable, well-balanced populations and which does not limit and effect the value of water as a resource (EEA, 1995a).

1.3.4 Legislative framework

Since the early 1960's it has been recognised that global degradation of hydrosystems is an important issue. Many global, European and regional initiatives have been introduced to encourage the protection of the environment. The 1972 Stockholm Conference on the Environment and the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro 1992, have promoted awareness of environmental issues on a global scale. The Berne Convention, which came into force in 1982, aimed to provide for the conservation of European flora and fauna and their natural habitats. In addition treaties such as the Ramsar Convention (1971) provide the framework for the protection of wetland sites of international importance.

The World Water Council (WWC), during the UN Conference on Water and the Environment (Dublin, 1992), promoted awareness of critical issues and efficient sustainable conservation and management of freshwaters. The UN Development Programme (UNDP) and the World Bank proposed a Global Water Partnership (GWP) which brings together a wide range of organisations, in an informal partnership to tackle the many changes in the water supply and sanitation sector. The main goals are integrated programmes at regional and national level, capacity building, sustainable investments and education.

The European Environment Agency (EEA) is progressively establishing itself as an independent source of the best available information on the environment in Europe. The European Topic Centre

on Inland Waters (formed in January 1995) is a key organisation in the EEA network and will act as a centre of expertise. The Water Research Centre (WRc) has been appointed the lead organisation of the Topic centre. Its main purpose is to provide the EEA with objective, reliable and comparable information for bodies responsible for framing, implementing and developing European Policy. The EEA will hopefully ensure a fully coordinated data collection system at European level via use of an Environmental Information and Observation Network (EIONET) as there is currently no pan-European water quality database.

The EEA (1995a) has identified the following information weaknesses with regard to inland waters: no pan-European water quality database; comparison of surface water quality across Europe (lack of reliable data) especially for small rivers and lakes; data on organic micropollutants and metals; data on quality and quantity of groundwater data. With reference to the urban environment, information on environmental performance of urban planning and management are scarce.

1.3.5 French Water Legislation

The administration of water management is divided between national, regional, departmental and local levels. At the national scale, French Water Law (1964), created the six Agences de Bassin, and subsequently nine years later, the Water Act (1973) created ten regional water authorities. The Agences de Bassin consist of two bodies: The `Comites de Bassin' (government representatives, local authorities, water users, water experts) which establish general policy and approve budgets and the `Agences Financieres de Bassin' which raise revenue to fund water management and pollution control measures.

River management is based in catchment areas but there can be conflict between Agences de Bassin and local administration about priorities, most are concerned with water quality. Thus water management plans are mainly concerned with water quality and controlling water pollution (law 64-1245 of 1964). The French Water Law (1992) introduced two major new tools for integrated water management - SDAGE and SAGE. The first of these, the Master Water Management Plan, is a statutory requirement and all six Agences are progressing these initiatives.

1.3.6 UK Water Legislation

In the UK, the Water Act (1989) resulted in the privatisation of the water utilities and the establishment of the National Rivers Authority (NRA) as an independent environmental watchdog. Following the Water Resources Act 1991, the NRA was assigned statutory duties and responsibilities relating to the quality of the aquatic environment including the functions of water resources, water quality, flood defence, fisheries, conservation, recreation and navigation. The process of discharge consents applied in both the UK Water Resources Act 1991 and the Environmental Protection Act 1991 also provides site specific standards for the protection of water quality (Environmental Advisory Unit Ltd, 1993).

The NRA sponsored by the Department of the Environment, had important policy links with the Ministry of Agriculture, Fisheries and Food (MAFF) and the Welsh Office (WO). The NRA set water quality targets for rivers, estuaries and groundwater. These targets are non-statutory and form the basis for the Asset Management Plan (AMP) negotiations with OFWAT and the Water Utilities, which establish the five-year programme for investment in sewage treatment improvements.

Statutory water quality objectives (SWQOs) based upon the RQOs, are now being developed. A General Quality Assessment (GQA) scheme considers temporal and spatial trends of water quality and is based upon general chemistry, nutrients, aesthetics and biology and it provides an objective and comprehensive classification framework for river quality surveys. Environmental Quality Standards (EQSs) for substances of concern to the Agency are also being developed.

The NRA and its existing duties and powers have been incorporated into the new Environment Agency for England and Wales as from 1 April 1996, together with Her Majesty's Inspectorate of Pollution (HMIP), Waste Regulation Authorities and the Waste management sector of the DoE. The Agency will adopt a more integrated approach to pollution control and the Environment Act, (1995) states that 'it shall be the principal aim of the Agency to protect and enhance the environment' and that the Agency's 'powers shall be exercisable for the purpose of preventing or minimising, or remedying or mitigating the effects of pollution on the environment'. Therefore, in order to achieve the goals for sustainable development, there will be an emphasis on pollution prevention, education and vigorous enforcement wherever necessary. Similarly for Scotland, on the 1st April the Scottish Environment Protection Agency (SEPA) was formed and for the Republic of Ireland -The Environment Protection Agency (EPA)[Appendix III].

1.3.7. The European position

The European Commission has developed its 5th Environmental Action Programme (1992), in response to the United Nations Conference on Environment and Development (UNCED) summit meeting as a mechanism for the implementation of Agenda 21. This establishes Community Policy for water management and highlights the principle of prevention and control at source as a means of environmental management. The Maastricht Treaty (1992), in accordance, stated that policy aims for environmental protection and improvement should be 'based on the precautionary principle and on the principles that preventative action should be taken'.

The EU through a series of Directives [Appendix IV] has implemented many water quality standards and pollution control measures (for example, Directives on Urban Wastewater treatment, Nitrates, Dangerous Substances, Groundwater, Drinking Water). The AESN and the Agency are required to oversee monitoring and law enforcement within the scope of each of the European Water Directives. These are mostly sectorial directives, unlike the Habitat Directive, which focuses more on global ecosystem protection. Future EU water policy will encourage a more integrated approach and significant changes to the existing EC legislation for the protection of the aquatic environment are being contemplated by the EC Commission. The future EC regulatory system for the protection of the aquatic environment includes the proposed Directive on Ecological Quality.

The UK government has now agreed to the pilot introduction of SWQOs to provide a **statutory** basis for future rounds of AMP negotiations. The Agency also acts on behalf of the government as a competent authority for certain EC Directives in England and Wales (Directives for Bathing Waters and Dangerous Substances), and liaises with both DGXI (Environment) and DGXII (Research, Technology and Development) departments to ensure an active role in European research.

1.4 Water Management

1.4.1 Agenda 21 and Local Agenda 21

Agenda 21, a Global Action Plan for the next century, was adopted at the (UNCED) summit meeting in Rio de Janeiro on 14 June 1992 by the UN General Assembly. The principal aim of Agenda 21 is to integrate environmental concerns across a broad range of activities. Chapter 18 of Agenda 21 addresses the management crisis facing freshwater resources and associates a high priority to the protection of the quality and supply of freshwater resources and with the integrated development, management and use of water resources.

The local Agenda 21 Initiative (1993) is an international project by the International Council of Local Environmental Initiative (ICLEI) aimed at developing a planning framework for local sustainable development. The project was a direct follow up of UNCED and responds to a need to assist local authorities in the implementation of local Agenda 21 as established in Chapter 28 of Agenda 21. The initiative by ICLEI together with the International Union of Local Authorities (IULA) places specific attention on the application and redesign of environmental planning mechanisms such as consultation, audits, target-setting, monitoring and feedback to identify options and assess conflicting interests and values implicit in sustainability.

Regional planning and management of entire catchments are essential to prevent degradation of water quality. Local Agenda 21 stresses the importance of environmental considerations when assessing planning applications, the necessity to increase community involvement in water issues and the implementation of integrated catchment management. Indeed, by 1996 'local authorities in each country should have undertaken a consultative process with their population and achieved a consensus on a Local Agenda 21 for the community' thus emphasising sustainable development at the local level (UNCED, 1992). In total there are 541 principal local authorities in the UK (DoE, 1994a).

1.4.2 Sustainable Development

The issue of sustainable development is both complex and important. It is a multi-dimensional concept with socio-cultural, economic, political, environmental and moral dimensions. The concept of sustainable development was popularised in the Brundtland Report (1987) where it is defined as 'meeting the needs of the present generation without compromising the ability of future generations to meet their own needs'. The UK's Environment White Paper (HMSO, 1990) added that sustainable development means 'handing down to successive generations not-only man-made wealth, but also natural wealth, such as clean and adequate water supplies, good arable land, a wealth of wildlife, and ample forests'. A common European framework is important to identify and assess a broad range of options to operationalise sustainable development in urban areas for example, the Sustainable Cities Project (launched by the European Commission Expert Group on the Urban Environment in 1993) and The Charter of European Cities and Towns towards Sustainability (adopted at Aalborg Denmark, 27 May 1994).

One of the ways to achieve a measure of sustainable development is through the development of a set of indicators to help to inform people in government, industry, non-governmental organisations and the public (DoE, 1996). Both EA Thames Region and AESN have demonstrated a commitment

to the sustainable management of the water environment by publishing SDAGE and Thames 21.

Within many large conurbations, as in London, water abstraction has exceeded recharge of surface water and groundwater resources. Over exploitation of water resources resulting from regional imbalance is not sustainable. The NRA"s "Water : Nature's Precious Resource" identified key issues of concern in particular the development of a sustainable water resources strategy where there is `no long-term systematic deterioration in the water environment owing to water resource development or water use where in doubt a precautionary approach should be adopted". Licensed abstractions within the Thames Region, are greater than two thirds of the effective rainfall, water resources are sustained by a significant amount of re-use and during times of low flow the treated effluent can constitute for up to 70% of the locally available resource (NRA, 1994c).

The Thames Region of the Agency aims to promote sustainable development of water resources through a process of wide communication and options for water resource developments will be appraised for sustainability, on the best scientific knowledge. Management of the total water environment will be promoted through the Agency's LEAPs, development plans of Local Authorities and the Asset Management Plan negotiations with the water utilities.

1.4.3 SAGEs and LEAPs

The commitment at the Rio Earth Summit by UK and French Governments to sustainable development and to broad public involvement through Local Agenda 21 initiatives has positive implications for the implementation of both SAGEs and LEAPs. There are obvious advantages in collaborative R&D projects which endeavour to provide for the sustainable management of the water environment and which facilitate review strategies and implementation of both SAGEs and LEAPs. The EEA (1995) states that `water management should be linked to catchments and be carried out with the participation of a well-informed public".

SDAGE and SAGE

The four main aims of the SDAGE for each of the six bassins are :

- to encourage an integrated management of the entire hydrologic system
- to improve the quality of aquatic ecosystems
- to facilitate public education and knowledge
- to provide greater dissemination of information on water related issues

The SDAGE project for the Seine basin was adopted in June 1995 and it has been divided into 57 possible SAGE. The SAGE are applicable at a more local scale and aim to provide an optimal integrated management of the hydrosystem.

CMPs (LEAPs)

The Thames Region of the former National Rivers Authority (now part of the Environment Agency) was influential in the development of the concept of Catchment Planning. The original focus for Catchment Management Plans (CMPs) was the emphasis, following privatisation of the water industry, on an integrated approach to river basin management and a particular desire to

avoid undesirable environmental effects of continuing urban development on river corridors and flood plains.

The broad objective of catchment management planning was to conserve and enhance the total river environment through effective land and resource management. Catchment Management Plans (now LEAPs) described the current status of all water-related uses and activities in the catchment and provided proposals to protect those uses, to improve the quality of the catchment and to resolve problems and conflicts between uses. The relationship between land use and water planning has emerged as a key policy issue in the UK.

Thames 21 (NRA, 1995a) provided a regional overview of the pressures on the water environment, setting the overall context for individual CMPs: "CMPs are the vehicle for the integrated planning of the water environment". Inherent in Thames 21 was the recognition that the land use planning system had a major role to play in ensuring the long-term sustainability of the water environment. In the Environment Agency the concept of CMPs has been extended to cover the full range of Agency functions, in the preparation of Local Environment Action Plans (LEAPs). Thames 21 is also being expanded to cover all Agency functions and will be republished as Thames Environment during 1998.

1.4.4 Planning Related Issues

The planning system is a key instrument for delivering land use and development compatible with the aims of sustainable development. There are a wide range of planning and management options that can be utilised to achieve sustainable development within cities in particular urban planning, urban management, economic instruments, standards and public information (CEC, 1994). The interrelated nature of urban environmental problems requires that the actions undertaken at the various levels should be part of an integrated approach. The development of a strategic planning approach to the water environment will, perhaps, strengthen this process. European cities have adopted various environmental strategies and pollution control measures to improve the urban environment.

The 10th European Conference of Ministers responsible for Regional Planning (CEMAT) acknowledged, in 1994, the commitment by the countries of Europe in promoting sustainable development through urban and regional planning and recommended that regional spatial planning should be used as an important precautionary instrument for curbing urban sprawl, combatting pollution and in sustaining the use of natural resources. The exchange of expertise coordinated by the CEMAT and the Council of Europe should make it easier to disseminate examples of best practice. The Community's member states and the EC have devised a European Spatial Development Perspective (ESDP) in order to identify the strengths and weaknesses in regional planning within Europe.

Whilst responsible for the functioning of the hydrological system, especially with regard to the river corridor, the Agency has very little control over the mechanisms which determine landuse change on a catchment-wide basis. This is largely the responsibility of local planning authorities through the implementation of the Town and Country Planning Acts (NRA, 1994a). The Environment White Paper ` This Common Inheritance" (HMSO, 1990) sets out a series of environmental objectives and describes how the planning system can help in their achievement. Local Authorities are required to

draw up their development plans on the basis of these objectives which provide a firm foundation for sustainable development. The Government subsequently revised guidance on future Town and Country planning and landuse policy for local authorities in the UK Sustainable Development Strategy (DoE, 1994a, Chapter 24).

Planning Policy Guidance 12 'Development Plans and Regional Planning Guidance" indicates how development plans should take environmental considerations into account, and additional guidance on good practice is contained in 'Environmental Appraisal of Development Plans" (DoE, 1994b). This sets out an approach for considering sustainability criteria for a range of global, local and national resource issues. Local plans should make provision for development consistent with Regional Planning Guidance 9 (RPG9) (DoE, 1994a) and reflect its priorities for the protection and improvement of the environment. Local planning authorities should also consult with the Agency and the water industry to ensure that development proposals fall within the capacity of the local water supply and sewerage infrastructure whilst not compromising environmental objectives.

The government is establishing Integrated Regional Offices (Employment, Environment, Trade and Industry, Transport) in order to promote a co-ordinated approach. The Secretary of State for the Environment will have regard to the extent to which structure and local plan proposals are consistent with RPG9 and environmental sustainability.

1.4.5 Indicators

'Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems." (UNCED, 1992 CHPT 40)

There is a widespread interest in the international community in the possibility of developing a set of key indicators covering a range of environmental or sustainable development issues. Such indicators would monitor changes in the regional and global environment and pressures due to economic development to establish the relationship between change in the state of the urban environment and the pattern of urban development. The environmental performance of urban areas needs to be monitored through a consistent set of urban environmental indicators to provide guidance in formulating and implementing urban environment policies.

The Organisation for Economic Co-operation and Development (OECD) has been working on developing indicators and published a core set in 1994. The UN Commission on Sustainable Development and the World Bank have produced draft frameworks for indicators and work is being carried out within Eurostat (the Statistical Office of the European Communities) and the European Environment Agency (DoE, 1996). Within the UK local authorities, as part of their local Agenda 21 initiative, are developing a set of indicators to show whether at a local level policies are leading to environmental improvements. The Local Agenda 21 steering Group has commissioned a study into local sustainability indicators and is considering with central government how this might fit into a broader framework of national indicators.

The DoE has selected key sustainable development indicators for freshwater (eight) and for water resources (six) within the UK. The key sustainable development objectives are to 'sustain and improve water quality and the aquatic environment" and to ensure that 'adequate water resources

are available to meet consumers" needs"(DoE, 1996). For freshwater quality examples of indicators include chemical and biological measures of freshwater quality, concentrations of important pollutants and water pollution incidents. For water resources, key indicators include comparisons between overall demand and the available resource, rates of use for particular purposes and the efficiency of remedial measures" [Appendix V] (DoE, 1996).

2. KEY ISSUES FOR R&D CONSIDERATION

Theme areas and project topics were appraised during a series of meetings between the partners where research and development expertise in AESN and the Thames Region of the Agency were identified for areas of common interest. Each partner would benefit from the exchange of expertise and approach and the outcomes of the collaboration would be applied at a national level. The exchange of staff and students was to be encouraged given the collaborative objectives of the study. Short-term research projects were favoured with the option of further extended R&D initiatives.

Middlesex University was present during meetings held on 23 and 24 October 1995, 8 March 1996, Paris 14 November, Middlesex University-Trent Park 10 January 1996, Middlesex University-Bounds Green. The AESN and CERGRENE also attended the October and January meeting and, in addition, held a meeting on 6 December 1995 in Paris. Selection of projects was based upon the objectives and criteria listed in the Terms of Reference [Appendix I], whilst considering the following:-

- The comparison of two large conurbation's Paris and London, which experience similar problems with respect to point sources of pollution (for example, sewage derived wastewater)

- The key planning issues facing the AESN and Agency, in particular the desire for the protection of ecosystems and groundwater, the need for effective surface water management of urban runoff and a greater knowledge of the control of non-point pollution sources

- The importance of dissemination of information and knowledge (democratisation) concerning the water environment.

On the basis of these considerations, three key issues were determined:-

(I) Wetlands for Water Quality Improvement
(ii) Sustainable Management of Urban Runoff
(iii) Environmental Education and Information

2.1 Wetlands for Water Quality Improvement

SDAGE endeavours to improve the protection and restoration of various aquatic ecosystems, especially wetlands, through increased consideration of landuses, greater control of discharges in the basin and a reduction in the impact of mineral extraction. Both AESN and the Agency have many sites which could benefit from the use of macrophytes for water quality improvement. Within this study, the use of macrophytes for water quality, forms a continuum of research ranging from natural wetlands to fully constructed wetland improvement. CERGRENE has identified study sites which are monitoring natural wetlands receiving agricultural runoff and wastewater from sewage treatment plants and UPRC are studying constructed wetland sites for the treatment of urban runoff.

The principle of environmental capacity recommends that cities are designed and managed in order to deliver basic environmental, social and economic services, within the limits of the natural

environment (EEA, 1995a). Wetlands assist in the maintenance of water quality as a by-product of their ecosystem functioning and thus the use of wetlands as a sustainable means of wastewater treatment and pollutant control is an important area of scientific research and development at present. Wetlands have long been recognised as being important in both ecological and conservation terms but more recently their potential environmental capacity to assimilate pollutants has been acknowledged.

2.2 Role of wetlands

The Convention of Wetlands of International Importance was signed in 1971 by 70 nations in the Iranian city of Ramsar and came into force in 1975. During the Ramsar conference a worldwide decrease in wetlands was recognised by several nations and their importance was stressed in terms of bird life and flood protection areas. Article 1 of the Ramsar convention describes wetlands as `areas of marsh, peatland or water whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt." The natural distribution, extent and character of European wetlands are influenced by climate and water flow movements together with geomorphic and associated ecological processes such as coastal erosion and sedimentation, floodplain dynamics, the accumulation of detritus and vegetation succussion in open water and physical build-up and collapse of peat bodies (Maltby *et al*, 1994).

Ramsar sites amount to 215,277ha (57 sites) and 422,585ha (8 sites) in the UK and France respectively (EEA, 1995a). France officially agreed to the Ramsar convention in 1986 (Commissarait Général du Plan, 1994) and `the Camargue was the first site to be recognized as a wetland of international significance. The Thames estuary, together with adjoining estuaries on the Kent and Essex coast from the Swale to the Blackwater and the Colne, forms one of the most important wetland habitats in Europe especially for bird life.

In most countries, wetlands have been reclaimed over the centuries in favour of more `deserving" landuses. In France, during the 16th and 17th centuries, the development of extensive drainage and irrigation schemes resulted in an increase in cultivated land and a decrease in the number of wetlands. Other major reasons for their demise were concern for public health and also land-take for industrial developments - as in the case of coastal wetlands located in major harboured estuaries (Commissariat Général au Plan, 1994). Large scale wetland drainage ceased in France in 1992 as a result of the European Agricultural Policy.

The Conventions Bureau is backed by the International Waterfowl and Wetlands Research Bureau (IWRB) and the World Conservation Union (IUCN). The Convention co-ordinates the `Rational Use of Wetland Project" which gives government detailed guidance, based on current projects and how to make rational use of national resources which local communities derive from wetlands taking into account the natural, institutional, legal and technical factors involved. The IWRB is coordinating the project development phase of a wetland inventory. Sub and pan-European projects have culminated in the publication of Important Bird areas in Europe with emphasis on water bird habitats.

Wetland degradation and loss is continuing in Europe despite a realisation that, in addition to their conservation value, the natural processes which occur within the wetlands suggest other environmental and ecological benefits. These include water quality improvement, flood control and

the provision of places for recreation. At present there is no definite policy for the protection of wetlands in Europe as a whole and so no comprehensive strategy by which enhanced conservation and rehabilitation of degraded habitat can be achieved. Optimum functioning of these ecosystems requires protection of their intrinsic hydrological system as well as appropriate management. In order to achieve wetland protection and improved management innovative planning and assessment techniques are required as a decision support system (Maltby *et al*, 1994).

2.2.1 Buffer Zones

Buffer zones offer considerable opportunities for enhancing conservation values and improving water quality. Riparian buffer zones have been identified as providing the regulation of ecosystem dynamics by controlling surface runoff regulating subsurface flows providing organic matter to the river storing water and influencing the movement and migration of fauna (NRA, 1992). Thus the environmental capacity of buffer zones for pollution control could facilitate enhancement of the local environment. Ellis *et al.*, (1994b) stressed the potential of emergent macrophyte species in providing a control and treatment buffer for toxic discharges associated with trafficked surfaces in urban areas.

The potential for using willows as components of natural buffer zones in water course management has recently been addressed (Parfitt and Greaves, 1996). The Agency is part funding a PhD student at the Centre for Aquatic Plant Management (CAPM) to research the potential nutrient immobilisation and uptake by roots of different willow clones. These tree species are efficient at nitrate and phosphate uptake from groundwater and surface water which flows through the root zone. Increased use of willows in buffer zones may help to reduce the impact of increased nitrate concentrations from groundwater sources on in stream aquatic vegetation.

2.2.2 Wetland Functions

Hydrological, biological, chemical and physical processes occurring naturally in wetlands result in ecosystem functions such as groundwater discharge or recharge, flood control, nutrient transformation, productivity and habitat development or maintenance. Process interactions maintain ecosystem elements or components such as the water regime, character of soil, interstitial water, plant and animal populations, nutrient pools and soil or sediment properties (Maltby *et al*, 1994). There is still a need to establish the scientific principles behind wetland ecosystem functioning and how different environmental factors and processes interact to control functioning (Maltby, 1991).

An interdisciplinary pan-European project entitled Functional Analysis of European Wetland Ecosystems (FAEWE), with sites in France and the UK, has been established under an EC Science and Technology for Environmental Protection (STEP) environmental programme (the Agency is a participant in this project). The aim is to develop a science-based procedure for evaluating the functioning of European wetland systems, in particular river marginal wetlands. The rationale behind the development of the functional assessment procedures is built on the possibilities of predicting wetland ecosystem functioning by characterisation of distinctive ecosystem/landscape complexes called hydrogeomorphic units (HGMUs). Phase II is currently looking at broadening the functional assessment procedures to the catchment scale and incorporating economic evaluations. These procedures have the potential to be integrated into the catchment management planning process.

Wetlands have the capacity for management of flood control as they impede precipitation and runoff and can therefore reduce the severity of flood events. In Wisconsin, for example, catchments with 15% wetlands coverage had flood peaks 60- 65% lower than similar sized catchments without wetlands (Novitzki, 1979).

2.2.3 Natural Wetlands

The waste assimilating capacity of natural wetlands provides opportunities for environmental sustainability at low construction and maintenance costs. The importance of wetlands in France has been highlighted by the Water Law (1992), which stresses the need to adopt integrated policies towards hydrological systems. Following the recommendations of the national evaluation report (Commissariat Général au Plan, 1994), a scientific group was established to coordinate scientific research into wetlands. This led to a call for research proposals (currently under consideration), which also referred to "numerous smaller wetlands which might play an important role on a full basin scale". The proposals are expected to cover faunistic issues (wetland and specific habitats for many species), hydrological issues (river discharge regulation, ground water recharge), water quality issues (pollutant retention in wetlands) and economic issues (raw materials exported from wetlands, recreational and patrimonial aspects).

Protection and restoration of wetlands is a key issue in the AESN SDAGE. It is considered that wetlands play an essential role in the behaviour of rivers, and that the reduction of wetland area at the basin level has to be stopped. In order to ensure the success of wetlands, the following priorities have been identified: the protection of priority sites through legislation, management, and land occupation the development of a customised management practice and the retention of river characteristics and biodiversity in aquatic ecosystems. Wetlands are also mentioned in SDAGE as an important means for flood prevention (zones naturelles d'expansion des crues) and river management, where they are designed not to increase water velocities in the main stream without a careful study of downstream consequences.

AESN/CERGRENE are studying the influence of natural wetlands (Marais de Buno) for the treatment of diffuse runoff from agricultural sources. Nitrate concentrations have been steadily increasing in France causing a serious pollution threat to aquifers. For the aquifers in the Seine Basin, nitrate concentrations in one quarter of the area could increase to levels between 50mg/l (threshold of the European standard) and 100mg/l in the next 40 years in the absence of control measures (Roux, 1995). Indeed, the calculated concentration of nitrate in the leachate from agricultural soils at 1m depth, reveals that large areas of the Seine and Thames basins have concentrations between 50-100mg NO_3/l. This presents a definite risk to aquifers (EEA, 1995a).

In the Seine basin, alluvial wetlands exist mostly in the eastern part of the basin and they are also associated with small rivers in other areas of the basin. The wetlands located downstream of the basin have been drained, (for example, around Paris) for sanitary reasons, gravel extraction and construction. A benefit of wetlands is their natural ability to reduce nitrate leakage into freshwaters. Several processes influence the fate of nitrate as it percolates from the root zone to the groundwater - denitrification removes nitrate by conversion to gaseous oxides or nitrogen. The relationship between the nitrates leaving the plants root zone and nitrogen applied as fertiliser is not straightforward and leaching losses vary spatially and temporally. Important denitrification

processes take place in the waterlogged habitats bordering rivers and lakes and the restoration of riparian zones on the flood plain would increase the capacity for nitrate removal and thus prevent its infiltration into groundwater supplies.

Constructed or modified wetland management does not appear in the list of actions given by the SDAGE to improve water quality. These actions are oriented towards sources of pollution, not to the potential use of features within the river basin for the treatment of such pollutants. This confirms the need to evaluate this potential and utilise UK experience on the use of constructed wetlands for the treatment of pollution.

2.2.4 Constructed Wetlands

Constructed wetland technology is emerging as a low cost easily operated efficient alternative to conventional treatment systems (Cooper *et al.*, 1996). In the UK, the Environment Agency (EA) and the Department of Transport have expressed interest in the potential use of constructed wetlands to treat urban runoff. UPRC has much experience in the use of macrophytes for water quality control. Dr Brian Shutes is the UK Coordinator of the International Association of Water Quality (IAWQ) specialist group on the use of Macrophytes for Water Pollution Control.

Rapid removal of surface water runoff into watercourses causes the pollutants present to degrade the receiving water quality (CIRIA, 1994). The wetlands are natural wastewater treatment systems which combine biological, chemical and physical treatment processes to treat a variety of pollutants from point sources, municipal and certain industrial wastewater effluents, for example organic matter, suspended solids, COD, BOD, heavy metals, hydrocarbons (Mungur *et al.*, 1994). Although constructed wetlands have been mainly designed to treat municipal and industrial wastewaters, research has also been conducted into the treatment of urban runoff, and more recently highway runoff (Ellis, 1994a, Ellis *et al.*, 1994b Mungur *et al.*, 1994, 1995).

2.2.5 Constructed Wetland Principal Design Criteria

A major problem in the design and performance of constructed wetlands for urban runoff, is that influent quantity is variable, thus potentially resulting in variable effluent quality. The engineering methods applied in runoff collection, transport and treatment, and evaluations of the systems in current use have been reviewed by the Construction Industry Research and Information Association - CIRIA (1994) and Startin and Lansdown (1994).

A manual recommending criteria for the design and management of constructed wetlands will be published by CIRIA in 1996. In order to maintain optimum efficiency of established wetlands, management guidelines are necessary. Anton Crescent wetland, located on the Pyl Brook, Sutton, is currently undergoing a desilting programme as part of an agreed prescriptive management plan for the site (NRA, 1995b). It has been found that many species of wetland plant are tolerant of high metal concentrations but there is a risk that their accumulated heavy metals may enter the food chain. It is recommended that contaminated sediment should be removed approximately every 25 years to prevent seepage and groundwater contamination (Yousef *et al.*, 1994).

The design of constructed wetlands is generally influenced by land-take requirements and the level of water quality required. There are two major types of constructed wetland in use today, surface

and sub-surface flow systems.

Surface flow wetlands are similar to natural marshes as they tend to occupy shallow channels and basins through which water flows at low velocities above and within the substrate. The basins normally contain a combination of gravel, clay or peat based soils and crushed rock, planted with macrophytes. The important parameters for the design of surface systems are detention time, organic loading rate, water depth, aspect ratio (ie length:width ratio) and hydraulic loading rates. Optimum water depths can be chosen for selected wetland species. Surface flow wetlands are simple to design and construct and require simple inlet distribution structures, but they are susceptible to ice-cover in winter which may result in reduced treatment efficiencies as effective water depth and retention time are reduced (Kadlec, 1989).
In sub-surface flow wetlands, wastewater flows horizontally or vertically through the substrate, which is composed of soil, sand, rock or artificial media. The purification processes occur during contact with media surfaces and plant rhizospheres. Detention time, BOD and solids loading rates and media depth and size are important design criteria. Within this system, hydraulic conductivity is an important determinant in pollutant removal efficiency. Sub-surface flow systems are more effective than surface flow systems at removing pollutants at high application rates. However, overloading, surface flooding and media plugging (especially by metal hydroxide precipitates and invasive weeds) of sub-surface systems can result in a reduction in effectiveness and loading rate.

The lifespan of constructed wetlands has been demonstrated as being approximately 20 years for organic waste treatment (Ellis and Revitt, 1991) and a similar time period for urban and highway wastewater treatment has been estimated. For the latter, removal of contaminated sediments every 25 years has been suggested in order to prevent seepage into groundwater (Yousef, *et al.*, 1994). Constructed wetlands can be designed to form an aesthetically pleasing and functional landscape which can be incorporated into residential developments (Mungur *et al.*,1994). Wetlands form a valuable ecological habitat for wildlife.

2.2.6 Pollutant removal performance of wetlands

Biological, physico-chemical processes immobilize and transform a wide range of compounds. Chemical reactions and biological decomposition break down complex compounds into simpler substances. The removal of nutrients is assisted by absorption and assimilation processes. Both natural and constructed wetlands may create conditions favourable for nitrogen transformation/removal by soil microbial processes such as denitrification, with as much as 100% of the nitrate being removed in these zones (Vought *et al.*, 1994). However, there is a deficiency of research data on how these removal processes operate and upon the nutrient balances of wetland water quality in rural catchments in the UK. The findings from the FAEWE project, where the Torridge river system was studied for the level of fertilisation and nutrient enrichment, may help to redress this imbalance.

Natural filtration, sedimentation and other processes assist the removal of many pollutants.
Some are physically or chemically immobilised and remain in the wetland permanently unless disturbed. Ellis (1994) examined the pollution removal efficiencies of water quality parameters using experimental reedbeds and found removal rates of 45% for nutrients, 83.1% and 89.5% for COD_5 and BOD_5 respectively, and up to 99.9% for Faecal coliforms.

Research to date has shown that aerobic microorganisms control hydrocarbon degradation (temperature dependent). Nix *et al.* (1994) reported 96% removal of total extractable hydrocarbons after 5 hours from storm runoff containing petrol passing through a constructed wetland. Bacteria, actinomycetes and filamentous fungi are all important members of a soil microbial community and they are widely distributed in the soil, sediment and water and their abundance is influenced by previous exposure to hydrocarbons. There have been few studies which compare the performance of different plant species for hydrocarbon degradation and metal immobilisation and uptake in relation to their associated microbial communities in varying substrate and salinity conditions. CAPM is investigating the allelopathic effects of the roots and rhizomes of *Schoenoplectus* species. Some reports indicate the possibility of an allelopathic effect of roots of this species on bacteria especially those of sewage origin (*E.coli*).

2.3 Wetland Site Descriptions

2.3.1 Marais de Buno - Natural Wetland

The Marais de Buno is a peat formation surrounding the Essonne river. The Essonne river drains water from the Beauce ground water system, which is heavily loaded with nitrates. Most of this watercourse is surrounded by wetlands, and the majority are peaty. The river discharge regularly increases, as a result of constant recharge from the Beauce groundwater system.

Previous studies by the DIREN Ile de France and supported by AESN, reported a slight decrease in nitrate levels in the Buno area, which may suggest denitrification processes occurring in the river or in the adjacent ecotones where, removal of a fraction of the nitrates carried by groundwater could occur before entering the river.

During the summer, the Marais de Buno behaves like a sink for water and is fed by water from the Essonne, and also (perhaps) by groundwater. This results in a complex pattern of water circulation in the area with localized inputs from groundwater and outputs to peat formations surrounding the river. A major reason for this occurrence might be due to water uptake and evapotranspiration by the reeds in the Marais. Thus, the study of water quality inside the Marais de Buno was not conclusive in determining which factors could explain the decrease of nitrogen concentrations in the Buno area (filtration of groundwater or in stream denitrification).

Nevertheless, the special water circulation in the Marais de Buno (water flows from the river to the inside bank) makes it an excellent site for the evaluation of potential bankside processes. Denitrification was observed and nitrates disappeared within a few centimetres. A peak of ammonium could be observed and this could be attributed either to a release of nitrogen from the degradation of organic matter by denitrification, or to dissimilative ammonification in the highly reductive peaty environment. Further studies are necessary to confirm these mechanisms and other processes could be studied in this site, in particular phosphorus and pesticides transport in the highly reducive groundwater systems.

2.3.2 Vesle River - Natural Wetland

The river Vesle receives partly treated wastewater from the city of Reims, where the sewage treatment plant is in need of improvement to fulfil new guidelines for water quality protection (the

new treatment plant project is still under study). The resulting water quality in the river Vesle is extremely poor, with dissolved oxygen as low as 0 mg/l, and ammonium levels up to 30 mg/l after discharge from the existing treatment plant (CERGRENE, 1994, ICE, 1991). The Vesle river is indeed one of the most polluted rivers in the Seine basin, with regards to micropollutants (SDAGE, 1995), as reported by inventories of the basin. During rain events, the water quality of the river is severely degraded as a result of the resuspension of polluted sediments. However, water quality does improve quite quickly after storm events, leading to a 50% reduction in ammonium and phosphate loads within a downstream distance of 20km.

The urban district of Reims city requested that CERGRENE undertake a study involving the modelling of water quality in the river Vesle. As in other small rivers, the existence of macrophytes (mostly *Potamogeton pectinatus*) in the upper part of the river, immediately downstream of Reims, has been identified as a major factor in the explanation of water quality improvement in the river Vesle. Firstly, the macrophytes reduce the river velocity and thus assist in the sedimentation of suspended matter. Secondly, macrophytes support epiphytic bacteria, which may explain the high nitrification (and denitrification) rates observed in this river, compared with other deeper polluted rivers (typically the river Seine downstream of Paris). Thirdly, macrophytes rapidly increase the denitrification rate, and a possible explanation is that the root exudates in the rhizosphere provide highly degradable organic matter to the microorganisms present in the sediments. However, a simple epiphytic effect cannot be excluded.

2.3.3 UK Constructed Wetlands

Two constructed wetlands located at selected surface water outfalls (SWO) have been identified for investigation in the county of Essex. Both wetlands were constructed by the Thames Region of the Agency and are being monitored by Middlesex University Urban Pollution Research Centre (UPRC) with an Engineering and Physical Science Research Council (EPSRC) Industrial CASE research studentship together with funding from the Agency, Thames Region. Both reed beds were constructed between January-April 1995. Constructed wetlands take between 1-3 years to become established and efficient as wastewater treatment systems and therefore it seems appropriate to choose sites currently in operation.

Chemical water quality monitoring was initiated by the NRA in 1994 to assess background water quality at both sites. Watercourses receiving water from SWO"s in urban areas are susceptible to the `first flush" phenomenon. Anoxic sediments which have built up in-sewer, especially after dry periods, are discharged and have a serious effect on receiving water quality. Both sites receive effluent from domestic and industrial sources which are incorrectly connected to the surface water drainage system and ultimately the watercourse (Scholes *et al.*, 1995).

2.3.4 Brentwood (Sub-surface Flow System)

The Brentwood site (TQ 583 928) is located on land owned by Thames Water Utilities Ltd (Figure 1). It consists of a constructed wetland and an adjacent area of natural wetland (surface flow system). The constructed wetland is built on the site of a flood basin which receives flow from the Kavanaghs Road SWO (draining a catchment area of 400ha) before joining the Upper Ingrebourne river close to its source, where urban runoff constitutes the majority of the flow. Water quality analysis by the Agency has identified elevated Biological Oxygen Demand (BOD) levels and heavy

metal concentrations in particular, lead and zinc.

During normal flow conditions, water first enters a settlement zone, reducing water velocity and encouraging settlement of suspended solids and then passes through the constructed wetland planted with *Phragmites australis*. Stormwater discharges also pass through the natural wetland which offers less resistance (planted with *Typha latifolia*) but water levels within the wetlands are controlled and both discharge into an outlet chamber before rejoining the River Ingrebourne.

2.3.5 Dagenham (Surface Flow System)

The Dagenham site (TQ 503 840) is located on the Wantz stream on land owned by the Agency (Figure 2). The Wantz receives substantial surface water discharges from the surrounding urban catchment. Chemical analysis of water samples prior to the construction of the wetland reported elevated BOD levels, heavy metal concentrations and the presence of trihalomethanes (THMs). THMs are designated UK Priority Hazardous substances and under the North Sea Action plan are targeted for a 50% reduction by 1995. During storm events the watercourse exhibits 'flash' characteristics due to the impermeable nature of the catchment area and there is a visible deterioration in water quality.

The wetland is 250m long and is constructed in a specifically widened part of the stream which is divided into a series of four weirs. The latter control the flow into the three separate reed beds to prevent hydraulic short-circuiting and to enhance aesthetic appeal. Suspended solids are initially removed in a settlement zone located behind the first weir. The first wetland is planted with *Typha* and the next two with *Phragmites*. A surface water system was selected in preference to a sub-surface water system which requires more cross-sectional area perpendicular to the direction of flow and which would also present a physical barrier to upstream movement of fish and other aquatic fauna.

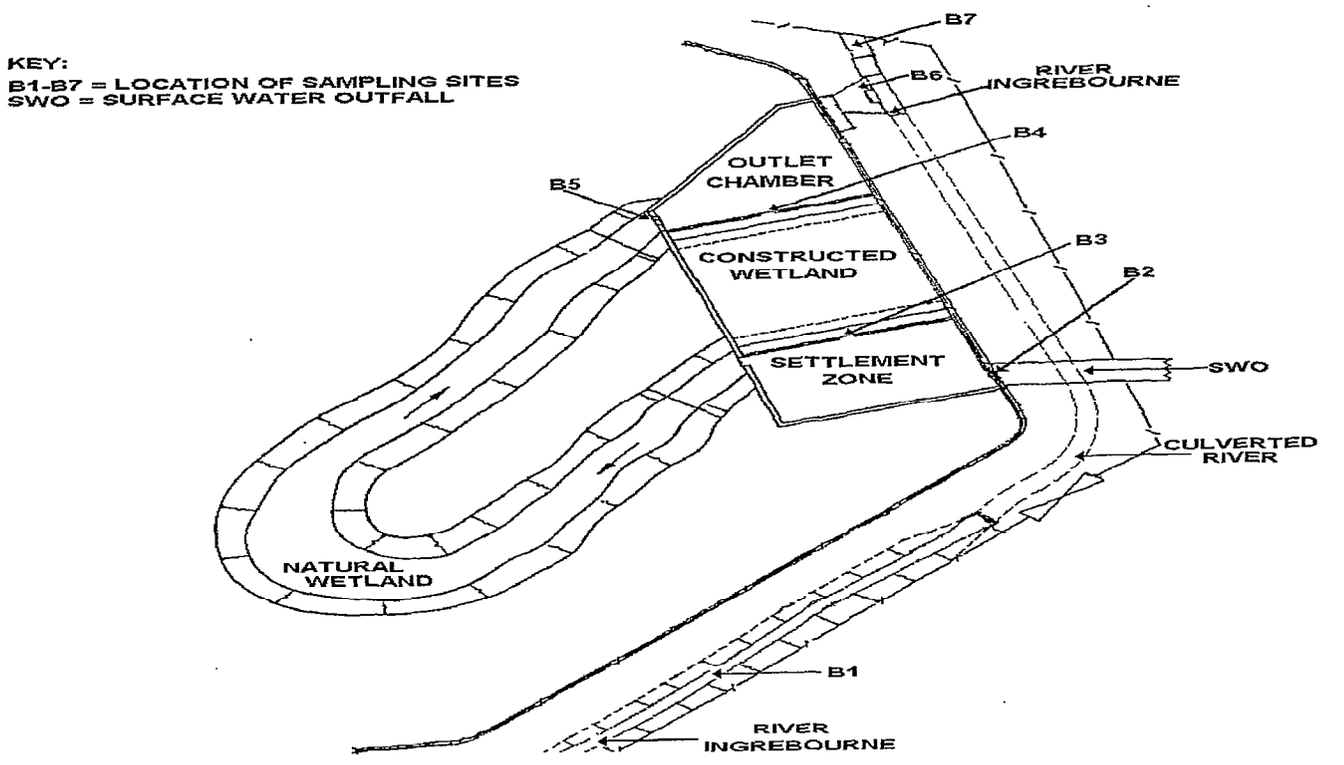

Fig. 1 Diagrammatic representation of the Brentwood Wetland

KEY:
D1-D5 = LOCATION OF SAMPLING SITES

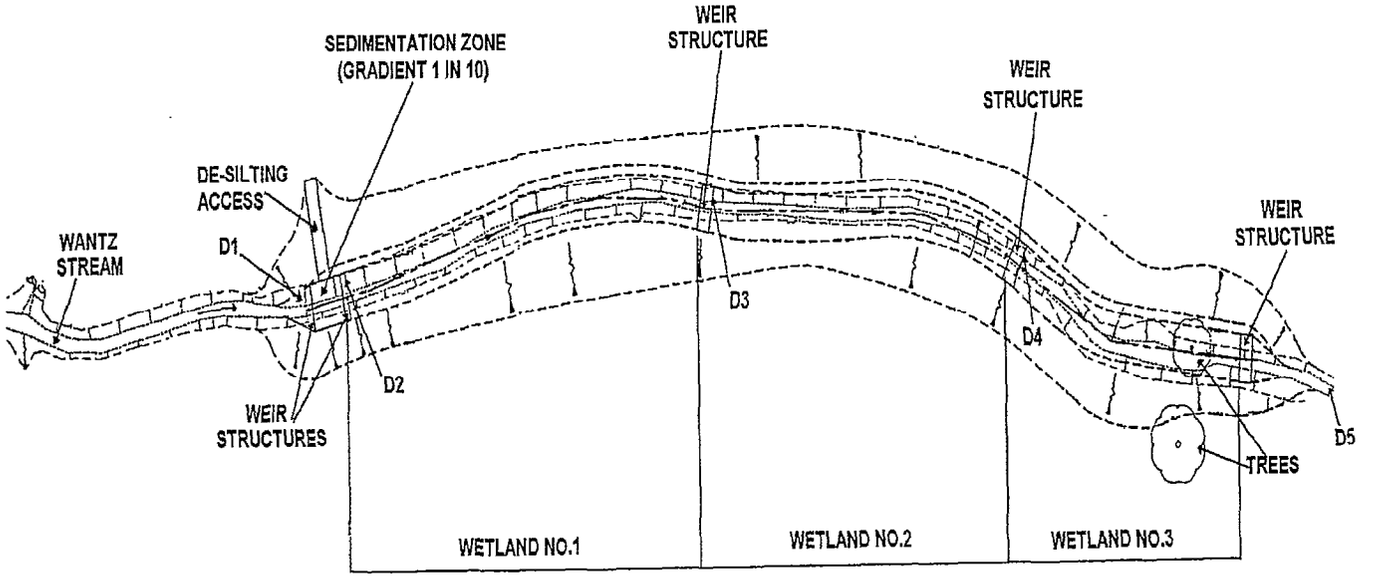

Fig. 2 Diagrammatic representation of the Dagenham Wetland

2.3.6 Existing and On-going R&D Objectives

AESN/CERGRENE

- the yearly monitoring of various riparian wetland areas
- the assessment of the potential of natural wetlands for the improvement of water quality, with special attention to diffuse agricultural sources of pollution
- the establishment of experiments using different types of substrates (peat, gravels....) and different types of pollutants (nutrients, pesticides, or other micropollutants in urban areas) to ascertain the removal efficiency of wetlands

Environment Agency/UPRC

- To improve water quality by natural means and to enhance the area downstream for fish and macroinvertebrates.
- To treat non-point sources of pollution by natural and sustainable methods and to evaluate the practical use of the `test beds" for future national R&D projects.
- To assess the operational efficiency of the reed beds in terms of the removal of suspended solids, heavy metals and specific organic compounds including THMs, thus expanding the scientific knowledge base.
- To carry out bacteriological surveys of the two sites (Spring 1996) and examine the mechanisms and processes involved in the removal of heavy metal pollutants by microbial populations.
- To consider the performance of each wetland in relation to its design and to make recommendations, if necessary, for alterations to each design of wetland to improve pollutant removal performance.
- To establish management guidelines for the maintenance of the reed beds for urban runoff pollution treatment.
- To inform the public of the role of wetlands, and to encourage community participation in their management. Constructed wetlands create wildlife habitats in an urban areas and can enhance the landscape.

2.4 Sustainable Management of Urban Runoff

The problems associated with the sustainability of water resources is compounded by the degree of urbanisation which impacts upon the quality of the urban environment and places a heavy demand on local natural habitats. Urban rivers are under pressure from the expansion of built-up areas, uncontrolled use of water resources and from pollutants. Landuse development and an increase in impervious surfaces of sealing off land accelerates runoff and during periods of heavy rainfall severe

contamination of the receiving waterbody can occur due to the combination of sewer overflows or by direct rain runoff through separate sewer systems. These rainfall events can result in increased bacterial concentrations, oxygen depletion, increased concentrations of nutrients, heavy metals and polyaromatic hydrocarbons (PAHs), as well as a decrease in aesthetic value.

The EC 5th Environmental Action Programme (CEC, 1992) highlights the principle of prevention and control at source as a means of environmental protection. The Maastricht Treaty in which current European Union policy aims for environmental protection and enhancement states that 'environmental damage should as a priority be rectified at source". This can be applied to the principle of using runoff control to protect the existing hydroecological regime within the catchment, and thus minimise local environmental impact. The UK Government's national strategy for sustainable development (HMSO, 1994), together with Local Agenda 21 outlining the local authority framework for sustainability strategies (LGMB, 1993), provide the broad policy criteria and principles of relevance to urban runoff management. Similar policy approaches to integrated water management have been adopted in France under the SDAGE arrangements.

Traditionally, best practice has recommended rapid removal of surface water to prevent flooding. However it is necessary to adopt a more integrated approach to surface water management and to thus establish the current best management practice. The Agency published guidelines (NRA, 1994a) for the local planning authorities and a policy statement for 'Surface Water Runoff' proposes that the planning authority should "normally resist development which would result in adverse impact on the water environment due to additional surface water runoff". Local Agenda 21 provides the framework for the establishment of greater liaison between local authority planners, industry and the Agency over Development Planning and subsequently in sustainable surface water drainage policies. Both Agency/AESN have introduced the LEAPS/SAGE as a non-statutory means for establishing an integrated, multi-functional approach to managing the water environment.

More practical advice on planning approaches for sustainable urban drainage are contained in Regional Planning Guidance (eg RPG 9 and 23) and Agency guidance documents (NRA, 1994 and 1995). Technical guidance and design protocols to best management practices (BMPs) for the control and treatment of urban runoff are also now available (CIRIA, 1992 Hall *et al.*, 1993 CIRIA, 1996) Valiron and Tabuchi, 1992) and both UPRC and CERGRENE staff have been centrally involved in these seminal works.

A recent report has emphasised the importance of source control as a key concept in sustainable urban runoff management (CIRIA, 1996). The role of innovative technologies in urban storm drainage has also been the core theme of the 1992 and 1995 NOVATECH meetings in Lyon, France as well as the basis for the Standing Conferences on Stormwater Source Control organised by Coventry University, UK. Both CERGRENE and UPRC have contributed to these meetings with Professor J B Ellis (UPRC) and Professor J C Deutsch (CERGRENE) being members of the NOVATECH Scientific Committee.

There is therefore considerable advice and guidance now available to developers, drainage engineers and regulators on the planning framework and technical design for sustainable, integrated urban runoff quality systems and both UPRC and CERGRENE have made contributions to the debate. There are also a variety of modelling procedures which have been successfully developed to predict pollutant fluxes associated with urban wet weather discharges. CERGRENE has considerable

experience of FLUPOL which it has used in studies of the Vesle basin in Reims and in experimental urban catchments within the metropolitan Paris region. UPRC has also used a variety of regression and probabilistic models to define pollutant loadings associated with experimental urban catchments in N. London. Both French and UK experimental catchments have full real time, remote monitoring and sampling capabilities. In addition, CERGRENE and AESN has stewardship of the French national urban runoff database and the UPRC has been responsible for collating a European-wide database on urban runoff quality under the aegis of the European Water Pollution Control Association. The UPRC is also custodian of the database for the US EPA Nationwide Urban Runoff Program.

2.4.1 Tools and Needs

In order to achieve integrated sustainable objectives, it is necessary not only to identify and implement appropriate planning and design guidelines but also to select those urban source control BMP options which will be capable of achieving effective and efficient performance for both flow and quality. The proper selection and optimisation of the various components of the surface water management system are essential for sustainable urban LEAPs which in turn must be amenable to the progressive introduction of Statutory Water Quality Objectives (SWQOs).

Such selection and optimisation criteria are entirely compatible with the Agency's new duties and powers contained in the 1995 Environment Act (clauses 5, 7(b) and (c)]. They are also appropriate to the Ministerial guidance on the Agency's objectives with regard to achieving sustainable development, particularly in terms of integrating technical, environmental and economic factors in BMP decision-making. The availability of proven and widely acceptable selection and optimisation guidelines for urban storm drainage BMPs would also give confidence to the 'shared-responsibility' partnerships necessary to deliver integrated, multiple-use urban drainage systems.

Whatever techniques and tools are developed for identifying and implementing BMPs for urban drainage quality, there will be a need for them to be reviewed in the context of a rational decision-making support system (DSS). Such DSS methodologies offer decision-makers (from regulators to technical managers) a means of solving both structural and semi-structural problems faced in water quality management. Decision-makers are commonly faced with the need to select and evaluate workable solutions from a set of alternatives the way an acceptable outcome is reached depends on the characteristics of the problems, on the defined objectives and on the selected criteria for the definition of priority of action.

DSS scenario-building offers an approach to sustainable urban runoff management based upon functional definition of inputs and is designed to provide answers to decision-makers on the effects of alternative courses of action in terms of specified end-uses and standards (or SWQOs) for differing input conditions and control measures. A DSS for urban runoff quality management would provide a mechanism whereby the various stakeholders can examine and appraise the full range of drainage options for differing development scenarios to achieve the best practicable environmental outcomes.

2.4.2 Urban Runoff Quality Control

There is a need to draw together and review best practice for a variety of urban runoff quality

control measures. Scoring and rating techniques for ranking and weighting parameters as a basis for BMP screening have been variously proposed in the US (Terrene Institute, 1994), in Canada (Marshall Macklin Monaghan Ltd., 1994), in Australia (Land Systems EBC Ltd., 1992), New Zealand (Williamson, 1991) and in the UK (Forth River Purification Board, 1995). The NOVATECH and various IAWQ Urban Storm Drainage proceedings also contain papers from other European, American and Canadian sources proposing such multi-attribute techniques (MATs) to aid preliminary screening-level decisions for urban water quality management.

UPRC and CERGRENE have already undertaken work in this field (Ellis, 1996 Saget, 1994) and a collaborative study could draw together and distil published MATs into collective matrix approaches with guideline methodologies for practitioner use and as a basis for best practice training. This would complement the state-of-the-art review to be undertaken by CIRIA as part of its Research Project RP 517 on sustainable urban runoff management as well as supporting on-going Agency and AESN development work on the urban CMP process and help link this process to key urban runoff sustainability indicators.

2.4.3 Optimisation of Urban Water Quality BMP"s

The generic technical basis for the optimisation of urban water quality BMPs needs to be addressed. This is a key issue for urban surface water management planning and is central to the LEAP process and to both and AESN responsibilities as for example, stated in Clause 47 of the 1995 Environment Act. UPRC is already undertaking work (through a PhD study) to evaluate urban drainage engineering alternatives on the basis of cost-effectiveness analysis rather than by cost-benefit.

Cost-effectiveness analysis is deemed to be appropriate for preliminary planning of urban runoff quality BMPs because system performance and direct costs can be used as the evaluation criteria. The analysis aims to determine the least-cost relationship between increasing cost and improving water quality performance. Such a relationship will be very useful for the subsequent design of urban runoff quality control systems because the engineering design performance may then be specified with the knowledge of marginal cost of and marginal improvement in urban runoff control. Moreover, design level analysis of BMP alternatives may concentrate on the least-cost relationship developed in preliminary planning analysis.

The optimisation procedure will utilise constrained cost minimisation procedure and isoquant analysis to determine least-cost system performance. With a knowledge of the cost functions for alternative control measures the least-cost mix (or combination) of BMP measures to achieve specified levels of quantity/quality control performance will then be determined by Lagrangian optimisation. The approach can be used for extreme event control (as measured by the N-year-event detention storage overflow volume) and for long term, average quality control performance based on combinations of downstream storage systems and/or upstream source control systems. The algorithms will be PC coded and will incorporate a simple sensitivity analysis utilising a standard package such as LOTUS.

2.4.4 Decision Support System

The development of a 'wrap-around' decision support system (DSS) for urban water quality

management planning is required. It is anticipated that a DSS will incorporate the conditions relating to the following issues and questions:

- objective setting what water quality levels are needed to allow a given set (or mix) of development uses.
- action definition what pollutant levels need to be reduced to the required level of water quality what impacts result from changing pollutant loads which controls are appropriate.
- control location what are the optimal locations, capacities and performance criteria that need to be met.

A DSS design would use a synthesis of databases and models, for example, using descriptive statistics to compress the databases and transfer functions instead of dispersion models. A DSS would be designed to illustrate the potential applications of popular hypermedia tools for urban water quality management planning and utilising WINDOWS screening and menu systems.

A DSS could be developed as a best practice training tool and as a scenario-building technique to provide preliminary planning-level solutions to developers and decision-makers on the effects of alternative courses of action and alternative BMP options.

2.5 Environmental Education and Information

There is a need to promote public interest in the move towards sustainability and the adoption of local Agenda 21 and consequently Thames 21 and SDAGE. The main objective of environmental education within Agenda 21 is the 'capacitation and motivation of people for the effective realisation of sustainable development" especially with reference to the importance of water as the support of life.

There is a need for education initiatives aimed at local people and their involvement and participation ideally as a broad cross-section of community members, with an appropriate emphasis on the education and motivation of young people. There is also a need to understand public perception of the pressure on the environment communication, participation and education are all important in this approach.

Information technology can be employed to inform all user groups. The development of an interactive IT programme for the provision and interpretation of water quality monitoring data could be beneficial for different user groups. The transformation of data into information could provide support to decision making in enterprises, research organisations and within the local community.

Opportunities now exist for widespread dissemination of environmental information via world-wide information systems such as the Internet. The Agency will be "seeking to exploit the new avenues opened by rapidly developing information systems technology to bring about a quantum leap in the way that information on the environment is made available to all those that want it" (Environment Agency, 1996).

The Freedom of Access to Environmental Information Directive (90/313/EEC) places a duty on member states to ensure that public authorities make information on the environment available to all persons requesting it. Local Agenda 21 recommends a commitment to broad public involvement and the key concepts and principles inherent in sustainable development are to inform and guide decision makers in the public and private sectors and members of the public. The UK Government in its consultation paper (DoE, 1993) reported that education was a fundamental aspect of sustainable development. It was suggested that schools and colleges should focus upon a holistic approach, starting with local problems and working to global issues and their interrelationship - a process intended within the confines of this scoping study.

The Dobris assessment highlighted the need to produce information in a comprehensive framework, but which has a wide audience and various uses, and it states `It is clear that the capacity to address urban environmental problems requires improved information" (EEA, 1995a). The EEA proposes to select elements of the Dobris assessment and re-produce using in the form of booklets, CD-Roms and discs to target different audiences. Packages of educational material whose development will be carried out in transnational teams with pedagogic experience will also be produced. One will result in a printed book plus companion disc targeted at pupils aged 11-16, and this will be created in partnership with the education department of the World Wildlife Fund (WWF). The International Centre for Conservation Education will prepare a series of slides, script notes and teacher guides describing the natural environment of Europe and its main threats.

Paris and London have an established infrastructure and are confronted with the problems associated with the interactions between population, economic development and environmental change. The management of freshwater resources is a major concern for the future and spatial planning and the management of water flows in relation to a infrastructure development have become necessities to reduce adverse environmental impacts. Thames Region needs to plan to avoid a major deficit in water resources over the next 30 years (NRA, 1994e). In a previous survey of rivers within the Agency's regions, 17 rivers were identified as suffering from problems of low flow and 5 of these were located within the Thames region.

European initiatives to educate and inform water users are important and lead to the formation of partnerships and thus exchange of knowledge. The AESN and the Agency have formed an association with the Academie Environment. The Academie de l'Eau was established by AESN as the newest French "Academie" and comprises many eminent academics and water professionals. NRA - Thames was invited to join in the autumn of 1995. The Academie has initiated a study on the topic "Water, the city and town planning", and suggested the development of "Observatoires de l'Eau et de la ville" or an Observatory on water and city.

The Agency aims to co-ordinate a fully comprehensive set of environmental data and information which the Agency will continue to draw together and make publicly available. If the Agency is to achieve its principal aims, it is essential that there is a wider public understanding and debate of such environmental issues (Environment Agency, 1996). At the local level the public need to be informed how to change their behaviour patterns in order to exercise environmental choice and to take practical action at the grass root level to improve their local environment.

Two major routes where the public can become better informed are:-

1) education at schools and colleges.
2) continuous education and environmental awareness raising.

These two routes imply various ways of teaching and other pedagogical approaches and dissemination of information.

2.5.1 AESN action in Environmental Education

AESN communication strategy aims to show that its activities link development and environment protection, that is sustainable development.

This strategy is based on various actions :-

(I) on a media basis
-improving relationships with newspapers.
-developing advertisements in both radio and TV channels
(ii) on an information basis
-production and diffusion of reports concerning the Agence's activity and especially research and studies
-participation at various exhibitions, jointly with other agencies.
(iii) on a teaching basis :
-increasing the number of "classes d'eau"
-broadening the target population.

Thus 2,300 classes d'eau have occurred since the beginning of this method of communication in 1987. In 1995, 515 classes d'eau occurred, showing both the need for a such teaching program and the size of the pool of interested people. Initially, "classes d'eau" were only open at a school/colleges level, but they are currently available at all educational levels, from the kindergarten to the postgraduate level, including continuous education for adults.

Since 1987, 70,000 people have received general information on water they represent only 1.5% of the pupils and students in the Seine-Normandie Basin. Other sources of information, like the competition << eau pure, eau propre >>, or information packs explaining the role of the AESN, also contribute to the communication strategy of the Agence.

2.5.2 Agency action in Environmental Education

The Environment Agency places an increasing emphasis on educating and informing the general public and external organisations. The recent commitment to the recruitment of Regional Education Co-ordinators is part of a strategy which aims to raise awareness of key environmental issues, influence external parties and policies and change patterns of behaviour, through the dissemination of information.

LEAPs provide an opportunity, through the collation of environmental information and the generation of local interest in environmental matters, for the provision of relevant, issue-focused and targetted educational material. The Agency's Thames Region has proposed the establishment of

local educational partnerships involving inspectors and teachers in the production of Education Supplements to CMP/LEAP Annual Reviews (NRA, 1995b). Through the LEAP consultation process and the preparation of Annual Reviews, community awareness will be generated and participation promoted [Appendix VI].

The main approaches adopted by the Thames Region (TR) of the Agency are:-

(I) provision of information for :-
-technical audience, general community and schools
-conferences/seminars/lectures/exhibitions
-operational work
-integration into the National Curriculum

(ii) communication with the media :-
-liaise with over 300 newspaper groups
-collaborate with over 40 radio stations
-maintain links with 8 television channels

(iii) respond to individual inquiries :-
-TR Press Office considers 200-250 requests/month from schools, colleges and universities

(iv) consult with various local organisations :-
-development of LEAPs

2.5.3 Agency Environmental Education in Schools and Colleges

Environmental education has a principal role in changing behaviour patterns and protecting and enhancing the environment. In the context of Agenda 21, sustainable development and the need to focus limited resources, the primary target of education initiatives should be school children who will be the environmentally aware citizens of the future. The Agency has produced a considerable amount of information in relation to the management of the water environment. This needs to be available in a form which is comprehensible, stimulating and easily used for by school projects.

Thames Water also produce a variety of educational material for schools and colleges including workbooks, videos, computer programs, activity cards and role play assignments. The education liaison department also offers teacher workshops, visiting speakers and tours of the treatment works. Greater collaboration between private water companies and the Agency could avoid duplication of material whilst providing perhaps more continuity of educational material on the water environment.

The former NRA has produced information packs for schools including a 'Riverwork' teaching pack aimed at primary schools, a 'Sources' booklet on river catchments for use by secondary schools and national riverwatch schemes (1995b). Both the Riverwork and Sources information packs were made directly available to all schools in England and Wales. These resources address catchment management and the factors which influence the river catchment, whilst encouraging the study of the local water environment. Teacher training days focusing on local rivers have been available in some areas (NRA, 1995c). However, improvements in riverbank access, the provision of information on measurement/sampling techniques and the development of customised Agency generated data sets for local rivers would facilitate greater participation by schools (Townsend and

Symonds, 1995).

Indicators provided by the DoE (1996) are focused at the national level and may not adequately reflect the situation within a particular geographical area. However wherever possible the indicators have been selected with the local dimension in mind and in many cases it should be possible to desegregate and apply them to the local level. For example, `state" indicators showing the average concentrations of pollutants or proportions of river length of a particular quality standard could be calculated for a smaller geographical area and compared with the national "norm". Thus the use of key indicators for water quality, could be introduced to encourage schools (possibly in conjunction with their local authorities) to consistently monitor their local water environment. It is hoped that environmental indicators can be used as a tool for measuring the attainment of local sustainability (Townsend and Symonds, 1995).

Examples of existing Agency sites could be used to inform children of sustainable methods of water quality improvement in a natural environment without the use of chemicals and ideally with support from the local community. Anton Crescent, a constructed wetland site located in Sutton, is a valuable conservation and educational resource. Public safety features should perhaps be considered in the future design of constructed wetlands to allow for monitoring and maintenance by local schools. The use and function of the `Thames bubbler" which becomes mobile during periods of high biological oxygen demand in the River Thames, should be publicised to demonstrate how suitable environmental conditions are maintained for fauna to survive.

2.5.4 Agency Environmental Education in the Community

Much of environmental education lies outside the realm of the formal education system and has to take into account the livelihood of the people whom it aims to educate and whose behaviour it seeks to influence. The most common method of dissemination is the publication of reports, brochures and leaflets. Each of the eight regions of the Agency produce fact files and answer direct enquiries from members of the public. The Agency provides a list of fact files for many rivers and their tributaries with, for example, the River Thames being covered by four fact files and Agency's Thames Region also produce individual fact files on various topics - fisheries, flood defence, conservation, environmental quality, recreation and water resources.

The Guardian of the Water Environment, written in a non-technical style, provides an update of Agency work. An Agenda 21 (Townsend and Symonds, 1995) Pack has been produced to explain the role of the Agency in promoting the principles of sustainable development and Agenda 21 in the management of the water environment. The pack is especially directed towards voluntary and community groups and members of the public. However, public awareness is raised by ongoing pollution prevention campaigns eg `oil care', 'emergency hotline' and 'Thames Clean' campaigns as well as talks and Agency attendance at local events (NRA, 1995b).

The Thames Region of the Agency is aware of the growing need to identify key environmental indicators for planning the maintenance and improvement of water quality. Land Use Consultants (NRA, 1996) are examining ways in which such indicators could help local authorities and communities incorporate local Agenda 21 initiatives and thus sustainability. The Environment Agency will be developing Environmental Indicators which integrate and analyse data on the quality of air, water and land.

2.5.5 Information Technology and Telematics

The Dobris assessment highlights the problems associated with data and information. One major constraint at European level is the lack of comparable, compatible and verifiable data across European countries. There is a need to collect accurate information on the quantity and quality of water resources, as well as the need for an international and harmonised monitoring network for freshwater resources which is recognised by many, for example GEMS/WATER Global freshwater Monitoring Network established jointly in 1979 by UNEP, WHO, WMO and UNESCO (EEA, 1995b).

Water quality data from 1972 onwards (although a baseline of 1990 is used by the Agency) is stored on the GIS (Geographical Information System) within the Agency Regions and it can provide an illustration of the General Quality Assessment scheme in the form of maps for the entire Thames Region. The integration of Thames Region data into national databases is now in progress in order to create a national database of the quality of rivers in England and Wales. It is at its most basic a computer based system for capturing, storing, checking and manipulating data that are spatially referenced.

GIS is also used by English Nature, National Parks, Natural Environment Research Council (NERC), and the Countryside Commission who are developing extensive environmental mapping databases. The development of interactive databases, forecasting methods and economic planning models appropriate to the task of managing water resources in an efficient and sustainable manner will require the application of techniques like GIS and other expert systems to gather, assimilate, analyse and display information.

Improving the state and provision of water environmental information is a high priority as this will help to ensure that actions and decisions taken by policy makers, the public and all sectors of society are directed towards the sustainable management of the water environment.

Telematics

Exciting opportunities now exist for rapid and widespread dissemination of information via a World Wide Web (WWW) involving interactive use of databases and geographical displays. The EEA has been established for this purpose - its European Environment Information and Observation Network (EIONET) is now being developed to ensure the supply of objective, reliable and comparable information on the environment. The Agency will endeavour to provide a nationally consistent approach to environmental monitoring and it will meet the need of increased access to information, by seeking to "exploit new avenues of IT to bring about a quantum leap in the way information on the environment is made available to all that want it" (Environment Agency, 1996). The Agency are now presenting information on a web site. This includes general information and in particular items from their recent publication on `A snapshot of the Environment' (Environment Agency, 1996).

In the next 5 years, it is proposed that the Agence will maintain its effort in the field of communication. Moreover the SDAGE Seine-Normandie proposes to improve and coordinate all

information of concern to all users involved in water management at the basin level. This includes not only communication aspects as previously mentioned but also a better dissemination of the data collected within the basin using Information technology and telematics.

Telematics is derived from the word telematique, referring to the combination of telecommunications and computers or informatics (Singh and Liebowitz, 1984). The applications of environmental telematics, represents a comparatively new market with confident growth potential with emphasis to shift to the requirements of users. Transmission of information across distance is rapidly increasing within the EU through electronic networks and this reflects a worldwide trend within which the EU as a major economic force needs to keep pace. Nearly all environmental information systems projects integrate existing information systems. Access is improved through the use of networks and the Internet GIS and relevant databases enhance the utility of the information.

The UPRC is a partner in an EC funded Environmental Telematics project entitled 'integrated Environmental Monitoring, forecasting and warning systems in Metropolitan Areas", known as EMMA. Netscape interface software is utilised to access the internet and the WWW for air quality data. At present there is no comparable telematics application for the collation and presentation of national and pan-European water quality data. UPRC is actively seeking new contract bids involving water quality and total environmental indicator systems. Appendix VII gives details of current water telematics projects.

Development of the WWW is to be transferred to the French national institute for computer science and control (INRIA). INRIA will be funded by the telematics programme of the European Commission to study many issues including information services on the Web and promotion and dissemination in Europe.

The Internet can be constantly upgraded with little effect as far as the end user is concerned. Different parts of the net are constantly being changed, added, removed and improved. Thus information provided would be current and available to a wide audience. Experience gained through such media will benefit the participants by preparing them for the inevitable use of telematic technology inherent within much of societal infrastructure.

2.5.6 Recommendations for application of Agency resources

The Agency has adopted a pollution prevention principle and therefore for this approach to be successful there is a continuing need to inform all members of the public. Conferences, seminars, videos, competitions, exchange of good practice all contribute to the establishment of a broad knowledge base.

It is important that the provision of education material within the Agency is centrally co-ordinated to avoid duplication of material. Some form of prioritisation is necessary both nationally and regionally to ensure that money is well spent.

- Continued emphasis on the integration of Agency material into cross-curricula interdisciplinary educational programmes and polices within the National Curriculum. Provision of multimedia packs for schools including video/CD ROMS with possibly more

emphasis on a series of "pollution prevention pays videos" as these have the potential of reaching a wider audience. Possible co-ordination with WWF and International Centre for Conservation Education (in relation to Dobris assessment information).

- Strengthen dissemination of educational information through empowerment of government and other organisations. Mechanisms of transfer of the appropriate information are necessary in order to ensure that the most relevant people gain the most appropriate knowledge.
  eg Association of Science and Education, Department for Education and Employment, Welsh Office Education Department, The National Organisation for Adult Learning (Niace), Thames Water, Thames Explorer Trust, River Thames Society, Thames Heritage Trust.

- Provide use of a support system for teachers (in conjunction with education councils ie NERC). Establishment of Teacher Workshops for awareness training on issues of sustainability and water resources and linking in with the objectives of the LEAPs.

- Utilise LEAPs to identify key themes and messages associated with the management of the water environment, to be conveyed to school children. TR engaged in a pilot study for the production of a `Urban rivers education pack". This could be developed as a national model for a supplementary catchment management plan education pack aimed at Key Stages I and II. This pack seeks to provide a river related teaching resource at the local level whilst promoting the understanding of catchment management plans. Key Stages III and IV to follow?. The concept of sustainable development needs to be defined in practical detail to aid its stepwise application ie, use of Environmental Indicators as an educational resource.

- Communicate through the use of seminars and conferences. eg, Inform Young Farmers and the National Farmers Union groups of best practice for agricultural pollution preventative measures whilst providing an explanation of how excessive nutrient concentrations in water supplies can be both ecologically harmful to the environment and deleterious to human health. Currently a national information pack for agricultural students is being produced.

- Involve communities in the development of new technologies, eg wetlands for the treatment of urban runoff. Place information boards at existing sites, encourage local environmental groups in conjunction with schools and colleges to organise `wetland awareness meetings".

- Informal environmental learning experiences such as those promoted at interpretive centres, museums and heritage sites are increasingly being used by teachers to promote environment education aims. (Incorporation of an Agency display into The Science Museum, Natural History Museum)

- The Agency has produced a state of the environment report which will be placed on the internet. The development of this information into a potential education resource aimed at Key Stages III and IV. This information could be made accessed in association with Campus 2000, BTs education network. As the Agency's web site develops it could be linked with EIONET.

3.0 THEMES AND PROJECTS FOR FUTURE R&D CONSIDERATION

3.1 Summary of Identified Themes

THEME (I) Wetlands for Water Quality Improvement

Projects:

I Review of State-of-the-art selection criteria for wetlands for point and non-point source runoff pollution control.

II Scientific understanding of the microbial processes operating within wetland ecosystems

III Establish a Monitoring Network/Specialist Group (UK/France) to assess and coordinate data on the operational efficiency of wetlands and improve the infrastructure for innovative R&D

THEME (ii) Sustainable Management of Urban Runoff

Projects

I Review of BMP performance criteria for urban runoff quality management

II European database about urban runoff water quality

III Development of rainfall generators

IV Technical software for efficiency assessment

V European network of experimental urban catchments

VI Optimisation procedures for the evaluation of urban drainage alternative for water quality management and control.

VII A decision support system (DSS) for urban water quality management planning.

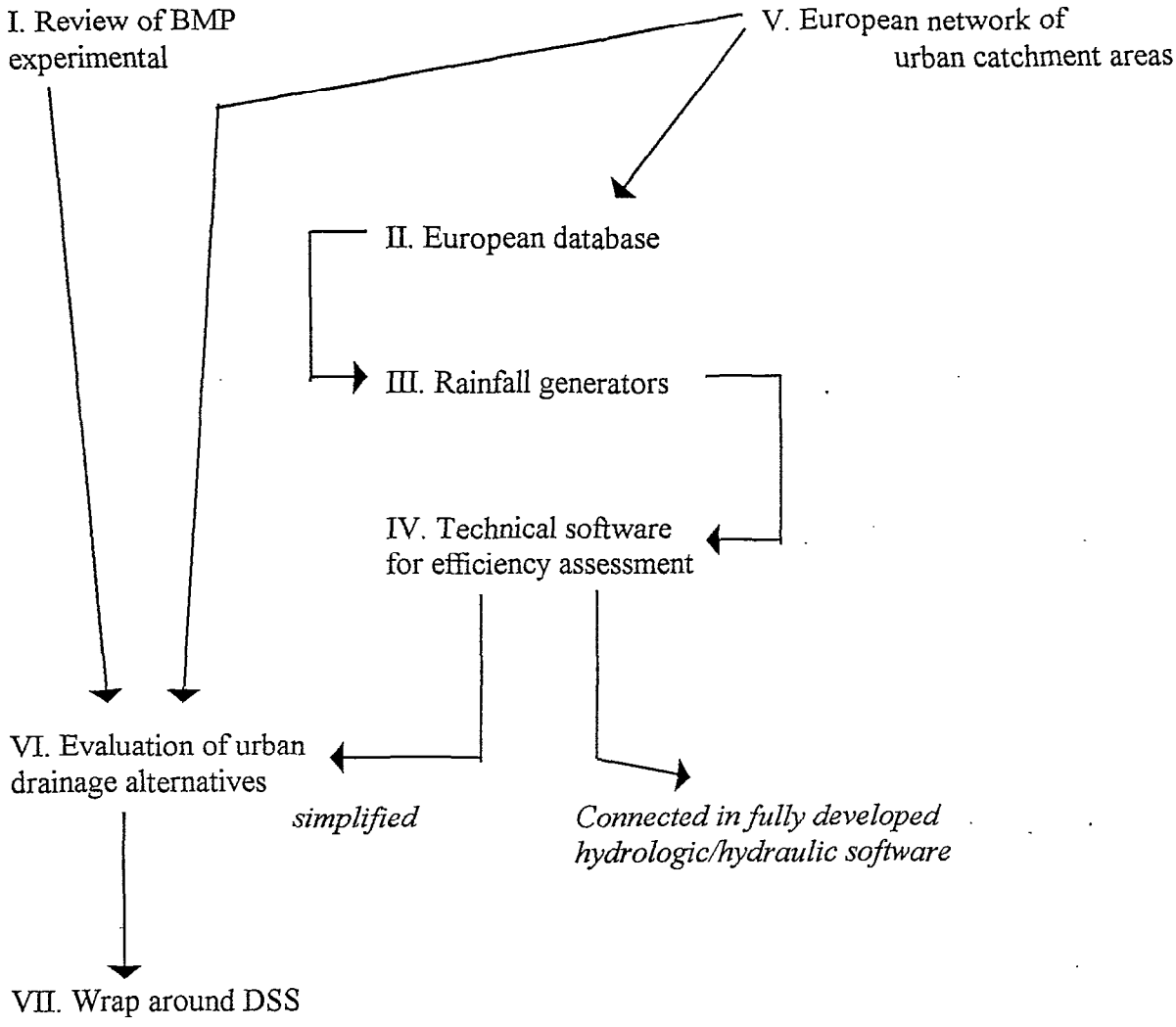

Figure 3 **Illustration of the links which exist between the sub-projects of theme (ii).**

THEME (iii) Environmental Education

Projects

I SAGE and LEAP Education Packs.

II AESN/Agency Exchange of expertise for best management practice applicable to different users within the community. Establishment of community awareness and involvement in local water issues.

III The development and use of Environmental Indicators.

IV Development of linked London-Paris Observatoires de l'Eau et de la Ville (Observatories on water and cities).

3.2 Detailed Analysis of Identified Themes

3.2.1 THEME (I): Wetlands for Water Quality Improvement

Wetlands as a by-product of their ecosystem functioning can assist in the management of water quality. The utilisation of wetlands as a sustainable means of pollutant control is an important area of scientific research and development at present.

Benefits from collaboration

The combined expertise of CERGRENE and UPRC constitutes a continuum of research ranging from natural to fully constructed wetlands for water quality improvement. Both SDAGE and Thames 21 have a commitment to water quality improvement and management. The development of a UK/French monitoring network and subsequent database with practical application would place AESN and the Agency as leaders in this field.

Links

• Industry - CIRIA Research Project 507. The Design and Management of Constructed Wetlands for Wastewater Treatment (in press).

• Reed Beds and Constructed Wetlands for Wastewater Treatment. Water Research Centre Publications (1986). Brian Shutes (UPRC) joint author and presenter at Workshop, Kenilworth 19-21 June 1996.

• EPSRC CASE Studentship. Constructed Wetlands for the Treatment of Urban Runoff. October 1995 - October 1998.

• Scientific groups Comite Scientifique and Comite de Pilotage to co-ordinate inter-Agence Research Programme - Programme National de Recherche sur les Zones Humides (PNRZH). Agence Rhone-Mediterranée-Corse will pilot a Programme of wetland research for the Agences (1996-1999).

• FAEWE (Functional Analysis of European Wetlands) project (DGXII STEP) and proposed PROTOWET project (Ed Maltby UK and Bernard Clement France).

• IAWQ Working Group on the use of Macrophytes for Water Pollution Control (Brian Shutes, UK co-ordinator. There is no French counterpart.

• The Environment Agency has on-going R&D project into wetland conservation (Project Proposal No F02(92)2) and effective management strategies.

Project I: Review of State-of-the-art selection criteria for wetlands for point and non-point source runoff pollution control.

Objective: Produce a guidance manual with selection criteria and supporting training workshop for the use of wetlands for water quality management of runoff

Outcomes:

1.1 Production of a manual in the short term to accompany the training workshop and decision support system which will provide practical guidance to Agency/AESN staff for the use and management of wetlands as a method of water quality management. The manual can be initially supported by existing reviews (CIRIA) and subsequently expanded and updated with on-going R&D. Training workshop to include French/UK case studies/site visits to illustrate procedures and approaches adopted for the management of wetlands and control of pollutants.

1.2 Assess a measure of the operational efficiency and establish a cost/benefit analysis for the use of both natural and constructed wetlands as a sustainable method of water quality management and Best Practicable Environmental Option.

1.3 Recommendations for the integration of wetland systems into the river catchment plans of SAGE and CMPs (LEAPS - Local Environmental Action Plans). Advise on the rehabilitation/conservation of riparian wetlands for dual ecological and buffering capacities. Draw up guidelines with regard to the integration of sustainable environmental (wetland) systems into urban planning.

Draft Product Description

1.1 Compile, compare and critically evaluate studies of existing data on the pollutant removal efficiencies of wetlands.

1.2 Establish current scientific understanding of utilisation of wetlands for runoff management. Advise on current best practice, selection criteria and areas where further R&D is necessary.

1.3 Provide guidance for the selection and design criteria and management guidelines for wetlands. Consider the performance of wetlands (especially constructed) in relation to the current design and to provide and update design recommendations for maximum operational efficiency and management techniques for reed beds in general.

1.4 Access public perception in response to the use of natural/constructed wetlands for water quality control. (Ecological value, design, maintenance, participation).

Benefits from collaboration:

CERGRENE are currently researching into the functioning of natural wetlands whilst UPRC have

undertaken many studies on the use of constructed wetlands for runoff control. This facilitates a continuum of research from natural to constructed and can be expanded to encompass other partners and initiatives (Centre for Aquatic Plant Management - CAPM; FAEWE; PNRH). The combined research will address a number of environmental conditions and endeavour to establish a robust operational system assessable to a wide audience of users. The exchange and collation of scientific expertise within existing best practice manuals from both AESN and the Agency will form a firm foundation and cost effective basis for future R&D.

Links

• IAWQ establish French counterpart. Dr Brian Shutes to update current scientific understanding of wetland systems/processes at IAWQ 5th International Conference on Wetland Systems for Water Pollution Control, Vienna (September 96).

• UPRC. Environmental management and training programme in Kazakhstan funded by the UK Government Know How Fund.

• Environment Agency R&D project on wetland conservation (Project Proposal No F02(92)2) and effective management strategies.

• Inter-Agence Research Programme - PNRZH

• AESN/CERGRENE is studying the processes within natural wetlands.

Project II: Scientific understanding of the microbial processes operating within wetland ecosystems

Objectives: To identify microbial processes operating within wetlands which are responsible for the biodegradation of organic molecules and those responsible for metal immobilisation and hydrocarbon degradation. Increase the understanding of microbial process occurring in both natural and constructed wetland

Outcomes:

1.1 To obtain a fundamental understanding of the mechanisms, functional role and rhizosphere plant interactions of the microbial community and make recommendations for the maximisation of operational efficiency of wetlands with regard to microbial degradation processes.

1.2 To establish a methodology for the monitoring of microbial communities within wetland ecosystems.

1.3 To develop a coupled ecological and water quality model which could be based on the presence/absence of certain microbial species and the use of indicator species.

Draft Product Description

1.1 Investigate the influence of organic compounds (pesticides), heavy metals and hydrocarbons on the performance of microbial communities. Assess the methods by which the functions, products, attributes and interaction of wetland microbial ecosystems may be modified by human activities in order to maximise pollutant treatment efficiency.

1.2 Wetlands assist in the maintenance of water quality as a by-product of their ecosystem functioning and their use as a sustainable means of runoff management. Their environmental capacity must not be exceeded to the detriment of their ecological functioning. A greater understanding of the scientific processes operating within wetlands would facilitate their sustainable management.

Benefits from collaboration:

The AESN/Environment Agency are at the forefront of research on the mechanisms and processes involved in the removal of pollutants by microbial populations for natural and constructed wetlands.

Links

Project III: Establish a Monitoring Network/Specialist Group (UK/France) to assess and coordinate data on the operational efficiency of wetlands and improve the infrastructure for innovative R&D

Objectives: Develop network/establish monitoring programme (6 months). Data collection and assimilation. Establish European database.

Outcomes:

1.1 Formation of Representative and Scientific methodologies for UK/France and subsequently European Monitoring Programme (short term) resulting in the development of a European database (Long term).

1.2 To establish performance criteria for the evaluation of urban runoff quality. Provide firm recommendations for the operational efficiency and selection of wetlands for runoff management.

Draft Product Description

1.1 Produce a compendium of existing and representative wetland data leading to the development of a UK/French and subsequently European database with telematic support. Establish a specialist base offering scientific expertise.

1.2 Establish scientific protocols for the monitoring of parameters within wetland systems. Standardise inflow/outflow chemical analysis. Provide a reference to the

possible antagonistic, synergistic and additive effects of pollutants.

1.3 Provide guidance for best management practice and operational efficiency of wetlands in controlling specific pollutants with regard to their environmental capacity and thus prevention of deterioration of wetland ecosystems.

1.4 To treat non-point sources of pollution by natural and sustainable methods and to evaluate the practical use of the `test beds" for future national R&D projects. To increase European awareness of wetland ecosystems and their evolving role in water management.

1.5 To establish a network as a foundation for external funding applications.

Benefits from collaboration:

Agency National R&D links with AESN inter-Agence Programme and both organisations could initiate the development of a pan-European project with many participants. Coordination of R&D would avoid duplication and therefore offer greater efficiency. Monitoring Network with (UK/France) Advisory Role.

Links

• Project - Review of State-of-the-art selection criteria for wetlands as a method of water quality treatment

• Project - Scientific understanding of the microbial processes operating within wetland ecosystems

• International Association on Water Quality via Dr Brian Shutes

• Inter-Agence - Programme National de Recherche sur les Zones Humides (PNRZH).

• The Sustainable Cities Project (launched by the European Commission Expert Group on the Urban Environment in 1993) and The Charter of European Cities and Towns towards Sustainability (adopted at Aalborg Denmark, 27 May 1994).

• FAEWE project was involved in the assessment of the capacity of the field sites to remove nitrate through the process of denitrification, an important contributor to the improvement of water quality.

• Post FAEWE - Proposed Procedural operationalisation of Techniques for the functional analysis of European wetland ecosystems (PROTOWET) project 1996-99 which looks at extending the environmental gradient and wetland types

• Possible Planning links - The Council of Europe and the CEMAT - Conference of Ministers Responsible for Regional Planning (CEMAT) provides an open forum for the development of concepts and solutions for the policies of sustainable development. Wetlands have been acknowledged as a sustainable method of water quality control for a multiplicity of pollutants.

• Collaboration with regional planning for example the European Spatial Development Perspective (EDSP) which includes Paris and London.

3.2.2 THEME (ii): Sustainable Management of Urban Runoff

Source control approaches have been emphasised as best management practices (BMPs) for achieving sustainable urban runoff quality. The correct selection and optimisation of the various components of the surface water management system are essential for sustainable urban catchment management planning (CMP). The links between the projects outlined below are shown in Figure 3. However, it is possible for most of the projects to run independently.

Benefits from collaboration

Draw together widely disparate theory and field experience of BMP performance within France and the UK to enable a broader based comparison of the solutions that have been implemented (or suggested) in both countries at an experimental level. Provide support to DoE Planning and UKWIR interests in terms of catchment surface water management planning.

Links

• CIRIA Scoping Study on sustainable urban runoff management and recommendations for further work which includes references to need for appropriate MAT techniques. However, no comprehensive guidance or manual is available for the screening assessment of runoff management options.

• The Agency and AESN research interests in the development of techniques necessary for assessing environmental costs and benefits and problem-specific methodologies for BMP performance evaluation.

• IAWQ Conference on Stormwater Source Control (5/6/96) and diffuse pollution video (Nature's Way) and SEPA's (formerly Forth Purification Board) guidance documentation to source control BMP.

• Other European datasets on urban runoff water quality, agreements are been obtained with German and Dutch owners of such datasets.

• Existing or under development hydrological or water quality models such as FRQSIM (the Agency), NOE (FRANCE), PROSE (Seine basin).

Funding

Foundation work on the optimisation analysis will enable application to be made to UK Research Councils (ESRC/NERC) or to CNRS in France. Theme is also of relevance to NERC priority research areas contained in the URGENT and CERI programmes and DSS concepts may be of relevance to EU Framework IV. The database maintenance following its development might be funded by a special income from future measurement programmes organised by AESN/ Agency.

Project I: Review of BMP performance criteria for urban runoff quality management

Objective: To draw together and revise best practice approaches and criteria for a variety of urban runoff quality control measures through the development of MAT matrices.

Outcomes:

1.1 Production of guideline methodology for evaluation of urban runoff quality Baps. Such selection criteria are compatible with Agency duties and powers as contained in the 1996 Environment Act (clauses 5, 7b and c). They are also appropriate to the Ministerial guidance on the Agency"s objectives with regard to achieving sustainable development, particularly in terms of integrating technical, environmental and economic factors in BMP decision making. The availability of selection criteria and guidelines for urban drainage Baps would also give confidence to the "shared responsibility" partnerships necessary to deliver integrated, multiple-use urban drainage systems. Additionally, the development of sustainable selection criteria might enable the identification of feasible sustainability indicators for urban runoff water quality.

1.2 Develop the basis for training and workshop courses appropriate for the wider practitioner and regulatory agency market including developers, planners, regulators, local authorities, drainage engineers and environmental consultants.

1.3 Software application to aid screening level selection criteria for urban water quality Baps and in support of Agency/AESN regulatory functions.

Draft Product Description

1.1 Desk study compilation and evaluation of available source control performance parameters from US, Canadian, European and Australian literature but with particular emphasis on UK and French conditions.

1.2 Development of scoring and rating matrix techniques for ranking and weighting parameters as a basis for the preliminary BMP screening.

1.3 Guidance methodology for selection of appropriate site BMP based on iterative parameter and performance requirements in relation to known site constraints. The methodology will utilise user-friendly and menu-driven PC program suitable for Microsoft Windows application.

Project II: Urban runoff water quality database

Objective : Integration of English data into the AESN-CERGRENE French database about urban runoff water quality (QASTOR database).

Outcomes :

1.1 Develop a comprehensive database of all existing French and English data about urban runoff water quality coupled to the necessary hydrological and land-use data. The database will be developed on DBase compatible format for easier transfer. It only may contain data which have been obtained at the outlet of urban catchments where a minimal set of events have been monitored in order to match representative criteria.

1.2 A user manual will accompany the distributed database to make it available to any person concerned with urban runoff water quality. Training sessions may be organized for new users of the database.

1.3 Comparison of urban runoff water quality in European countries. Strong differences exist between urban development characteristics in European countries. In particular, the development of London and Paris conurbations have been very different during the last century with the promotion of greener areas in London and a very dense situation in Paris. Differences with southern counties may even be much more important. A long term objective of the database is to specify the need for local interpretation of future European recommendation concerning urban runoff control and BMP's.

Draft Product Description.

1.1 Collection and analysis of the available English data sets regarding urban runoff water quality. Evaluate their relationship to previously established data selection criteria. Presentation of the data sets including a description of the catchments.

1.2 Statistical analysis of the differences induced by land use of he water quality of urban runoff, with respect to event mean concentration, pollutant flux to catchment area ratios, existence of first flush effects.

Benefits from collaboration:

Such an integration of data from various sources cannot be conceived without a strong collaborative effort. Urban runoff water quality data shows high variability. The only way to obtain relevant information about the differences induced by land-use on urban runoff water quality is to use an extensive and homogeneous database. Cooperation with Germany and Netherlands is already being sought to extend the database.

Links with other existing projects :

• The extension of the national database about urban runoff at a European scale is a common objective of AESN and CERGRENE.

• Several other campaigns are still running in France, which outputs should become part of QASTOR database.

• European directive about waste water (1991) and its application in France requires impact studies

for combined sewer overflows and large urban runoff inflows. A comprehensive database is a important device in the tool box which has to be developed for such studies.

Project III: Rainfall generators.

Objectives : To develop a framework for the parametrization of a statistical rainfall generator.

Outcomes :

1.1 A user friendly software for rainfall time series analysis based on the most operative procedure, coupled with a statistical rainfall generation system. The statistical rainfall generator is able

(I) to analyse existing rainfall series and to provide their statistical characteristics in order to feed the generator.
(ii) to generate rainfall series at small time steps (typically 5 minutes).

1.2 A practical guide accompanying training session for practitioners will be proposed. The training sessions are proposed to the technical staff from the Agency/AESN but also to engineering companies which may have to face the problem a statistical design of urban runoff control systems.

Draft Product Description

1.1 Review of existing statistical time series analysis procedures which can be applied to rain series including the simulation of dry weather durations as well as seasonal effects.

1.2 Decide about the more relevant statistical system, implement it on a PC and treat one French and one English example of long-term time series.

1.3 Analysis based on existing dense rain gauges networks (Seine Saint Denis in France for example) and meteorological radar images of the opportunity and possible methodologies to include a spatial statistical analysis of rain fields structures

1.4 Couple the time series statistical rainfall generator with a spatial structure reconstruction system

Links

Christian Roux

Project IV: Linkage of the rainfall generation system and the urban runoff water quality database with other systems.

Objectives : A simplified pre-definition software system for the design of urban runoff control systems including BMP's.

Outcomes :

1.1 A simplified pre-definition system including the rainfall generation system and a simple distributed urban runoff model. Water quality data will be added to this system through the use of selected outputs from the data base. Simplified functional descriptions of any sources control or treatment technique can be parametrized in this pre-definition level software system.

1.2 Manual plus training sessions to teach about this new system. Training sessions are conceived for technical staff of the Agency/AESN but also for any person from an engineering office facing problems with the design of a network of possible urban runoff control solutions.

Draft Product Description

1.1 Simplified models and parametrization of the functioning of existing urban runoff control units as well as of BMP source control techniques.

1.2. Selection of the most pertinent distributed urban runoff simulation system. FRQSIM will be specially considered.

1.3 Design of the coupling with the urban runoff water quality database through the design of relevant query system.

Project V: European urban experimental catchments.

Objectives : To develop the basis of an European network of experimental urban catchments.

Outcomes :

1.1. Experimental catchments can be used to identify problems associated with the quality of urban runoff including :-
(I) analysis of input/output relationships, quantitatively assess the real sources of urban runoff pollution,
(ii) study the effect of various urban technical practices (street washing, gully pots equipment and/or waste recovery....)
(iii) study real in-pipe sediment transport, as well as sewer cleaning procedures.
(iv) effect of various types of pavements on pollution exports.
(v) demonstration of the efficiency of urban runoff source control BMP"s.

1.2. Another important outcome from an European network of experimental urban catchments will be the design of common sampling techniques and strategies. They will allow real comparison of pollution loads as well as pollution control or treatment techniques. The network will provide yearly upgrades of an illustrated technical recommendation manual.

Draft Product Description

1.1 Contact all other European institutions which may be potentially interested by the urban catchment network (existing catchments plus international institution such as IAWQ and IAHR).

1.2. Produce a first synthesis about sampling techniques and strategies.

1.3 Produce a yearly activity report about each catchment in the network, and the launching of ad hoc thematic groups.

Benefits from collaboration :

The basic hydrologic equipment of experimental catchment requires heavy investments to obtain reliable results. Various types of catchments should be part of this European network, it is not cost-efficient that each country develops its own catchment network, networking allows cost-sharing. A leading committee should promote common research projects as well as operational protocols for urban runoff pollution measurement. The EEC will have to modify the 1991 Directive regarding Urban Wastewater in order to consider the problems associated with periods of heavy rainfall. The proposed European network would be a centre for European expertise.

Links with other existing projects :

- An urban experimental catchment has been implemented in central Paris by CERGRENE.
- Experiments in South Oxhey Estate by UPRC.
- Experimental catchments in Brussels, in Dundee.
- GEMCEA test platform in Nancy.
- IAWQ sewer sediments group

Project VI: Optimisation procedures for the evaluation of urban drainage alternatives for water quality management and control.

Objective: To develop a generic technical basis for the optimisation of urban water quality BMPs based on cost-effectiveness analysis.

Outcomes:

1.1 Development of a robust performance optimisation procedure for alternative BMP urban drainage control measures based on cost-effectiveness rather than cost-benefit.

1.2 An optimisation algorithm to support the LEAP process central to both the Agency

and AESN regulatory functions.

Draft Product Description

1.1 Develop cost-effectiveness analysis as a basis for the preliminary planning of urban runoff quality BMPs. This is deemed appropriate because of urban runoff quality BMPs. The analysis aims to determine the least-cost relationship between increasing cost and improving water quality performance which will be of direct benefit to design level analysis.

1.2 The optimisation procedure will utilise constrained cost minimisation procedure and isoquant analysis to determine least-cost system performance. With a knowledge of the cost functions for alternative control measures (to be determined from UK and French surveys), the least-cost mix (or combination) of BMP measures to achieve specified levels of quantity/quality control performance can then be determined by Lagrangian optimisation. The approach can be used for extreme event control and for long term, average quality control performance based on combinations of downstream storage systems and/or upstream source control systems.

1.3 The optimisation algorithm will be PC coded and will incorporate a simple sensitivity analysis utilising a standard package such as Lotus.

Project VII: A decision support system (DSS) for urban water quality management planning.

Objective: To develop a decision support system (DSS) for scenario-building evaluation of sustainable urban runoff management strategies and to provide answers to decision makers on the likely effects of alternative courses of action in terms of specified end-uses and standards (or SWQOs) for different input conditions and control measures.

Outcomes:

1.1 The DSS will be developed as a best practice training tool and as a scenario-building techniques to provide preliminary planning level solutions to developers and decision makers on the effects of alternative courses of action and alterative BMP options.

1.2 A DSS for urban runoff quality management would provide a mechanism whereby the various stakeholders can examine and appraise the full range of drainage options for differing development scenarios to achieve the best practicable and sustainable environmental outcomes.

Draft Product Description

1.1 Develop a "wrap-round" decision support system (DSS) for urban runoff quality management scenarios based upon functional definition of inputs for specified conditions.

1.2 The DSS will incorporate:
(a) Objective Setting water quality levels needed to allow a given set (or mix) of development uses
(b) Action Definition pollutant levels needed to be reduced to achieve the required level of water quality and definition of impacts resulting from changing pollutant loads and alternative control measures.
© Control Location definition of optimal locations, capabilities and performance criteria that need to be met.

1.3 Production of dialogue, data and model management components for the DSS utilising in-house UPRC and CERGRENE databases and models. The DSS design will use a synthesis of databases and models using descriptive statistics to compress the databases and transfer functions instead of dispersion modelling.

1.4 The DSS will be developed as a hypermedia application tool utilising Windows screening and menu systems.

3.2.3 THEME (iii): Environmental Education and Information

There is a need to promote public involvement in the move towards sustainability and the adoption of local Agenda 21 and consequently Thames 21 and SDAGE. There is a need for educational initiatives aimed at local people and their involvement and participation ideally as a broad cross-section of community members.

Benefits from Collaboration

Both partners have expertise in the preparation of educational material and wish to encourage public participation in the preparation of SAGE and LEAPs. The exchange of experience and good practice would be beneficial and would contribute to the establishment of a broad knowledge base and extended to the entire community.

Links

• The Thames Region of the Agency - 'Go with the Flow' and 'The Agency Files' are education packs derived from the Hogsmill CMP and compatible with the requirements of the UK schools National Curriculum (Key Stages 1&2 and 3&4 respectively).

• AESN Classes d'Eau. A one week course on water issues aimed at schools and colleges.

• WWF and International Centre for Conservation Education are producing education material in relation to the Dobris assessment.

• NERC, government organisations (eg Association of Science and Education, National Organisation for Adult Learning (Niace) and community groups (Thames Explorer Trust, River Thames Society, Thames Heritage Trust).

• The Agency Web site and the EIONET and EEA (European Topic Centre 'Inland Waters')

• The Agency R&D Projects: Best Practice Manual (A07(94)7) and Effective methods of water saving education and demand management (W6E(95)03).

• Clifton Scientific Trust (CFT) Science for Real and the Water Environment.

Funding

UK Research Councils (NERC). Financing from `environmentally aware" Corporations.

Project I: SAGE and LEAP Education Packs

Objective: Develop educational packs within the framework of Local Agenda 21, SDAGE/ SAGEs, LEAPs and focusing particularly on water-related aspects of integrated environmental management.

Outcomes:

1.1 Provide a national education model for the dissemination of information on water and environmental issues within the community, schools and colleges and which is applicable at the LEAPs/SAGE level.

1.2 Provide use of a support system for teachers (in conjunction with education councils ie NERC). Establishment of Teacher Workshops for awareness training on issues of sustainability and water resources and linking in with the objectives of the LEAPs.

Draft Product Description

1.1 The objective of SAGE/LEAP education packs would be to provide a teaching resource, applicable at the local level and generally based on integrated river basin management. Pilot packs produced as a consequence of the Wandle, Beverley & Hogsmill CMP are fully compatible with the UK schools National Curriculum.

1.2 Utilise SAGE/LEAPs to identify key themes and messages associated with management of the environment. The education pack could facilitate a greater understanding of the conflicts between different landuses (industry, residential, agriculture and recreation) and thus raise awareness of the issues associated with environmental management.

1.3 An education pack would strengthen understanding of the aims of SAGEs and LEAPs and therefore increase participation in local environmental management..

1.4 An overview of the problems facing large urban areas could be used to emphasise the wider issues including water quality management and control. A comparison of the similarities and differences associated with environmental management of the Seine and Thames catchments could be made.

Benefits from collaboration

The development of a SAGE and LEAPs Education Pack would reinforce the aims of Agenda 21 with particular reference to public participation. AESN have much experience with school and college children in the provision of their weekly "Les Classes d'Eau". TR is engaged in a pilot study for the production of a "River Catchment Education Pack" aimed at Key Stages I and II. This could be further developed as a national model for application at the local level and later in the form of a supplementary LEAPs/SAGE education pack.

Links

• The Agency's Thames Region - River Catchment Education Pack and integration of Agency material into cross-curricula interdisciplinary educational programmes within the National Curriculum (Jean Harper)

• AESN Classe d'Eau

• The Agency's Thames Region on-going project into the integration of Agency material into cross-curricula interdisciplinary educational programmes and polices within the National Curriculum.

• EA R&D Projects: Best Practice Manual (A07(94)7) and Effective methods of water saving education (W6E(95)03).

• Clifton Scientific Trust (CFT) Science for Real and the Water Environment

Project II: AESN/Agency Exchange of expertise for best management practice applicable to different users within the community and encourage community awareness and involvement in local water issues.

Objective: To develop a guidance manual and supporting training workshop for the integration of best management practice for agricultural and landfill uses. Promote cooperation with local environment groups to encourage community awareness and increase involvement in local water issues.

Outcomes:

1.1 The provision of advisory information packs/video of current BMP, accompanied by a training workshop.

1.2 Communicate current scientific knowledge through the use of seminars and conferences.

1.3 The development of a training workshop for Agency/AESN staff, local authority and community representative.

1.4 To expand information on the Agency Web site to include material for different user groups. The development of an Internet server describing water quality of the

Thames and Seine basins.

Draft Product Description

1.1 Assemble and coordinate existing expertise, best management guidance and scientific knowledge

1.2 Community involvement in local schemes can be both beneficial and cost-effective where for example, to ensure the success of wetlands, in particular constructed wetlands, the community should be aware of their capacity for water quality treatment. Erect information boards and provide leaflets for the local residents outlining the role and function of the local wetland whilst encouraging community involvement. Encourage informal environmental learning experiences such as those promoted at interpretive centres, museums and heritage sites.

1.3 Strengthen dissemination of information through empowerment of government and other organisations. Mechanisms of transfer of the appropriate information are necessary in order to ensure that the most relevant people gain the most appropriate knowledge. eg Association of Science and Education, Department for Education and Employment, Welsh Office Education Department, The National Organisation for Adult Learning (Niace), Thames Water, Thames Explorer Trust, River Thames Society, Thames Heritage Trust.

1.4 Provision of information packs for community groups. Possibly more emphasis needed to provide a series of `pollution prevention pays videos" as these have the potential of reaching a wider audience. Encourage collaboration with WWF and International Centre for Conservation Education.

1.5 The Agency has an evolving Internet web site. The provision of water quality information could be achieved in cooperation, with the European Topic Centre concerning inland waters appointed by the EEA. This would provide a clear assessment of the current state of the water quality as well as obtaining trends in the water quality in both the short and long term.

Benefits from collaboration

Both AESN and the Agency have adopted a pollution prevention principle and therefore for this approach to be successful there is a continuing need to raise awareness within the local community. Both experience problems associated with groundwater contamination from agricultural runoff and landfill leachate. Centralisation of information and exchange of expertise between all partners will avoid unnecessary duplication of R&D and material and thus will be more cost-effective. The Agency has an evolving Internet Web site. Incorporation of water quality data for both London and Paris could provide a base for future action at the European level and it would assist operators and authorities by the careful selection and simplification of environmental data.

Links

• The Agency is developing a Best Practice Manual (Project No A07(94)7) to help Agency staff advise farmers on how to reduce the risks of farm pollution. (Completion due end 1996)

• AESN are producing a national agricultural best practice guide for distribution to farmers, etc (Completion 1997) and Artois-Picardie are evaluating the environmental impact of agricultural practices and devising a sustainable agricultural management strategy (1996-1999)

• The Agency Web site and the EIONET and EEA (European Topic Centre 'Inland waters')

• The Agency has produced a state of the environment report which will be placed on the internet. The utilisation of this information as a potential education resource.

Project III: The development and use of Environmental Indicators

Objective: The establishment of a set of key environmental indicators which monitor the performance of policies and thus help to improve water quality and the aquatic environment.

Outcomes:

1.1 A series of key environmental indicators applicable at the local level but fitting within a broader framework of national indicators. Encourage monitoring by the Agency, planning and community members. Indicators to provide a foundation for decision-making at all levels.

1.2 Data assessment and trends identified in order to assess indicator performance and to contribute to a self-regulating sustainability of integrated environmental planning. Indicators to assess the implementation and effectiveness of national policies on the local environment. The Local Agenda 21 steering Group has

Draft Product Description

1.1 The concept of sustainable development needs to be defined in practical detail to aid its stepwise application ie, use of Environmental Indicators as an educational resource.

1.2 Encourage public participation of ecological monitoring, through the use of key environmental indicators. Involve communities in the monitoring of environmental developments, eg wetland systems for the treatment of urban runoff. A comparison of the application of these indicators in different catchments could then be evaluated. Both schools and the local community could be involved in this monitoring process.

1.3 Establish a routine for annual reporting (Internet/EIONET) and evaluate the performance of indicators which are significant at the national level.

Benefits of collaboration:

There is a widespread interest in the international community in the possibility of developing a set of key indicators covering a range of environmental or sustainable development issues.
Such indicators would monitor changes in the regional and global environment and pressures due to economic development to establish the relationship between change in the state of the urban environment and the pattern of urban development. The environmental performance of urban areas needs to be monitored through a consistent set of urban environmental indicators to provide guidance in formulating and implementing urban environment policies.

The Thames Region of the Agency is developing a set of key environmental indicators.

Links

• Various R&D at present on environmental indicators: The Organisation for Economic Cooperation and Development (OECD) UN Commission on Sustainable Development and the World Bank Eurostat (the Statistical Office of the European Communities) and the European Environment Agency. 1996). Within the UK local authorities, as part of their local Agenda 21 initiative, are developing a set of indicators and the Local Agenda 21 steering Group has commissioned a study into local sustainability indicators. The DoE has selected key sustainable development indicators for freshwater (eight) and for water resources (six) within the UK.

Project IV: Development of linked London-Paris Observatoires de l'Eau et de la Ville. or Observatories on water and cities.

Objective: The development of a UK/French education initiative which would consider water management issues in urban areas.

Outcomes:

1.1 These observatories could form the basis of a powerful management tool, which would improve the ability of decision makers to include the consideration of environmental aspects into urban infrastructure.

Draft Product Description

1.1 To facilitate liaison between urban planners and water authorities and to establish common objectives. To promote an exchange of technical and scientific skills and training.

1.2 Use of appropriate indicators to monitor the water and urban amenities within a sustainable development policy.

Benefits from collaboration

A common European framework is important to identify and assess a broad range of options to

operationalise sustainable development in urban areas. AESN is currently in collaboration with the Academie de l'Eau and the Ile de France Regional Council (IAURIF) regarding the Obervatories.

Links

• European Topic Centre concerning inland waters appointed by the EEA.

• Sustainable Cities Project (launched by the European Commission Expert Group on the Urban Environment in 1993) and The Charter of European Cities and Towns towards Sustainability (adopted at Aalborg Denmark, 27 May 1994).

• Thames 21 (1995) A Planning Perspective and a Sustainable Strategy for the Thames Region.

3.3 Criteria for prioritising Theme (I)

(I) End-user need

The Thames Region of the Agency, has introduced two experimental constructed wetlands for the treatment of urban runoff (2.5.3-2.5.5). It is anticipated that there will be increasing demand at the local authority, regional and national levels of the Agency for the adoption of constructed wetlands as a sustainable method of runoff management for pollution control. The implementation of local Agenda 21 will drive this demand. Engineers and planners in the UK and France will require guidance manuals and training workshops on the criteria for the selection, design and operation of constructed wetlands for urban runoff treatment.

The role of natural wetlands in the treatment of non-point source agricultural runoff is a priority theme for L'Agence de l'Eau Seine Normandie (AESN) and the Inter-Agence Programme Nationale de Recherche sur les Zones Humides (PNRZH). The functional analysis of European Wetlands (FAEWE) programme which is coordinated by Professor Ed Maltby, Royal Holloway Institute of Environmental Research, will contribute to the research initiative with its French partners. Guidelines, manuals and training workshops for natural wetland selection and utilisation for non-point source pollution will be targeted at engineers and pollution control and conservation advisers in the regional and national Agency/Agence and non-government agencies (eg English Nature and the Royal Society for the Protection of Birds).

Natural and constructed wetlands are a relatively low-cost sustainable option of pollution control. The introduction of clear guidelines based on the operation of established treatment systems will meet the existing and anticipated future demand for information on wetlands for environmental management.

(II) Opportunities for excellent science

Wetland research has focused on nutrient balances in natural wetlands and removal efficiencies of water quality parameters in constructed wetlands (see 2.4.3-2.4.6). There has been limited research on the microbial community structure associated with wetland plants and substrates. The proposed focus of the research on the microbial process in pesticide and hydrocarbon degradation and metal immobilisation/uptake would provide an understanding of critical factors which influence the

pollution removal performance of wetlands. A successful outcome to the research would make a significant contribution to the scientific understanding of wetland processes.

(III) National and International relevance to the Environment Agency

The proven ability of constructed wetlands to treat pollution will enable the Agency to support the introduction of these systems within LEAPs. Similarly, the use of natural wetlands by the Agency would provide an additional method of reducing nutrient and pesticide concentrations from agricultural runoff. An Anglo-French collaboration to implement these methods of pollution control would possibly attract other European partners.

(IV) Middlesex University UPRC and the Agency's Thames Region Wetland R&D

The UPRC has seven years experience of research on pollution treatment (heavy metals and hydrocarbons) in natural and constructed wetlands involving the monitoring of heavy metals and hydrocarbons. A book (Cooper *et al.*, 1996), a number of chapters in books and articles in journals have been published. UPRC staff are represented on national and international constructed wetland advisory groups. Site descriptions and a list of the objectives of the EPSRC CASE Studentship between UPRC and The Agency's Thames Region are described in 2.5.3-2.5.6. The Agency's Thames Region has also initiated an R&D project on the use of constructed wetlands in integrated systems to treat highway runoff. Middlesex University UPRC is a partner in this study.

(V) CERGRENE

CERGRENE have completed R&D Projects for AESN and the Inter-Agences de l'Eau. They are leaders of the urban runoff sub-project of PIREN-Seine and scientific advisers on the rolling study for the complete sewerage system for Paris which is part funded by the Ministry of the Environment. Dr Serge Aguilar, Vice-Director of CERGRENE, is Chair of the Urban Runoff Working Group of the Societe Hydrotechnique de Paris.

(VI) Opportunity for R&D and Training

Theme (I) includes opportunities for both training and R&D which are summarised in the objectives and outcomes of projects (3.1).

(VII) Trigger for External Party Funding

The support of the Agency for the research element of the programme will assist applications for additional sources of funding from third parties including the Natural Environment Research Council (NERC), research awards and the Urban Regeneration Programme (URGENT), and Engineering and Physical Sciences Research Council (EPSRC) Sustainable Cities Programme. European Commission Funding from the IV and V Framework Environment Programmes will be sought.

(VIII) Development of existing team/relationship

Middlesex UPRC has established R&D and Training Links with the Agency's Thames Region and

CERGRENE. In addition to the wetland research programme, Agency staff have made presentations to Middlesex undergraduate and post-graduate programmes and to professional seminars. UPRC and CERGRENE offer a joint MSc and Diplome d'Etudes Approfondies (DEA) Water Pollution Control and have contributed to jointly organised seminars and research projects involving the support of AESN. The implementation of a collaborative research project involving the four partners would further develop this relationship. This report was prepared by the following members of the two research groups: UPRC Dr Brian Shutes, Ms Karen Adams, Professor Bryan Ellis, Professor Mike Revitt: CRGRENE Dr Jean-Marie Mouchel, Dr Bruno Tassin.

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5. APPENDICES

Appendix I Scoping Study Terms of Reference

1. Background

The Environment Agency (Thames Region) 'Thames 21' strategy and individual Local Environment Action Plans (LEAPs) on the English side, and AESN's SDAGE and SAGE initiatives for the French have much in common. The broad aim, in both cases, is to ensure a truly integrated approach to environmental management and to strengthen links to statutory land use planning. The commitment at the Rio Earth Summit by the UK and French governments to Sustainable Development and to broad public involvement in planning for sustainability through local Agenda 21 initiatives has implications for the implementation of both SAGEs and LEAPs.

Earlier discussions between Environment Agency Head Office and AESN against the background of the UK DoE/French Ministry of the Environment Bilaterals and the IVth inter-Agence Research Programme highlighted the advantages of working closely with AESN on R&D and, through them keeping closely in touch with R&D at the National level in France. Many of the 10 priority themes in the inter-Agence programme are topics of direct interest to the Agency.

Middlesex University is an evolving "centre of excellence" in urban pollution management and has strong links with the Agency. It also has an established teaching and research partnership with the Ecole Nationale des Ponts et Chaussees and their CERGRENE research groups in Paris. CERGRENE have worked previously with AESN.

2. Objectives of the Study

The primary aim of the Scoping study is to identify and prioritise topics for future joint R&D. The continuing dialogue between AESN and the Agency (Thames Region) and particularly the "shadowing" of SDAGE/LEAPs initiative indicates that suitable topics could be drawn from the following areas of common interest:

> Rural catchment issues such as the impact of minerals policy on water quality, identification of flood risk, bacteriological water quality, ecological surveys, diffuse agricultural pollution etc..
>
> Urban conurbations where there are problems from storm runoff (overflows from combined sewers), poor potable waste quality (due to the continuing use of lead pipes), increased runoff from the continuing development (source control) etc...
>
> The implementation of Thames 21, LEAPs, SDAGE and SAGEs. i.e links to local (land use/waste) plans, local Agenda 21 etc..

The Study must also investigate the potential links between AESN/Agency R&D and the IVth Inter-Agence R&D Programme, clarify and confirm the content of the latter and report on then relationship to the "Bilaterals". Specific recommendations are required on the following:

- The status and content of the Inter-Agence R&D programme.

- Constraints to the Scoping Study arising from the Inter-Agence programme and "Bilaterals" where "lead" status has been allocated to an Agence **other** than AESN.

- Co-ordination of Agency National R&D needs with the Inter-Agence programme and ways in which progress of the latter can be routinely tracked by the Agency.

3. Selection Criteria for Future Joint R&D

Topics for consideration and prioritisation should meet the following criteria:-

a) Be important to both the Agency and AESN. A sense of common "ownership" for future joint initiatives is essential for success.

b) Represent a field of particular expertise in which the Agency/AESN are leading national practice.

c) Represent a field in which there is scope for one partner organisation to learn from the other. eg, Minerals planning, flood risk mapping & integrated river management for AESN and "Source Control" as applied in development around Paris from the Agency.

d) Attract, if possible, external funding. A good example of this in the UK is the recently agreed studentship on Constructed Wetlands at Middlesex University.

e) They should address perceived gaps in each organisation"s existing R&D programme and be complementary to both National R&D and Regional initiatives (operational investigations).

f) They must be relevant to the practical implementation of existing or forthcoming European Directives.

g) Provide scope for the application of high-quality, innovative Science.

h) Have the potential to lead to recommendations that will be straightforward in application, perceived as relevant by professional and understandable by the public-at-large.

The topics to be identified will not be confined to any one professional discipline, but may address any of the following:- ecology, technical/engineering, socio-economics, management etc...

4. Management of the Scoping Study

The scoping study will be carried out by two teams:-

The Environment Agency

Team Leader:
Doug Mills, Catchment Planning Manager, Environment Agency, Thames Region, Sunbury.

Partner Institution:
Dr Brian Shutes, Professor Mike Revitt, Professor Bryan Ellis, Karen Adams
Middlesex University, Urban Pollution Research Centre (UPRC), Bounds Green, London.

Agence de l''Eau Seine Normandie

Team Leader:
Jean-Claude Vial, Directeur, Direction de l''Environment des Etudes et de la Recherche, Nanterre, France.

Partner Institution:
Dr Jean-Marie Mouchel, Dr Bruno Tassin
Centre d'Enseignement et de Recherche pour la Gestion des Ressources Naturelles et de l'Environnement (CERGRENE) within the Ecole Nationale des Ponts et Chaussées, Noisy-le-Grand, Paris.

5. Key Study Activities

- Agree ToR and final work programme for Scoping Study
- Hold start-up meeting attended by team leaders and research institutions
- Review issues/subject areas potentially suitable for collaborative R&D project, in terms of:

- general suitability for Agency/Agence Collaboration
- importance at National level
- importance at Regional level
- size of the issue and potential benefits
- implications for sustainable development/Local Agenda 21
- relevance to international/European legislation
- likelihood of successful R&D completion within reasonable timescale and cost

Shortlist top three potential areas
Evaluate the feasibility of a successful collaborative R&D project

- practicality and cost of work programme
- size of benefits
- practicality and policy relevance of output

Agree on preferred option, having taken views of senior management
Draw up detailed project plan for the preferred option, including:

- overall and specific objectives
- research programme, with timescales, targets etc
- research team composition and inputs
- description of proposed outputs
- description of type/user of outputs
- outline plan for dissemination, training and implementation of results
- special plans for co-ordination of the two parallel -programmes
- present findings and proposal to a workshop of senior Agency and Agence management

6. Outputs

(I) Review of issues/subject areas leading to short-list
(ii) Feasibility evaluation of short-listed areas
(iii) Project plan for preferred option(s)
(iv) Presentation to workshop meeting

Items (I) and (ii) will each comprise separate documents for the Agency and Agence viewpoints, with a short overview document. Items (iii) and (iv) will be common to both organisations.

7. Resources

Resource inputs to the Scoping Study should be maintained within the following ceiling

England/Wales	
Agency Team Leader	5 person-days
Middlesex University	10 person-days
Nominated experts	as identified by the Study Team

8. Constraints and risks

This is a time of continued change for both the Agence and the Environment Agency. Management should recognise this in agreeing work programmes.

Environment Agency Thames Region/Head Office

Appendix II Relevant UK Water Legislation

Public Health Act 1848
Salmon Fisheries Act 1861
Rivers Pollution Prevention Act 1876
Public Health Act 1936
Rivers Board Act 1948
Rivers (Prevention of Pollution) Act 1951
Clean Rivers (estuaries and Tidal waters) Act 1960
Rivers (prevention of Pollution) Act 1961
The Water Resources Act 1963
The Water Act 1973
The Control of Pollution Act 1974
The Salmon and Freshwater Fisheries Act 1975
The Water Act 1989
The Environmental Protection Act 1990
The Land Drainage Act 1991
The Water Resources Act 1991
The Water Industry Act 1991
The Water Resources Act 1991
The Environment Act 1995

Appendix III Main objectives of the Environment Agency

The Agency works towards Sustainable Development through seven objectives, sent by Ministers :-

1. An integrated approach to environmental protection and enhancement, taking into consideration the impact of all activities and natural resources

2. Delivery of environmental goals without imposing disproportionate costs on industry or society as a whole

3. Clear and effective procedures for serving its customers, including the development of single points of contact with the Agency

4. High professional standards, using the best possible information and analytical methods

5. Organisation of its own activities to reflect good environmental and management practice, and provision of value for money for those who pay its charges as well as for taxpayers as a whole

6. Provision of clear and readily available advice and information on its work

7. Development of a close and responsive relationship with the public, including Local Authorities, other representatives of local communities and regulated organisations.

Environment Agency (England and Wales)
Head Office
Rivers House,
Waterside Drive,
Aztec West,
Almondsbury,
Bristol. BS12 4UD
Tel 01454 624 400

SEPA Scottish Environment Protection Agency
Erskine Court
The Castle Business Park
Stirling. FK9 4TR
Tel 01786 457 700

EPA The Republic of Ireland"s Environment Protection Agency
Ardcavan
Wexford
Republic of Ireland
Tel 00 353 5347120

Appendix IV - European Directives

EC Directive on Risk assessment of new chemical substances (93/67/EEC)

EC Habitats Directive (92/43/EEC)
EC directive on the conservation of habitats and of wild flora and fauna under which sites will be designated special areas for conservation (SAC) and supported by the UK biodiversity steering group set up as part of the UK strategy to implement commitments made at the Rio earth summit.

EC Directive on the Protection of waters against pollution caused by nitrates from agriculture sources (91/676/EEC)
The Directive requires Member States to identify "polluted waters". For freshwaters, such waters are those where the nitrate limit set has been or could be exceeded. Alternatively the water may be either eutrophic or have the potential to become eutrophic. Land draining into these waters may need to be designated as vulnerable zones, within which action programmes must be established to reduce and further prevent the agricultural contribution to nitrate pollution. These measures will include rules on the application to land of chemical fertilisers and manure.

EC Directive Production and placing on the market of live Bivalve Molluscs (91/492/EEC)
The `Shellfish Health" Directive relates to the health of consumers. It specifies bacterial quality standards for classification of shellfish beds and levels of shellfish treatment required prior to marketing. it does not specify water quality criteria. The bacterial quality of shellfish may be affected by sewage discharges, and the locations of outfalls and CSO discharges need to be taken into consideration with respect to classified shellfish beds when sewage improvement are being planned.

EC Directive on Urban wastewater treatment (91/271/EEC)
This Directive addresses the collection, treatment and discharge of urban waste water (sewage), and the treatment and discharge of waste waters from certain industrial activities. It also sets out specific requirement for the consenting and monitoring of such effluents. The Directive established different levels of sewage treatment necessary (primary, secondary or tertiary) based upon the characteristics or `sensitivity" of the receiving waters to pollution.

EC Directive on Freedom of Access to information on the environment (90/313/EEC)
The objective of this directive is to ensure freedom of access to, and dissemination of, information on the environment held by public authorities and to set out the basic terms and conditions on which such information should be made available.

EC Directive on the Quality of water for Human Consumption (80/68/EEC)
This directive concerns standards for water intended for human consumption.

EC Directive on the Protection of Groundwater (80/68/EEC)
This Directive is aimed at eliminating or reducing hazardous substances in groundwater. Due to the inherent problems of monitoring groundwater quality, the emphasis of this Directive is on imposing control measures on the discharge rather than on setting a standard that the receiving water has to achieve. It provides guidance for the planning authority on dealing with surface water runoff from

developments and is contained within DoE circular 30/92 `Development and flood risk"). There are no specific monitoring requirements, although visits may be made to determine the effectiveness of the control measures in place.

Directive prohibiting the placing on the market and use of plant protection products containing certain active substances (79/117/EEC)
Examples of such chemicals are mercury compounds and persistent organo-chlorine compounds.

EC Directive on the Quality of Fresh Waters needing protection or improvement to support Fish Life (78/659/EEC)
The `Freshwater Fish" Directive provides the baseline quality objectives for pH, ammonia, dissolved oxygen and zinc in a substantial proportion of rivers, approximately 20,000km of river length in England and Wales. The Directive is a particularly important consideration in determining discharge consents for sewage works.

Directive for establishing a common procedure for the exchange of information on the quality of surface freshwater in the community (77/795/EEC)
Each Member State shall organise intercalibration at the national level amongst laboratories taking part in the collection and the analysis of data as may be necessary to ensure comparability of methods of measurement with those used in the laboratories of Member States. Identified 4 sampling or monitoring stations on the Seine and 1 on the Thames.

Directive on Pollution caused by the discharge of certain Dangerous substances into the aquatic environment (76/464/EEC) This Directive seeks to establish a framework for the elimination or reduction of pollution by certain specified substances in inland, coastal and territorial waters. This is achieved by classifying substances according to harmfulness as List I (most toxic eg, organo-halogens, organo-phosphorus) or List II (less harmful eg, biocides and derivatives, ammonia and cyanide).

Directive on the Disposal of PCBs (76/403/EEC)
Member States shall take the necessary measures to ensure that PCB is disposed of without endangering human health and without harming the environment. This includes the polychlorinated biphenyls and polychlorinated terphenyls or a combination.

Directive on the Quality of Bathing Water (76/160/EEC)
This Directive was adopted in December 1975 and Member States were required to improve bathing water standards by December 1985, primarily by the control of sewage discharges. The requirements of the Directive are now enforced in national legislation through the Bathing Waters (Classification) Regulations 1991.

Directive on quality of surface water for abstraction for drinking water (75/440/EEC)
This Directive defines different categories of surface water for abstraction of drinking water and associated water quality requirements. These requirements necessarily impact upon discharges upstream of the point of abstraction and the conditions imposed in the consent, to limit the concentration or load of key determinands discharged in the effluent, take account of the assimilative capacity of the waters.

Appendix V Environmental Indicators

Department of the Environment, (1996). *Indicators of Sustainable Development for the United Kingdom.* HMSO, London.

The following preliminary indicators have been selected:-

Freshwater Quality:

1. River quality Chemical and biological
The trends in the proportion of river and canal lengths in the UK classified in the top two chemical grades (good and fair) and the proportion classified in the top two biological grades. General chemical quality is assessed on the basis of three determinands: dissolved oxygen, biochemical oxygen demand and ammonia. Biological testing assesses the extent to which species of small animals, (invertebrates) are present in the river, and compares this with what could be expected to be present in an unpolluted river given the natural features of the particular location.

2. Nitrates in rivers and groundwater
The annual average nitrate concentration in UK rivers by landscape category, and the combined annual average nitrate concentration of 17 selected groundwater sites in England and Wales experiencing elevated nitrate levels.
(Groundwater nitrate levels proposed)

3. Phosphorus in rivers
The annual average phosphorus concentrations in UK rivers by landscape category.

4. Pesticides in rivers and groundwater
The proportion of river and groundwater samples in England and Wales exceeding recommended levels for 6 selected pesticides (Atrazine, Diuron, Mecoprop, Isoproturon, Permethrin and Lindane).

5. Pollution Incidents
Major and significant water pollution incidents in England by source (industry, agriculture, sewage and other) since 1991.

6. Pollution Prevention and Control
The percentage of monitored consents to discharge waste water into inland and coastal waters in England and Wales which meet the standards (numeric consents) set by the Agency.

7. Expenditure on water abstraction, treatment and distribution
The operational costs and capital expenditure on the public water supply in England and Wales, including costs of treatment in recent years.

8. Expenditure on sewage treatment
The operational costs and capital expenditure on sewage services in England and Wales, including costs of sewage treatment.

Acid Deposition

1. Exceedences of provisional critical loads for acidity

The exceedences of provisional critical loads for total acidity of freshwaters by sulphur and nitrogen deposition.

Water Resources

1. Licensed abstractions and effective rainfall

A comparison between licensed abstractions and effective drought rainfall by Region.

2. Low flow alleviation

The length of rivers in low flow alleviation schemes in England and Wales affected by over-abstractions since 1990/91.

3. Abstraction by use

The abstraction by use (electricity supply industry, public water supply, other industrial, spray irrigation, other) in England and Wales since 1984.

4. Abstractions for public water supply

The abstractions for public water supply per head in England and Wales since 1984 together with present patterns of water use by households.

5. Demand and supply of public water

The demand for pubic supply water in England and Wales in 1993/94 is given as a percentage of the available resource by Region.

6. Abstractions for spray irrigation

Abstractions for spray irrigation in England and Wales since 1982.

Appendix VI Environment Agency Educational Initiatives

The Agency produces and promotes educational material and many employees make time to be actively involved in educational activities. The Agency recognises that children are the future guardians of the environment and acknowledges the emphasis placed by the National Curriculum on the environment across subject areas and through progressive Key Stages. The following list is by no means exhaustive but gives an overview of current Agency assistance to education in this regard:

National

- Riverwork

A teaching pack developed for Key Stage 2 Geography covering the broad aspects of the water environment (includes 60 worksheets, teachers notes and 9 posters).

- Sources

A set of three packs developed for Key Stage 3 Geography covering
(I) Catchment Studies
(ii) Monitoring and Sampling
(iii) Flooding

- National RiverWATCH

The Agency supported a nationwide survey of the river environment using the River Water, River Bank and River Valley investigation packs. The aim was to involve children, families and teachers. A recent Three Year Project Review has estimated that over 170,000 children across the UK have taken part so far, and the packs have reached Russia, Hungary, Poland, Portugal and Australia.

- R&D Project No.732 New ways of sharing Agency Science with Schools

A three year project started Spring 1995 using the Clifton Scientific Trust as consultants. Aim to provide guidance to the Agency on new or improved approaches to presenting an understanding of the aquatic environment and the work of the Agency across Key Stages 1-4 and post GCSE.

- PR material

A large variety of leaflets, brochures on the work of the Agency can be useful educational resources along with data sets held on the public register.

Thames Region

- Thames Barrier Visitor Centre

Describes the construction, operation and need by video displays, working model and audio-visual experience.

- Regional PR material including Factfiles which have proved useful as educational resources.

- Maidenhead, Windsor, Eton Flood Alleviation Scheme Education Pack

Joint RTPI/Agency proposed initiative to raise children"s awareness of pressures for change on river using this flood alleviation scheme as a case study. Aimed at Geography Key Stags 1-4.

South-East Area

- River Ash Enhancement Project

The result of a working party of Surrey teachers and the Agency. It gives ideas for using the River Ash in Key Stages 1-3 Geography.

- ThamesClean interactive CD ROM

A complete education package focused on the tidal Thames. it is still in its infancy although consultant has been appointed with a scoping brief and it is likely to cover a variety of programmes of study across a number of Key Stages.

- PC Detectives Comic

Aimed at young teenagers with a strong theme of pollution prevention, prosecution and clean-up. Tested at Reading University on the Association of Science Teachers and received a positive response.

- Farm pollution model

An interactive model allowing children to use control panel to see potential polluting effects of farm wastes on a river. This is used at various Agency attended events and by Agency staff on school visits.

- Urban Rivers Education Pack

Based on the Wandle, Beverley Brook and Hogsmill river catchments. A consultant teacher has been appointed to encourage direct involvement of school children in monitoring and managing the future of their local rivers. Cross linkage with local Agenda 21 groups anticipated.

- Local community environmental education projects (various)

example: assisting the Thames Explorer Trust at Corney Reach by providing a foreshore exploration area with pools and reedbeds. Various examples of practical Agency help in constructing pond-dipping platforms, wildlife areas, information boards, help from the Agency's Fobney Mead Laboratory on Thames based river sampling school projects etc

- School visits, guest lecturing, attendance at Business/Education Partnership

events undertaken by a cross-section of Agency staff in addition to their normal duties.

Agency (Thames Regional Office) PR Department

Appendix VII

Water Quality Telematics Projects

1 Distribution Water Quality Monitoring using Sensor Networks (WaterNet)[1]

WaterNet aims to assist authorities and operators by providing an advanced system which will aggregate date from on-line sensors and laboratory analysis, assess and interpret the state of a river, and present the information in an appropriate form to the different users. This should help to achieve earlier warnings of and faster reactions to pollution events.

2 Environmental Monitoring Warning and Emergency System (ENVISYS)[2]

ENVISYS is intended to provide detection of oil spills, monitoring of marine pollution due to oil spills and support for clean-up operations. Detection and monitoring are reliant mainly on synthetic aperture radar imagery. Integration, and presentation of data will utilise GIS, databases, telecommunications and multimedia. In the future the system may be utilised for other emergency and warning applications, eg floods.

3 Telematics of Integrated Water Management[2]

This is a well developed and comprehensive monitoring system for the coastal region of Holland. On-line, in-situ sensors as well as remote sensing platforms are utilised in the monitoring process. The various local and regional systems are linked via a Wide Area Network (WAN) and use a standardised database system which enables harmonisation of data. From this software applications including modelling, simulation, a graphical user interface, and decision support have been designed. International application of the system is considered desirable for future effectiveness of water management and planning.

4 Arno Project[3]

Currently this is a flood forecasting system for the river Arno basin. It collects hydrological data from an on-line sensor network, weather radar data, satellite data, and geographical information. This is processed to produce forecasts and to enable flood control simulations. The system is intended to be expanded for water pollution monitoring.

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[1] European Commission. (1996) *Environmental Telematics, Project Summaries.* Telematics Applications Programme 1994-1998 (Brussels:ARRTIC)

[2] **Kaaijk, N. (1994) Developments in Telematics for Integrated water Management. In *Workshop Proceedings: Telematics Applied to Environment,* J. Cunge, eds (Brussels: European Commission DGXIII), pp139-141.**

[3] **Cappellini, V. and Giuli, D. (1994). Broad Band Communication Network for Hydrogeological Control of Arno Basin. In: *Workshop Proceedings - Telematics Applied to Environment,* J. Cunge, eds (Brussels: European Commission DGXIII) pp. 139-141**

Appendix VIII

Research Project Costings

Matched costings are proposed for Theme (I) projects I, II, III and Theme (ii) projects I, IV, V. Matched costings have not yet been agreed for Theme (iii) projects I-IV.

Theme (I) Wetlands for water quality improvement	UPRC	CERGRENE
Project I : CERGRENE/UPRC State-of-the-Art selection criteria for wetlands point and non-point source runoff pollution control		
6 months research assistant	£18,102	FF141.192,00
Travel and subsistence in France/UK	770	6.000,00
Travel and subsistence in UK/Paris (1 meeting)	770	6.000,00
Workshop organisation and support	3000	23.400,00
Total	22,642	176.592,00
Facilities overheads (20%)	4528	35.318,40
Total	27,170	183.830,40
Additional ENPC/Middlesex overheads (10%)	2717	2.119,00
Grand Total (HT)	29,887	223.101,00

Theme (I) Wetlands for water quality improvement	UPRC	CERGRENE
Project II : CERGRENE/UPRC Scientific understanding of the microbial processes occurring within wetland ecosystems. This budget is established on a per annum basis. The duration of Project II is three years.		
12 months PhD student/Research assistant	27,152	211.788,00
Travel and subsistence in France/UK	640	5.000,00
Travel and subsistence in UK/Paris (1 meeting)	770	6.000,00
Materials and equipment maintenance	6410	50.000,00
Total	34,972	272.788,00
Facilities overheads (20%)	6994	54.557,60
Total	41,966	327.345,60
Additional ENPC/Middlesex overheads (10%)	4196.6	32.734,56
Grand Total (HT)	46,162.6	360.080,16

Theme (I) Wetlands for water quality improvement	UPRC	CERGRENE
Project III : CERGRENE/UPRC Establishing a Monitoring/Network specialist group		
6 months research assistant	18,102	141.192,00
Travel and subsistence in France/UK	770	6.000,00
Travel and subsistence in UK/Paris (1 meeting)	770	6.000,00
Total	19,642	153.192,00
Facilities overheads (20%)	3928	30.638,40
Total	23,570	183.830,40
Additional ENPC/Middlesex overheads (10%)	2357	18.383,04
Grand Total (HT)	25,927	202.213,44

Theme (ii) Sustainable management of urban runoff	UPRC	CERGRENE
Project I : CERGRENE/UPRC Complement to the English counterpart. The task is to provide qualitative and quantitative information about BMP's established in France and their evaluation.		
2 months research assistant	6034	47.064,00
Travel + subsistence in UK/France	1282	10.000,00
Travel + subsistence in UK/Paris (1 meeting)	770	6.000,00
Total	8086	63.064,00
Facilities overheads (20%)	1772	12.612,80
Total	9858	75.676,80
ENPC/Middlesex overheads (10%)	985.8	7.567,68
Grand Total (HT)	10,843.8	83.244,48

Theme (ii) Sustainable management of urban runoff	
Project II : CERGRENE European urban runoff water quality database	
8 months research assistant	188.256,00
Travels + subsistence in Europe	15.000,00
Travel + subsistence in UK (1 meeting)	6.000,00
Informatics, softwares + equipment	30.000,00
Total	239.256,00
Facilities overheads (20%)	47.851,20
Total	287.107,20
ENPC overheads (10%)	28.710,72
Grand Total (HT)	315.817,92

Theme (ii) Sustainable management of urban runoff	
Project III : CERGRENE Development of a statistical rainfall generator *- This budget is established on a per annum basis. Analysis and addition of spatial rainfall structures to the system will require a second year.* *- Note also that no budget has been devoted to data. It is assumed that existing agreements between AESN/Agency and meteorological data providers will cover the data requirement needed for this study.*	
12 months scientist	329.448,00
Travels + subsistence in France	20.000,00
Travel + subsistence in UK (1 meeting)	6.000,00
Informatics, softwares + equipment	30.000,00
Total	385.448,00
Facilities overheads (20%)	77.089,60
Total	462.537,60
ENPC overheads (10%)	46.253,76
Grand Total (HT)	508.791,36

Theme (ii) Sustainable management of urban runoff	UPRC	CERGRENE
Project IV : CERGRENE/UPRC Development of urban runoff management practices simulator		
9 months research assistant	27,152	211.788,00
Travel and subsistence in France/UK	2308	18.000,00
Travel and subsistence in UK/Paris (1 meeting)	770	6.000,00
Informatics, software and equipment	3846	30.000,00
Total	34,076	265.788,00
Facilities overheads (20%)	6815	53.157,60
Total	40,891	318.945,60
Additional ENPC/Middlesex overheads (10%)	4089	31.894,56

Grand Total (HT)	44,980	350.840,16
Theme (ii) Sustainable management of urban runoff	UPRC	CERGRENE
Project V : CERGRENE/UPRC European urban experimental catchments network *This costings are established on a per annum basis*		
3 months research assistant	9050	70.596,00
meetings organisation and support	10,256	80.000,00
Total	19,306	150.596,00
Facilities overheads (20%)	3861	30.119,20
Total	23,167	180.715,20
ENPC overheads (10%)	2317	18.071,52
Grand Total (HT)	25,484	198.786,72

Theme (ii) Sustainable management of urban runoff	UPRC
Project VI : UPRC Optimisation procedures for the evaluation of urban drainage *This budget is established on a per annum basis: the duration of project VI is 3 years*	
12 months PhD student/research assistant	27,152
Travel and subsistence in UK	640
Travel and subsistence in Paris (1 meeting)	770
Materials and equipment maintenance	6410
Total	34,972
Facilities overheads (20%)	6994
Total	41,966
Additional Middlesex overheads (10%)	4196.6
Grand Total (HT), per annum	46,162.6

Theme (ii) Sustainable management of urban runoff	UPRC
Project VII : UPRC Decision Support System (DSS) for water quality management	
6 months research assistant	18,102
Travel and subsistence in UK	770
Travel and subsistence in Paris (1 meeting)	770
Total	19,642
Facilities overheads (20%)	3928
Total	23,570
Additional Middlesex overheads (10%)	2357
Grand Total (HT), per annum	25,927

Theme (iii) Environmental Education	UPRC
Projects I,III and IV : UPRC I Develop and education pack III Develop environmental indicators IV Develop UK/French education initiative The costs refer to each project	
6 months research assistant	18,102
Travel and subsistence in UK	770
Travel and subsistence in Paris(1 meeting)	770
Total	19,642
Facilities overheads (20%)	3928
Total	23,570
Additional Middlesex overheads (10%)	2357
Grand Total (HT), per annum	25,927

Theme (iii) Environmental Education	UPRC
Projects II : UPRC Development of education material and training workshop	
6 months research assistant	18,102
Travel and subsistence in UK	770
Travel and subsistence in Paris(1 meeting)	770
Workshop organisation and support	5000
Total	24,642
Facilities overheads (20%)	4928
Total	29,570
Additional Middlesex overheads (10%)	2957
Grand Total (HT), per annum	32,527