WATER RESOURCE MANAGEMENT – SUSTAINABILITY ISSUES

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ABSTRACT

The implementation of the EC Water Framework Directive in Ireland will influence the future management of the water cycle in Ireland by suppliers, consumers, regulators, and those who have an interest in the natural aquatic environment. This paper discusses approaches to the sustainable use of water resources in Ireland whilst meeting society's requirements under three key themes: Using, Understanding; and Protecting.

INTRODUCTION

The provisions of the EC Water Framework Directive (WFD) aim, inter alia, to ensure that the water environment is managed in a sustainable way. This approach will influence the future management of the water cycle in Ireland by all responsible bodies, from the abstractions at source and distribution of treated water through to collection and disposal of waste water.

Implementation of the WFD will focus on key themes which to date have been not been the main focus of attention in the management of many water supplies in Ireland. Such themes include the identification and regulation of raw water abstractions, both surface and ground water, and assessment of the impact of these abstractions on the "ecological status" of the entire aquatic environment with a view to developing comprehensive and sustainable management strategies.

The principle of sustainable management is to 'meet the needs of the present without compromising the ability of future generations to meet their own needs'. For public water supplies this will require:

- assessing an appropriate level of service;
- managing current demands;
- predicting future demands;
- assessing resource capacities and the requirements of the environment;
- assessing the impact of abstractions on the environment;
- identifying a range of options available for meeting requirements that provide flexibility to respond to changing circumstances and avoid irrevocable developments.

The Precautionary Approach is embodied in Sustainable Management and includes the prediction of environmental impacts and dealing with the cause rather than the effect of damage, and preserving options to allow future decisions which may be made under a different set of objectives and priorities and may use different techniques.

Sustainable Management requires increased public involvement, and an integration of economic, ecological and social goals. The United States Geological Survey Sustainable Water Resources Roundtable was created to promote exchange of information among representatives of government, industry, and environmental, professional, public interest, and academic groups. They summarise the challenges of sustainable water resource management as follows:

> "We now face progressively stronger and more imperative interrelationships among both familiar water disciplines and with economic and cultural elements. At the same time our institutional arrangements among hundreds of organizations are designed for past conditions and focus on physical, chemical, engineering, and other traditional water concerns. Although our institutions have served us well, they are pressed to cope with a future in which water quality and availability, freshwater and coastal waters, surface and ground water, water and land use, and physical, chemical, and ecological characteristics must be considered simultaneously in geographical settings of wetlands, watersheds and habitats. This great

variety of water-resources topics also must be related not only to other environmental and natural resource subjects, but also to all the aspects of our national economy and culture."

This paper discusses approaches to the sustainable use of water resources in Ireland whilst meeting society's requirements under three key themes:

- Using,
- Understanding; and
- Protecting.

All three areas have seen substantial investment by the Department of the Environment & Local Government in the last decade through various projects, large and small.

USING

Understanding the use of water resources across Ireland has improved enormously over the last 10 years, principally through three major projects.

- Greater Dublin Water Supply Strategic Study (1996), examining those systems supplied through the Greater Dublin network
- The National Water Study (2000), a comprehensive national study of the 91 water supply schemes supplying more than 5,000 consumers outside of Greater Dublin;
- The Rural Water Strategy (ongoing), which included Rural Water Strategic Plans being undertaken by every County Council examining the present and future needs of the rural water sector in Ireland.

These studies looked at all aspects of the water supply schemes. They considered the amount of water available in the natural environment, the capacity of water treatment works to process the raw water and make it suitable for human consumption, and the sufficiency of the water distribution systems to transmit the treated water to consumers.

The National Water Study in particular considered the current and potential future challenges for the Irish water supply sector and presented a platform with methodologies to improve the operation and efficiency of the Irish water supply system, much of which is presently being implemented by the Department of the Environment & Local Government.

Water demands of a growing prosperous society will increase, but there are other factors that tend to reduce the level of demands. A summary of the main drivers for both increasing and decreasing consumption are given below. The challenge for the water resource planner is to understand the often opposing factors and assess the relative magnitude of each.

Drivers for increased domestic demands include:

- rising population, and consequent increase in households
- greater affluence leading to greater ownership and use of domestic appliances such as automatic washing machines, dishwashers, power-showers
- changes in demography leading to smaller households
- lifestyle changes leading to more frequent changes of clothes during the day, and hence increased clothes washing
- climate change leading to greater discretionary use of water

Set against these drivers are:

- more efficient household appliances

- greater environmental awareness leading to conscious attempts to reduce water use

Without charging domestic customers for water consumption, or at the very least metering the domestic sector, it will be difficult to promote greater environmental awareness leading to conscious attempts to reduce water use among householders. However, developments such as the recently published Bye-Laws for the Management and Conservation of Drinking Water (Dublin City Council, 2002) provide an alternative means of effecting water consumption measures.

Drivers for increased industrial/commercial demands include:

- increased economic activity in both manufacturing and service industries

Drivers for lower water use are:

- increased penetration of charges for water based on actual consumption (for example the implementation of the Polluter Pays Principle through National Water Services Pricing Policy for the non-domestic sector)
- production efficiencies
- environmental awareness
- energy use efficiencies of which heating and cooling process water and housekeeping water can be a major part

Unaccounted for water or leakage is now seen as a major component of the demand on public water supplies, as the National Water Study and Greater Dublin Strategic Studies demonstrated. It is no longer acceptable to simply provide additional water resources and allow treated water to leak from the system. The subject has received considerable attention in recent years, through funding from the DoELG in the form of water conservation programmes, along with advances in metering & telemetry, leak detection technology and analytical techniques.

Drivers for increased levels of leakage include:

- higher traffic density in urban areas, combined with extremes of drought and flood causing ground movement, leading to greater stress on water mains and increased bursts and leakage through distorted joints
- lack of maintenance leading to continued deterioration of underground assets
- poor understanding of the components and layout of reticulation systems, combined with inadequate or inaccurate flow metering

Drivers to lower leakage levels include:

- wider metering coverage, which will be assisted in Ireland through having all non-domestic customers metered by 2006 as part of National Water Services Pricing Policy
- use of GIS to map current pipe networks with information on pipe material, age and condition allowing the application of the latest modelling techniques to target leakage effort to those areas where it can provide most benefit (in particular through the roll-out of Complete Information System (CiS) in Ireland)
- more sophisticated real-time monitoring
- water conservation programmes (DoELG funded through many individual projects across the country)
- increased public awareness of the value of water (for example the Dublin Region Water Conservation Project website www.codema.ie)

In areas of new development, it should be possible to design, specify and build distribution networks to achieve a minimum level of leakage. Achieving the design leakage level depends on good workmanship, active management of the system and timely repairs.

On existing systems, the issues are more complex, and where water resources are plentiful, there may be little economic incentive to devote operational resources to reduce leakage. High leakage levels may however be considered to be socially and politically unacceptable.

UNDERSTANDING

In water resource planning, the phrase "sustainable development" is sometimes applied only to water supplies, however it should also be applied to demands.

<u>Demand</u>

Understanding the characteristics of water consumption in both domestic and industrial sectors requires data from treatment works outputs, to flows through the distribution networks, and increasingly from industrial customers revenue meters. But the major consumption is in household properties that are not metered. Despite the apparent lack of data on which to base water balance calculations, the regulatory regime in England & Wales since privatisation has improved annual estimates of the volumes of water consumed and lost through leakage.

Current demand forecasting practice is to separate the domestic and non-domestic sectors in a component based approach (ref Graphical Representation below). Projections of population and households are the basis for the domestic forecasts, combined with estimates of per capita consumption (pcc); sometimes estimates of pcc are derived from micro-component analysis. The National Water Study (WS Atkins, 2000) examined this in some detail in an appendix "Annual Average Domestic Demand in Ireland 1997 to 2018.

Distribution Input						
UFW	Other legitimate uses	Domestic Demand	Non-domestic Demand			
			Agricultural	Commercial	Industrial	Municipal

Economic growth and employment projections form the basis for industrial consumption. In this sector any gradual trend in demand over time may be much smaller than step-changes in demand caused by the development of new industry or the closure of existing works, and provides a particular challenge for the demand forecaster. The time-scale over which industrial demand projections can be considered robust is often much shorter than that for domestic forecasts. The approach outlined above lends itself to assessing the potential consequences of "what-if" scenarios. A further appendix to the National Water Study, "Baseline and Forecast Sectoral Demand Estimation" examined non-domestic demand in Ireland.

<u>Supply</u>

Understanding the hydrological characteristics on which water resource systems are based relies on good long-term hydrological and meteorological data from which simple hydrological analysis can be based as a pre-cursor to advanced analytical and modelling techniques. A crucial issue is the question "whether past hydrology can be considered as a good representation of the future?"

Although the physical characteristics of a catchment will not change over time, other characteristics such as land-use, the temporal and spatial distribution of rainfall, and the upstream use of water may have an important impact on downstream flow-regimes. Extended periods of dry weather when run-of-river schemes are under most stress coincide with periods when the highest consumptive use of water for irrigation can be expected.

Recent work by the EPA identified critical drought years across Ireland, with 1976 and 1995 being amongst the most severe years on record in terms of minimum observed flows in rivers. Changes in land-use and abstractions upstream will have occurred since the 1995 drought, but using 1995 rather than 1976 for yield assessment will mean that some account has been taken of changes in upstream land-use change and abstraction and has been included in the analysis.

Advances in data processing, the spatial visualisation and analysis of land-use and other catchment data, through GIS and improved conceptual understanding means that the hydrologist and water resource planner has a powerful toolkit available. Some of the techniques will be described in later papers. But a fundamental issue remains "how to estimate yields at points for which no observed flow data are available?". In Ireland where many water gathering-grounds are on relatively small catchments, often with indirect catchwaters, the problem is particularly acute.

The spatial distribution of rain gauges and flow gauges in Ireland is low, because of its low population density. Based on a need for interpolation of a limited dataset to provide yield estimates at ungauged sites, and with recent developments in remote sensing techniques, there is an opportunity for the development of regionalisation techniques.

An example of such a technique is the statistical procedure developed as part of a European project to estimate the hydrological regime at ungauged sites in Ireland. The estimation method incorporated into the software package HydrA uses a database of extensive, good quality time series and spatial data. The database contains:

- long-term river flow data
- gauging station information
- digitised catchment boundaries
- catchment characteristic data such as rainfall, temperature, potential evaporation, soils, hydrogeology etc.

Once the user has entered the digitised catchment boundary the software calculates the mean flow and the flow duration curve (FDC). Q_{95} – the flow that is exceeded 95% of the time - is derived from the FDC and can be used to characterise the hydrological response of the catchment.

The prospects for further improvements in understanding the surface and groundwater hydrology of Ireland will be given further impetus through the requirements of the Water Framework Directive. Continuation and enhancement of existing monitoring networks, and characterisation of River Basin Districts is a fundamental requirement of the Water Framework Directive (WFD), and will provide information on the baseline conditions from which the impacts of catchment water management can be assessed. Understanding the variability in baseline conditions will be particularly important, and the potential impacts of climate change on hydrology will need to be assessed.

The WFD will stimulate the bringing together of information on the environmental requirements of water bodies in terms of water quality and ecological status.

<u>Water Quality</u>

Water resource planning is often based on considerations of water quantity alone, however issues of water quality should not be ignored. Poor water quality impacts on the availability of raw water for public water supply, and also on the ecological status of water bodies. Diffuse pollution from agriculture, transportation routes and urban developments can be as damaging as pollution from point sources such as effluent from sewage treatment works or industrial discharges or accidental spills.

Again the availability of databases on land-use, fertilizer consumption, factory locations means that GIS applications can inform the assessment of risks from diffuse pollution.

PROTECTING

Despite planned water conservation initiatives designed to reduce the level of losses from distribution systems, it is clear that there will still be a need to develop new water sources to continue to meet increasing demand, and to replace unreliable sources (for yield or water quality issues). Such developments should be implemented within a sustainable development context, in which the abstraction requirements of the WFD will play a major part. A key feature of the WFD is that it encourages optimal management of activities in the catchment to achieve appropriate ecological and water quality standards.

New abstractions should be managed on a catchment basis, using the GIS tools being developed in the River Basin Management Plans. The requirements for obtaining abstraction orders should become more stringent, and include more environmental analysis, even for smaller abstractions which are presently unregulated in the main. In the UK, the Environment Agency licences all abstractions greater than 20 m^3/day. Under the Water Framework Directive, abstractions are identified as a pressure on the river basin and should not impact on other water bodies to the extent which they may not achieve "good status".

The identification of pollution sources in each catchment, and implementation of a Programme of Measures to control these ensures that all activities in the catchment are operating in a sustainable way, and that the resource is protected in terms of its suitability for human consumption as well as providing a habitat for a healthy ecosystem. The effects of over abstraction on the water body should be carefully considered when setting an abstraction limit.

Where a Special Protection Area or Special Area of Conservation, as designated under European legislation may be affected by the abstraction, an appropriate assessment will need to be taken in order to comply with the EC Habitats Directive. In any case, a sustainable management approach would identify whether there is enough water available, identify the flow/level and water quality requirements of downstream ecology, assess the impacts of the abstraction, and mitigate against them. A sustainable management approach would need to go beyond the current legal requirements. For example, those who use the affected area should be engaged in this process and properly consulted at an early stage so that their concerns can be addressed at the impact assessment stage.

Techniques and tools available for the water resource planner

The River Basin Management Plan (RBMP) provides the framework for sustainable management of the water environment. Precisely how RBMPs will be developed in each of the Member States is the subject of on-going research and pilot studies across Europe. There are however already good examples of how integrated planning on a catchment scale can contribute to the process of promoting the sustainable use of water. The evolution of Catchment Abstraction Management Strategies (CAMS) under the aegis of the Environment Agency in England and Wales is one example. The CAMS process makes more information on water resources publicly available, and allows the balance between the needs of abstractors and the aquatic environment to be determined in consultation with the local community and interested parties. However the CAMS process will need further refinement and extension in the scope of what is covered, and in its delivery timetable in order to fully contribute to delivery of the WFD in England and Wales in which the focus is on the optimal management of all activities within a catchment as opposed to abstraction alone.

Public consultation and the involvement of all stakeholders will be an essential part of the process.

By assessing the availability of water resources within river catchments, CAMS highlight any areas where future development might take place. Where current levels of abstraction exceed the resources available, CAMS allows the issue of how to regain a sustainable level of abstraction to be discussed and to identify mechanisms for this to be achieved.

CAMS provides a series of principles that define the approach to water resource management. These principles are to:

- Secure the proper use of water resources for all purposes, including environmental need;
- Protect the environment by:
    - Identifying a minimum flow or groundwater level below which abstraction may be curtailed or augmented;
    - Protecting flow and level variability across the full range of regimes from low to high conditions;
    - Protecting the critical aspects of the water environment including, where relevant, habitats that are dependent upon river flows or water levels;
    - Recognising that some watercourses or wetlands are more sensitive than others to the impact of flow or level changes;
- Ensure no derogation of existing protected rights;
- Protect other legitimate river users interests;
- Be able to incorporate existing and future local requirements such as flows to estuaries;
- Take account of water quality considerations throughout the catchment in both surface waters and groundwater.

In some cases site-specific operating rules for managing river abstractions have been developed. However, most commonly, conditions are included in licences that require abstraction to cease or be reduced when a river flow or level falls below a specified level. These "hands-off" flows may be set to protect features that are locally unique to the water resource management unit or are significant on a catchment scale. A key component of the analysis will be to assess at what level the "hands-off" flow should be set. In the past Q_{95} has often been used as a flow trigger, but this does not take into account changes in the seasonal requirements for environmental and/or ecological flows.

The CAMS process has evolved from a 40-year legacy of water resource legislation that controls abstraction. The evolution of the process in England and Wales and the experience of its on-going refinement to adapt to the requirements of the Water Framework Directive may provide an example of the type of systematic approach to water resource management that will be required in Ireland. Fundamental to any approach to achieve sustainable water resource management is the need for robust hydrological analysis, using the full range of data analytical and mapping techniques that are available.

Environmental Assessments

The purpose of the Habitats Directive is to secure the long-term protection of the most important wildlife and geological sites in Europe. This is achieved through the designation of specific sites, the development of conservation objectives for these sites, and a review of all relevant authorisations such as abstraction and discharge consents to ensure that none could compromise the achievement of the stated objectives. The main issue relates to the strict requirement to apply the "precautionary principle", which can be interpreted as meaning that unless it can be clearly demonstrated that beyond reasonable doubt that an authorisation will not compromise achievement of a conservation objective for a designated site, the authorisation should be amended or withdrawn. But where this could impact on the security of water supplies, then the issue of "overriding public interest" should prevail.

The most appropriate techniques to assess impacts of different management and operating scenarios involve simulation of hydrology, water quality, ecology and environmental conditions. Despite the sophistication of water resource models such as AQUATOR, instream ecological models such as PHABSIM (**Ph**ysical **Hab**itat **Sim**ulation), and water quality models such as QUASAR (**Qua**lity **S**imulation **A**long **R**ivers), informed assumptions will invariably need to be made.

SUMMARY

The requirements of the WFD that enshrine the principles of sustainable development require water resource planning to cover a broader scope than hitherto. Sophisticated tools are now available to bring together hydrological, ecological and environmental analysis and produce outputs that are able to inform public debate and feed into the decision making process. But however sophisticated the techniques and tools, the ultimate output is only as good as the conceptual understanding of the system which must be based on sound data and reasoned judgement.

The challenges for the water resource planner, hydrologist and environmental scientist are considerable, but we have a good basis of knowledge and understanding from which to continue to make progress.

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