The Chartered Institution of Water and Environmental Management

A CIWEM Briefing report

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Integrated Water Management

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Executive summary

Background

Water is one resource but it has many uses. In its management are a complex and diverse range of both people and processes. As a result of the way the UK's water industry has evolved, issues in the water environment have traditionally been observed as either temporally or spatially discrete and worked within narrow disciplines to solve them. CIWEM considers that the administrative structures, boundaries, relationships and experience in the water industry will need to be evaluated in the light of changing needs.

Climate change, demographic change, economics and environmental legislation such as the Water Framework Directive all necessitate a more integrated approach to the management of water. CIWEM believes integrated water management (IWM) should be a process whereby human interventions can work within the natural water system, rather than disrupting it in ways that are ultimately unsustainable.

Scope

This report is the culmination of a CIWEM *workstream* on integrated water management. In October 2010, we held the 5th in a series of conferences on the topic to identify the criteria and principles of IWM and demonstrate examples of it in practice. Whilst achieving more integration has been on the agenda in the water industry for a number of years, and we have examples of best practice, meaningful progress has been limited. This report aims to identify why. What are the challenges and barriers to integration and how these can be potentially overcome?

CIWEM considers that the term "integrated water management" better reflects the wider considerations which are largely already ingrained within Integrated Water Resource Management. This report shows many examples of these principles being applied at different scales with varying ambitions for the degree of integration.

> **"Climate change, demographic change, economics and environmental legislation such as the Water Framework Directive all necessitate a more integrated approach to the management of water."**

Supporting this report is a case study document; and as IWM is a global issue, international examples will be drawn on to show if there is anything the UK can learn in terms of both policy and practice from abroad.

Findings

IWM allows us to manage water from a wider perspective. Looking at the wider water system identifies where an activity in one part of the system may create a benefit (or an unforeseen cost) to another. IWM moves our thinking beyond water to other agendas such as energy and carbon, planning, waste, biodiversity, agriculture and ecosystem services.

In a practical sense IWM can lead to cost savings by creating efficiencies between local and national projects. It can also make more effective use of project costs as the pooling of finances from a variety of organisations tend to create schemes that deliver multiple objectives and benefits. It also requires new environmental management skills and new organisational practices.

Water and catchment initiatives and projects are context dependent and the key is being able to understand a complex system to see where the leverage points for improvement are. This takes further time and money than 'off-the-shelf' solutions and requires skilled managers.

To deal with the complexity of situations in water management an adaptive management approach is required. This should encourage greater involvement of all stakeholders, which potentially means solutions put in place work more effectively in the long term. Where IWM has been successfully achieved there have been high levels of participation.

> **Significant changes are required in terms of how problems are framed and how different institutions and sectors work together to achieve common goals.**

Many of the principles of IWM and IWRM have been undertaken by certain parts of the environment sector (particularly in relation to water resources) for some considerable time, but no one has effectively put all of the principles in practice yet – at least on a large geographical and sectoral level.

Recommendations

In general CIWEM believes our institutional arrangements tend not to support cross-sectoral decision-making, with organisations and regulations having specific and potentially diverging remits which limit the ability to manage the water environment at a wider level. Significant changes are required in terms of how problems are framed and how different institutions and sectors work together to achieve common goals.

The Government has proposed a larger role for the third sector ("Big Society") in the delivery of water management as a partial replacement for "big government" action. The positive aspect of community involvement alongside local NGOs and local knowledge for delivery should be seen as critical and can help create more innovative approaches.

> **A shared vision of IWM is required, supported by new ways of working, new skills, and leadership.**

CIWEM is concerned that in an age of austerity, there are potentially serious resource issues in terms of funds, personnel, continuity and expertise, and this may impact upon catchment resourcing, governance and regulation. Enough resources will need to be found to be put towards effective community engagement programs to communicate information to non-specialist audiences.

A shared vision of IWM is required, supported by new ways of working, new skills, and leadership. A key barrier to achieving this is actually doing things fundamentally differently, rather than doing more of the same. The forthcoming 2011 Natural Environment and Water White Papers would be an ideal opportunity to look at the bigger picture and emphasise this need. Principles such as those highlighted in this report – using a systems approach, delivering multiple goals through common means, interdisciplinary and multidisciplinary approaches and those that foster sustainability and innovation – should be incorporated.

Contents

1 Introduction

1.1 Our management of freshwater

Water is essential for life; it is one of our most basic needs. Water is one resource but it has many uses; it is a central requirement for our food production, health, culture, energy supply, infrastructure and economic growth. It is also essential for healthy ecosystems which provide the goods and services which are fundamental to people, wildlife and the quality of our environment.

Our management of freshwater involves a complex and diverse range of both people and processes that act to modify the water cycle for human and environmental needs. Put simply: water falls as precipitation, replenishes aquifers and runs off and through the land to streams, rivers and lakes; humans take what they need for industrial, commercial, agricultural and domestic uses, treat it and later return it to the sea. Added to the management of this cycle are further interactions and pressures from development and recreation, and conflict in water stressed areas.

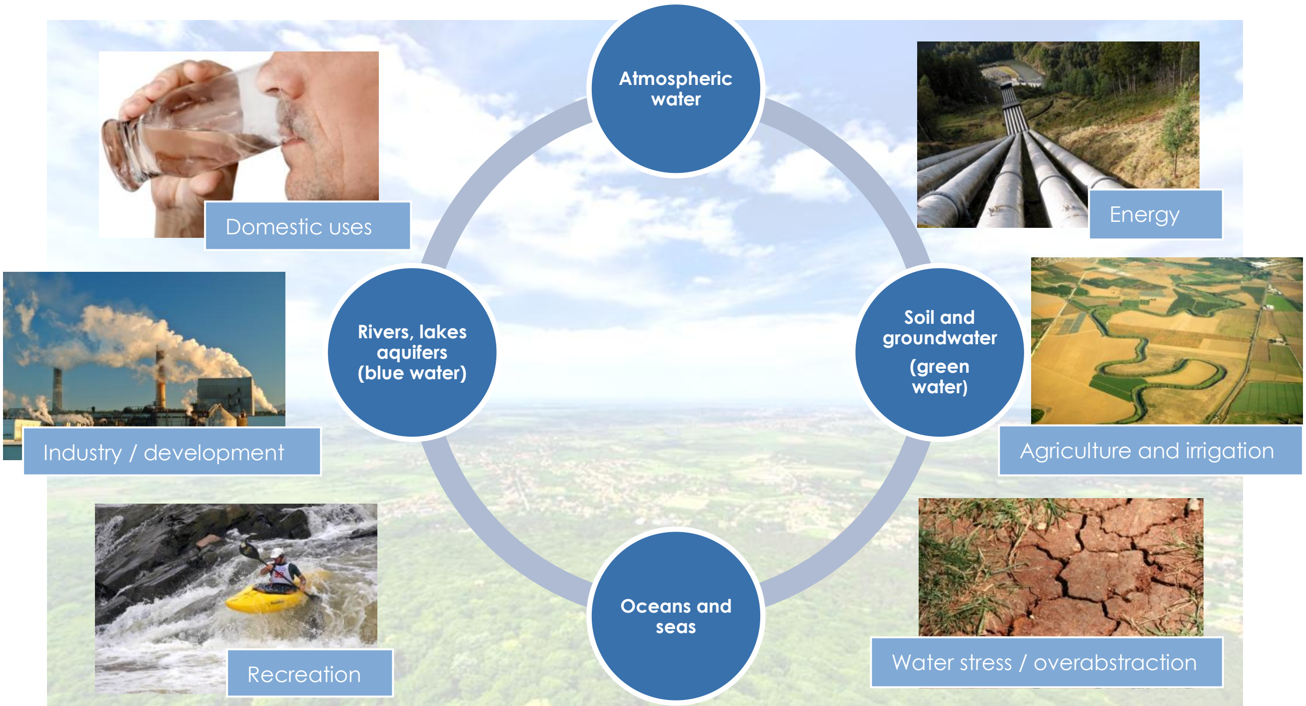

Figure 1. Basic water cycle and the human demands upon it.

In altering one aspect of this natural cycle, we have the potential to greatly impact upon other parts of the cycle. Integrated water management should be a process whereby human interventions can work within the natural water system, rather than disrupting it in ways that are ultimately unsustainable. This should not only recognise the physical aspects of the water environment, but also its political and social context.

1.2 UK context and current levels of integration

The UK water sector is extensive and has many specialist groups that deal specifically with drinking water, water resource planning, flood risk management, water treatment, environmental water quality and research. Each of these disciplines involve a wide variety of organisations with different interests (such as policy makers, legislators, regulators, private companies, consultants and wider stakeholders such as local authorities, planners, architects, highway authorities and farmers). We now have a highly fragmented sector and have historically observed issues in the water environment as temporally or spatially discrete and worked within narrow disciplines to solve them. This has led to a reliance on technical solutions which have paid limited regard to minimising social or environmental impacts[1]. Segregation can also lead to whole series of individual projects in the same geographical area that are unconnected and implemented by different agencies, increasing both costs and the potential for inconsistent outcomes.

Certain elements of the water industry have attempted to achieve more integration. In most parts of the country, the water supply sector and wastewater sectors have merged into one organisation - the Water Authorities, now privatised as the water companies to try to improve integration and allow for catchment planning. The management of flood risk has also begun to move into the realm of considering the wider scales of geography and time, with the discipline of hydrometeorology.

Is it worth trying to achieve more integration? Yes, if we want to meet the long term challenges facing water management and identify solutions that will be supported by the majority of people, work in the long term and create efficiencies in the sector. This report attempts to identify the challenges and barriers to achieving effective integration and suggests measures to overcome them.

1.3 Integration

1.3.1 Elements of integration

In order to define IWM it is worth considering what elements make up integration and how this relates to water management:

Sustainability

At present there is no shared vision or understanding of what the water environment is for (water supply? biodiversity? recreation?) so views on the priorities for the water environment vary widely. The most sustainable approaches will be those that have taken decisions not only based on water, but on whole life cycle sustainability - energy (operational and embedded), chemical usage, greenhouse gas emissions, economics, environmental services and quality of life. Trade-offs will inevitably need to be made but should take into account cumulative and long term impacts.

An integrated solution is one where multiple goals are achieved through common means[2]. In terms of water management this could include preventing and decreasing flooding through upland management which would reduce drainage costs downstream and protect ecological systems and enhance quality of life.

Inter-, multi- and trans-disciplinary approaches

Whilst the water sector excels in specialism in particular areas it is less adept at taking a holistic approach. To deal with complex issues and to identify more sustainable solutions requires bridging sectoral interests for the 'greater good'. Data sharing and integration between research and implementation aspects are also important to enable a two-way flow of knowledge, insights and conclusions between researchers and practitioners.

Multidisciplinary work on planning and design, landscaping, hydrology and water resource management, ecology, economics and sociology are needed as well as trans-disciplinary working which moves people beyond their specialism and working with diverse bodies of knowledge.

Systems approach

Understanding integration requires an appreciation of systems[3]. A systems approach helps to understand the broader context whilst still retaining the complexity of such systems. Considering a catchment (or other element of the environment) as a system means taking account of the multiple perspectives, stakes, purposes, boundaries, interdependencies, controversies and practices within it. A systems approach is able to integrate aspects such as upstream and downstream interests, water quality and quantity, surface and groundwater, land and water resources.

There are arguments both in favour and against management at the local level, river basin level and political level. CIWEM considers that most the appropriate level will depend on context and that there is not a 'one-size fits all' way to achieve integration; effective IWM is therefore context specific.

Engagement

Informing and building stakeholder participation can increase local actions and ownership. More and more is being asked of community and environmental groups to deliver IWM on the ground, so goals should be meaningful at a local level and fit in with higher policy objectives. Real engagement requires a shift in culture, and the necessary skills and resources. It needs to be practicable, taking account of the resources available and the timescale to ensure expectation management[4]. Localism is a key priority of the Coalition Government and should mean real engagement that unlocks creativity at the local level to resolve complexity and conflict.

The CIWEM co-authored *Engineering for the Future* report: *Global Water Security*, argued for a systems level perspective to water management.

This includes the whole water cycle and the human, economic, and environmental systems that depend on it, rather than focusing on individual components.

More information at www.ciwem.org

The *Cloud to Coast* methodology by Halcrow and Cardiff University is a good example of systems thinking. It extends the traditional boundaries of a problem and includes a stakeholder participatory component to provide solutions that meet the needs of relevant legislation and identify cost savings.

More information at: www.halcrow.com

Rural problems for example, are quite different to those in towns, yet often we use urban-developed infrastructure in villages where we have more ecosystem delivery opportunity that we do not optimise.

Innovation

Innovation and new ideas in the management and practices of the water environment will be needed to solve the long term issues facing the sector. Markets and research need to be stimulated to identify new methods and ways of working. Key to this is employing sound scientific data, tools, and techniques in an iterative decision making process. Both quantitative and qualitative data are important because this can provide information on why decisions are made and why people have certain perceptions, which often dictate whether technical solutions actually work. With monitoring we can evaluate progress and the effectiveness of measures taken.

The River Wensom Demonstration Test Catchment transmits real time data on a range of pollutants in the river water as part of a study to understand, predict and control diffuse pollution from agriculture.

More information at www.wensumalliance.org.uk

1.3.2 Defining Integrated Water Management (IWM)

Through the workstream it has become apparent that integrated water management can mean different things to different people and there is no widely accepted definition of the term.

In this report CIWEM discusses IWM in regard to what is often termed "Integrated Water Resource Management" (IWRM) in international literature. This has been defined by a number of sources but we consider The Global Water Partnership's definition from 2000 to be most apt. This described IWRM as:

> ***"the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems"[5].***

Other approaches that get confused with IWM are Integrated River Basin Management (IRBM) and Integrated Catchment Management (ICM):

- Integrated River Basin Management (IRBM) is a sub-set of IWRM at the spatial scale of a river basin or sub-basin, rather than IWRM which stresses the need for integration on all spatial scales or hydrological units[6]. This is generally related to the Water Framework Directive and the management of larger rivers such as the Rhine and Danube in Europe.

- Integrated Catchment Management (ICM) is a process that delivers cleaner source water by controlling the land use within a catchment to improve and protect water quality. It can be defined as "*a process that recognises the catchment as the* *appropriate organising unit for understanding and managing ecosystem processes: in a context that includes social, economic and political considerations, and guides communities towards an agreed vision of sustainable land and water resource management for their catchment*"[7].

IWRM, IRBM and ICM are broadly compatible approaches in that they have all been developed in response to shortcomings of traditional water management and seek to achieve more sustainable use of freshwater[8].

This report however, presents examples of progress towards the principles set out in the definition of IWRM above, based on the understanding that water is an integral component of ecosystems, a natural resource, and a social and economic good[9]. We aim to examine the UK application of IWRM principles looking at initiatives where the physical water environment has been considered as a whole, looking beyond water supply to environmental and land management practices that also deliver improvements to water quality and flood risk management. Case studies where water governance has improved by integrating economics, cultural values, policy and planning, and the effective participation of all stakeholders including the wider community are included to illustrate the direction in which freshwater management must progress.

1.4 Challenges facing water management - Drivers for more integration

With a number of complex issues on the horizon, we will require a more integrated and holistic view of water. Globally 80% of the population already live in areas with significant water security problems or threats to river biodiversity[10]. A rapidly growing population, increased urbanisation, higher standards of living and intensified agriculture are adding to the challenges of water management. This is set against a backdrop of climate change that may exacerbate or bring new water challenges with changes in water availability, quality and its distribution.

Population growth will cause the carrying capacity of the natural environment to be tested and often exceeded, placing added demands on our land to deliver food and water and retain the functioning ecosystems upon which we depend. There will be more demand for water supply, and hence more need for water storage and operational / demand-side measures, and additional need for wastewater systems. Greater populations will place added demands for food created by intensive agricultural techniques that rely on irrigation and create more associated pollution of the water environment. In some areas particular stakeholders may become 'crowded out' of the decision making process for example indigenous groups.

Water supply issues will vary regionally according to population. In the UK much of the population resides in the south east, placing high demands on the water environment. Three million new homes are needed in England and Wales by 2020 and water companies have had to consider this and produce Water Resource Management Plans to show how they will meet future demands for the next 25 years. In some cases the development of new water sources are required. There is a disjoint here as water is not considered a pre-requisite to housing growth strategies and water resources should be fully integrated into spatial planning.

In England and Wales the Environment Agency (EA) forecasts that demand for water could increase by 5% by 2020[11] as a result of demographic change and greater use of domestic appliances[12]. This will have to be countered by water demand management with more efficient water appliances, increased metering to reduce demand and incentive tariffs. Non-household water demand in many areas is reducing as water using heavy industry closes or becomes more water efficient. Were a higher value to be put on water then the water companies would have an incentive to reduce their leakage further.

Environmental directives - The Environment Agency spends £8million annually on reducing diffuse pollution (to limited effect[a]). Diffuse urban pollution of water is seen as one of the big obstacles to achieving compliance with the Water Framework Directive (WFD). The issue is fraught with complexity, subtlety and lack of ownership. Where water abstraction is thought to adversely affect river designation under the WFD, then the Environment Agency is requiring water companies to conduct studies; these could lead to significant reduction in water resource availability and abstraction licence quantities.

Climate change will profoundly affect the water environment. Current projections suggest that there will be changes to the seasonal distribution of precipitation (warmer wetter winters and hotter drier summers[13]) which will potentially cause more droughts and flooding. Increased temperatures will increase evapotranspiration, meaning soils will dry more and less runoff will reach the river systems. Small changes to levels of precipitation can cause disproportionate changes to river flow and in the UK will adversely affect the yield of surface water sources[14]. For groundwater, the extra winter rainfall may not have time to enter the aquifer and the higher temperature and drier soils may curtail the aquifer recharge period.

Climate change will also affect the chemical characteristics and other properties of rivers and streams (and environmental quality). If rain falls in small bursts it is less likely to find its way into usable resources[15] and requires further management to eliminate flood risk and more treatment to safeguard water quality. Higher mean water temperatures may improve biological treatment processes yet reduce drinking water quality in reservoirs[16]. Water resource management should be flexible so as to be able to cope with changes in availability (drought management) and demands for water, and the inherent uncertainties within this.

In terms of mitigating climate change, the water industry currently accounts for 5 million tonnes of carbon dioxide emissions per year - almost one per cent of UK greenhouse gas emissions. In the face of the stretching UK target, to reduce greenhouse gases by 80 per cent by 2050, the water sector has an important part to play in reducing its carbon emissions[17]. The UK Carbon Reduction Commitment (CRC) is an emissions trading scheme for medium to large energy users and applies to water companies and other major abstractors. Allowances will have to be bought each year to cover emissions arising from electricity use and other energy sources.

[a] The NAO has concluded that this has had limited effect on agricultural diffuse pollution. Less is known about urban diffuse pollution. (National Audit Office, 2010, *Tackling Diffuse Water Pollution in England*).

Economics are a key consideration in water management. The water sector in England and Wales is highly regulated and water companies must work within the Asset Management Planning and Business Planning process that is open to regulatory scrutiny by OFWAT.

Chemical costs are increasing and are one of the main expenditures in the water treatment industry. Chemical production is highly energy intensive and so chemical costs also inflate when energy costs inflate. In the USA chemical costs doubled between 2008 and 2009. In the UK commercial energy costs have increased from 4.5p/kWh to 7.5p/kWh within a year and are expected to inflate by 11% per annum[18]. Certain industries (the electronics industry for example) require very high quality pure water for their operations. Finding approaches that produce cleaner source water will reduce the need for chemicals.

Ecosystem goods and services are supposed to be taken into account in all government policy appraisals. This incorporates the multiple and simultaneous ways that ecosystems support human well-being in cost benefit analyses by looking at the connected system. This helps to avoid perverse outcomes that arise from narrowly defined solutions and interventions and allows us to innovate in our approaches to water management[19]. The right incentives: polluter pays, abstractor pays, payment for environmental services, value of water, water trading and nutrient offset schemes need to be considered as part of IWM.

2. Initiatives

Although many of the initiatives cross over, they are broadly divided between those for water resource management (both droughts and excesses), water and land management and water for other uses. A summary of the benefits and risks of each approach is also suggested.

2.1 Water supply / resource management

Water is an economic good and is used to advance a country's social and economic development goals. In many parts of the world demand for water is greater than that which is available. Cities are extracting and importing more and more water leading to less being available for the water environment, potential causing environmental problems. Changes in the hydrological cycle and precipitation patterns are also leading to droughts.

In The UK some twenty five million people live in areas where there is less water available per person than in Spain or Morocco. A third of the catchments across England and Wales are now judged by the Environment Agency to be either over-abstracted (15%) or over-licensed (18%)[20]. Studies are underway to identify whether environmental damage is being or would be, caused and if so what measures should be taken, so what can we learn from other countries?

The European Union is currently reviewing its water policies, with a 'Blueprint to Safeguard European Waters' due for publication in 2012. Over the past thirty years, droughts have increased in number and intensity in the EU. The number of areas and people affected by demand exceeding developed supply went up by almost 20% between 1976 and 2006 with a total cost of €100 billion[21]. At least 11% of the European population and 17% of its territory have been affected by water demand exceeding developed supply to date[22]. Climate change is almost certain to exacerbate these adverse impacts in the future, with more frequent and severe droughts expected across Europe and the neighbouring countries.

Worldwide, models have shown that increased demand for water (consumptive and environmental demands) will cause an 18% reduction in water availability for agriculture by 2050[23]. According to the European Environment Agency (EEA), agriculture already accounts for 24% of water abstraction in Europe and up to 80% in some southern member states. Whereas in other sectors water is returned to the environment after use, only around a third of the water used in agriculture returns to a water body[24]. As such the EC has identified agriculture as the priority sector in which measures to combat water scarcity need to be considered. Reforms to the Common Agricultural Policy (CAP) could have implications for rural land use from 2013 onwards. For instance it could mean a change in the crops grown, changing from water intensive crops such as padi rice or melons for crops that use less water. The EU is contemplating a specific study on water management in the post-2013 CAP. In the UK, irrigated agriculture takes a low amount of water as few farmers find mains water economical. New farmers' abstraction licences are generally for winter only, meaning that UK farmers have to store water in reservoirs for use on their crops.

Since 2007, the EU has promoted a Water Hierarchy to cope with water scarcity, which prioritises reducing demand above all other measures. This includes land-use planning, water pricing, water metering, promoting water efficient devices and practices, education, and information and communication to raise awareness. Alternative sources of water supply are to be considered when all demand reduction options have been exhausted[25]. The UK has required such water demand management measures and the twin track approach for about 20 years. The use of economic instruments is important to stimulate efficient use of water through different technologies. For example, the draft long-term Strategy for Water in the Mediterranean promotes key WFD concepts, such as the "user-pays" and "polluter-pays" principles, and focuses on demand management rather than on the development of non-conventional water resources (e.g. large-scale desalination)[26]. The Environment Agency has operated similarly for many years.

Several options are already in use around the world to improve self-sufficiency and ensure efficient use of water, such as reclaiming wastewater, collecting rainwater and desalinating seawater[27]. Places such as Singapore are leading the way in water self-sufficiency, however not by the most sustainable means (see case study 2 in the supporting document). In the UK most future resources will involve the reallocation of existing resources, the enlargement of existing reservoirs, the construction of new ones, inter-basin water transfer, or water reuse.

2.1.1 Water reuse

Much of the water we use for non-potable purposes such as industrial applications, toilet flushing and irrigation, is unnecessarily treated to potable-water standards (we only need 3% of our water to be potable in the domestic context[28]). Water reuse, the practice where suitably treated wastewater from one process is reused for a different beneficial purpose can provide an alternative water supply for both households and industry.

It is likely that industries such as pharmaceuticals and food production will have to start using more water reuse as process industries are predicted to increase their water use by 200% in the next 10-15 years. It is likely that as the pharmaceutical sector has risk-averse regulators they will need to work with the water industry and use their expertise to understand the risks.

The effluent from inland towns is treated to a high standard, discharged into the local river and is then often abstracted further downstream for the part of the water supply to a downstream town. This is called indirect reuse. Thus London's supply comes partly from the effluent treatment works of Swindon, Oxford, Reading and Maidenhead.

Much treated effluent from coastal towns is discharged to sea and is lost, whereas it could be treated further and returned to inland water courses. Treated effluent can be returned further up the river to augment resources. Herne Bay treated effluent has been discharged into the Kent Stour for downstream abstraction at Plucks Gutter water treatment works for about 20 years. This can be particularly helpful when it supports the minimum flow of the watercourse, thus allowing extra abstraction further upstream, as Anglian Water have proposed for the Rutland water scheme. Alternatively it can be treated further, diluted and pumped to a reservoir, as is done at the Langford scheme in Essex.

Unplanned indirect reuse is commonplace throughout the water industry but planned indirect reuse is still restricted, largely due to the perceptions of risks to public health. This is despite the adoption of stringent effluent treatment standards. A coherent government policy and the publication of guidelines utilising the Drinking Water Quality Standards for the protection of public health and the environment is needed to increase water reuse. Perceptions need to be changed through more education and awareness to provide a greater public understanding of the benefits of reuse, as several water companies have not made use of available options due to public acceptability worries.

Effluent reuse where reverse osmosis is used is highly energy intensive. More work is needed to understand the greenhouse gas emission impacts of water reuse compared to those of other water supply options including desalination, rainwater harvesting, winter storage reservoirs and demand side options to reduce deficits in supply.

See case study 1 in the supporting document on direct potable reuse in Windhoek, Namibia.

Benefits: provides additional water supply; makes use of already treated water; increases baseflow, largely climate change proof in that the source is always available and does not need a long distance transfer

Costs: carbon costs need to be justified; public perceptions need to be changed

2.1.2 Water storage

Reservoirs enable water to be captured in times of plenty for use in times of shortage. They can provide many benefits including water supply, floodwater control, power generation, irrigation and recreational use. Their construction, however, has sometimes required the relocation of people living in the impounded area, and some reservoirs have had significant environmental impacts such as loss of high quality agricultural land, changes to downstream flow patterns and impacts on fish migration and microclimates. There is a lively debate as to whether the social and environmental impacts outweigh the benefits.

Storing wet season runoff is a long term sustainable method of providing water and will be important in the future, especially with more instances of shorter, higher intensity precipitation. However reservoir schemes need careful environmental and social impact studies in order to test their viability and all appropriate measures should be taken to minimise any negative impacts. New reservoirs have large embedded carbon costs. Raising existing dams to store more winter rainfall could be advantageous as the demand for more water resources increases. This has less of an environmental impact as the infrastructure is already there and significant extra storage can often be gained cheaply. This has been done at Ladybower, is being done at Abberton reservoir in Essex, and is proposed for Bewl reservoir in Kent.

In the UK it is likely that alongside demand side measures, new water supplies will be required. Most of our sustainable groundwater is already fully committed, and during droughts there is little water in some of the rivers that is not required to maintain a healthy environment. Water transfer between river basins can be expensive, and can result in ecological stress and change. However different river systems can have different hydrological regimes. For instance the river Thames is largely groundwater driven whereas the larger and less developed river Severn obtains most of its runoff from the mountains of Wales. The risk of a drought occurring in both at the same time is low.

Benefits: water storage for times of drought, potential for recreation

Costs: land lost to reservoirs, large carbon impact, impacts on base flow

2.1.3 Aquifer Storage and Recovery (ASR)

The rate at which water is withdrawn from aquifers is often far higher than their natural rate of replenishment. Water tables are largely replenished naturally by rain, rivers and streams, however in several European regions aquifer levels are dropping by one to three meters a year due to overuse[29]. Aquifer Storage and Recovery is one form of artificial groundwater recharge and recovery whereby water is injected into an aquifer via a borehole during times when water is available, and the recovery of water via the same borehole during times when it is needed.

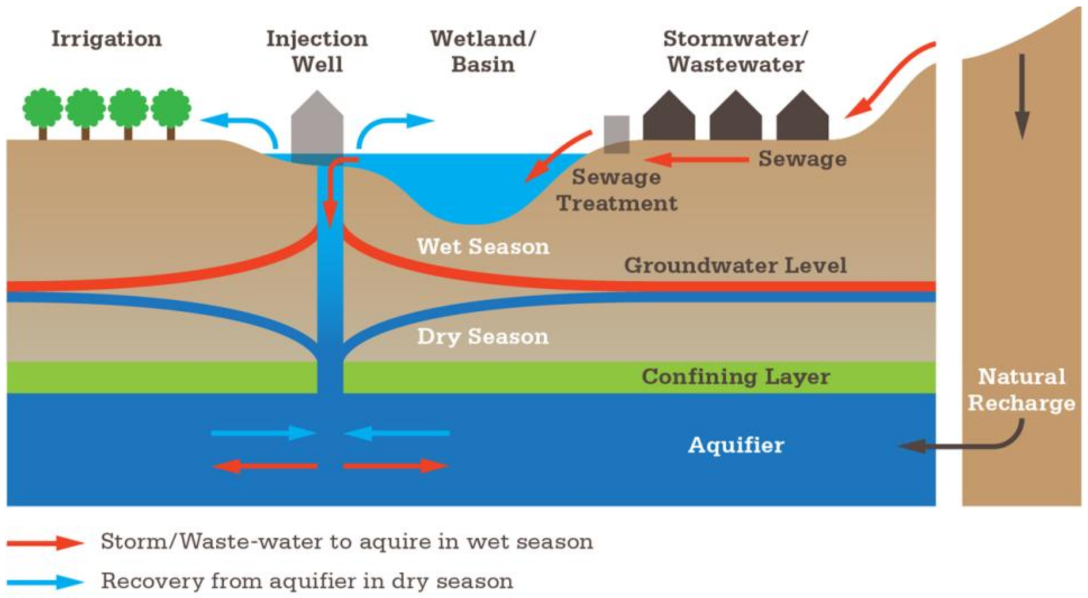

Figure 2. Aquifer storage and recovery (Diagram courtesy of IMechE[30])

ASR can replenish groundwater levels and is one of the highest growth alternative water resource solutions in USA and Australia. As yet, it has not received similar attention in Europe.

Restoring aquifers can be achieved artificially using treated surface water, storm water or wastewater. There may be water quality issues associated with ASR and CIWEM advocates that the water to be stored in the aquifer must meet certain water quality standards.

Benefits: seasonal storage, more environmentally sensitive than reservoirs, less capital costs than other water supply alternatives, replenishes groundwater

Costs: water quality issues, contamination of natural aquifers

2.1.5 Rainwater harvesting and Grey-water recycling

Rainwater harvesting involves the collection of rainwater (normally from a roof or land surface catchment) into a storage container for use at a later time. Rainwater may be better than tap water for use in the garden as it generally has lower dissolved solids and does not contain the chlorine levels of potable water.

A risk to the quality of rainwater is the surface catchment from which it is collected. A reasonably common cause of contamination comes from lead roofs, animal or bird defecation and grit from tiles, or from treatments to prevent moss growth. Generally, the water quality from rainwater harvested on a well maintained roof catchment is of superior quality to rainwater collected from a catchment on the ground. Rainwater is often of superior quality to domestic grey water.

Grey water is often more contaminated than rainwater and can have similar pathogen and organic loads to mixed wastewater. It is not recommended that untreated greywater or rainwater are used for drinking, cooking, food preparation or washing water.

Rainwater harvesting and greywater reuse are unlikely to contribute significant quantities to the overall resource. However CIWEM advocates rainwater harvesting and greywater systems should be built into new build community schemes and potentially individual homes to move towards better understanding and use of water for the environment, potable water and reused water for different purposes. This should be decided by the context as de-centralised greywater recycling can reduce pressure on water supplies, but can be energy intensive in comparison to remaining on centralised systems for mains water and sewerage. Savings in water are made at the expense of additional energy usage (which in turn requires water to produce). CIWEM's Policy Position Statement on water quality issues for household water reuse has a matrix of appropriate sources and uses[b].

Benefits: more sustainable than treating water

Costs/risks: water quality issues need to be resolved, can be energy intensive

[b] See CIWEM's PSS Water quality issues for household water reuse at: http://www.ciwem.org/policy-and-international/policy-position-statements/water-quality-issues-for-household-water-reuse.aspx

2.1.6 Desalination for water supplies

Desalination can provide significant benefits to communities that have depleted or limited access to traditional ground or surface water supplies. 16 billion gallons are produced daily by the world's 14,450 desalination plants[31].

Arabian Gulf countries rely mostly on seawater. Most of their plant use multi stage flash desalination heating sea water until it turns to steam then condensing it. This is an extremely costly technology and highly energy consumptive. In the Arabian Gulf area this is sometimes partly provided by waste gas that would otherwise be burnt off. Desalination also leaves a concentration of brine which is difficult to dispose of and harmful to the environment. It has been found that inland desalination plants are raising the salinity of the Arabian aquifer, making it more expensive and energy intensive to desalinate the water.

Technologies for desalination are continually improving. The current state of the art method is being used in Tampa Bay, Florida and in Perth, using reverse osmosis. Here water is forced through a membrane at more than a thousand pounds per square inch to catch the salt. This takes less energy than multi stage flash boiling but is still expensive. Three new technologies are being developed to reduce the energy requirements. The closest to commercialisation is forward osmosis. This draws water through the porous membrane into a solution that contains more salt than seawater, but of a type that is easily evaporated. Another redesigns the membrane using carbon nanotubes as the pores, with the other, biomimetrics, using the same proteins that allow water through the membranes of living cells. It is likely that the costs of these will only make it commercially viable where there is no other water resource option.

In 2010 Thames Water opened the first municipal desalination plant in the UK (Beckton on the Thames Estuary). The economic regulator agreed with Thames Water's assessment that they had a supply demand deficit under sustained dry conditions and that there was little alternative but to develop a desalination scheme. Thames have spent £250m building the plant and pipes which will only be turned on at times of drought and can supply 1 million people with water. Thames have been criticised for not doing more to fix leaks and reduce demand before building the plant.

Also see case study 2 in the supporting document on Singapore's water policy.

Benefits: provides water in areas with limited water supplies

Costs: very expensive; new technologies do not offer help to the world's poor; disposal of brine; highly energy intensive

2.1.7 Integrating wastewater planning

CIWEM supports initiatives which involve integrating urban planning with water and wastewater utility planning. The term 'wastewater' is unhelpful in that it implies that it is a waste to be disposed of and it would be more helpful to label it as 'effluent'. Wastewater systems constructed for many years have separated foul water and surface water drainage. However in city centres of old towns such as London, the drainage systems are combined in one pipe. In these areas an increased degree of separation in foul and surface water is needed for waste water systems. This would allow solid waste to be separated and used in anaerobic digestion as an energy source, whilst surface water would require less energy intensive treatment. However, where this has been studied, it has been found not to be economic.

2.1.8 Water cycle studies assess the capacity of water supply, wastewater infrastructure and the water environment in growth areas. They are undertaken by local authorities (non-statutorily) during strategic growth planning to ensure that new development can be supplied with the required water services it needs in a sustainable way whilst meeting legislative requirements such as the Water Framework Directive.

See case study 3 in the supporting document on the Ashford Integrated Water Management Study.

Benefits: take a holistic view of water management, meet legislative requirements, often find solutions to multiple problems, value ecosystem services

Costs: not statutory, resource requirements, expectation management is required

2.2 Land management & Water

Land as well as water is a finite resource. There are a number of pressures to and from land use that can affect water quality in both urban and rural environments. Impermeable surfaces in urban areas exacerbate run-off and carry a range of pollutants from the surfaces of buildings and streets into watercourses, impacting water quality in rivers. Ageing and inadequate sewerage systems also risk overflow and flooding. Increasing pressure for land and a lack of planning controls have allowed flood plains to be developed, removing their natural flood protection and putting buildings and people at greater risk. Climate change is already affecting the quality and quantity of raw water supplies collected in reservoirs and that abstracted from rivers, whilst centuries of agricultural innovation and intensification have boosted food productivity at the expense of biodiversity, hydrology and the production of clean water[32].

The Water Framework Directive[33] (WFD) aims to ensure secure and sustainable sources of water in the future. This is achieved through the protection of water bodies via River Basin

Management Plans (RBMPs) that endeavour to improve land management and create better habitats for wildlife. The spirit of the WFD is integrated water management to achieve healthy ecosystems and cleaner water, however as it was devised before the carbon agenda became a high priority, the most sustainable solutions are not always selected. The tradeoffs between water quality and its carbon implications need to be included and discussed.

Criticism to the approach taken with the implementation of the WFD in England and Wales is that it is not embracing the principles and concepts of the Directive through a lack of shared vision. There is also an issue with RBMPs working on a regional scale where a catchment scale may actually be more appropriate in terms of engagement and getting the community involved. Our river basins do not lend themselves to large scale joined-up planning, geographically or institutionally. We consider that a combination of grassroots level knowledge and involvement with top-down buy-in at a catchment scale would help to deliver on its aims.

There is also the problem that the WFD cycle is 6 years in length whereas the water regulation cycle lasts 5 years. This results in a mismatch of the identification of need for action to be taken and the agreement for funding for the action to be taken.

The WFD has brought together different parts of the Environment Agency who previously had little contact, particularly those who manage water resources and water quality. CIWEM members have claimed that there is surprisingly little overlap between water supply, wastewater provision and flood risk, except in the areas of drainage, sewer flooding, rainwater harvesting and greywater recycling. We consider that there is scope for further integration of policy and practice such as:

- Re-naturalising river channels for water quality, biodiversity, landscape and flood risk management benefits;
- Controlling farmland use and management to minimise downstream diffuse agricultural pollution where ecological risks and / or clean up costs for treatment of public supplies are greatest etc; and
- Targeting SUDs in development planning where infiltration is most needed for aquifer recharge or wetland restoration.

Diffuse urban pollution of water is seen as one of the big obstacles to achieving compliance with the WFD. There are inherent complexities with the multiplicity of pollutants, sources and pathways and also the many organisations and regulatory instruments involved in the governance of the process. Many of the effects of diffuse pollution are chronic rather than acute so the effects are not always as obvious as those from water discolouration or the death of wildlife. Potentially all people and urban infrastructure can cause pollution and in the wider water environment there are a wide range of pollutants from misconnections of domestic waste water, highway drainage, poor design and control of light industrial estates, illegal disposal of wastes to sewers and drains, inadequate maintenance of sewers, and leaching of contaminated land.

Grey – water contamination is a recurring problem which requires local level action. This is where dirty water from sinks, baths, showers, appliances or toilets are connected to the surface water system instead of the foul water sewer, and end up polluting local rivers. In the same way, if gutters and gulleys are wrongly connected to the foul water sewer, surface water can overwhelm the foul water system and cause flooding.

Grey water contamination is often more serious than storm sewage contamination as it occurs when stream base flows are low so the proportionate impact is high. Inspection of most urban streams shows them to be similarly affected, and whilst the water is often fairly clear, the stream is lifeless.

Estates built over the last thirty years are generally separately sewered, with rear drains going to foul systems and roof water going to surface water drains. A problem occurs when householders install washing machines into their garages with their discharge connected to a gully grate leading to surface water drains. Often householders are not aware of the problem, although they are legally responsible, and this situation could be addressed by a public awareness exercise[c].

Agro-chemicals such as nitrates and pesticides are the long term and persistent pollution issue for groundwater. Diffuse and point source pollution from agricultural practices has much improved in recent years, partly due to nitrate sensitive areas which severely curtail the amount of nitrate that can be applied to land and crops in nitrate sensitive areas. However they continue to place some constraint on some water companies' resources. Groundwater in chalk catchments is particularly vulnerable, due to the persistence of solutes within these aquifers[34].

Improving environmental water quality needs to be linked to land use practices, which means agencies engaging with the agricultural community. Defra (as part of the England Catchment Sensitive Farming Delivery Initiative) are engaging with a small group of farmers to monitor water quality and through shared learning to identify practical measures to effectively mitigate diffuse pollution. Farmers are monitoring their own fields using simple field test kits. This participatory approach to monitoring hopes to raise awareness by engaging and empowering stakeholders to consider the downstream environmental impact of their activities[35].

Evidence that intensified farming leads to increased runoff rates has been established. Fast, well connected flow paths are clearly contributing to localised 'muddy floods'. By targeting runoff in fields and farm ditches a significant component of flood generation can potentially be managed at the catchment scale.

See case studies 8, 9 and 10 in the supporting document on catchment schemes.

2.2.1 Green and environmental infrastructure

Increasing green space in urban areas can increase natural infiltration and reduce run-off helping to reduce flood risk and the transportation of pollutants[36,37]. Urban layout and landscape should be carefully designed to allow the space for flood water to pass freely along pathways. Roads and streets constitute up to 70% of impervious areas in urban areas and as such they act as major conveyors of storm water and an important flow path when

[c] Further information is available in the Environment Agency leaflet: http://www.environment-agency.gov.uk/static/documents/Business/Misconnections_Unbranded_Leaflet_FINAL_2010_0202.pdf

the drains beneath them are full to capacity. It has been suggested[38] that new roads should be designed in close consultation with planners, road engineers and drainage experts to create continuous flow paths along roads to the outlet of a regional drainage system, without going through local depressions that have no natural outlet.

In the past the solution to flooding in most urban areas has been to straighten rivers and contain them in channels and culverts. However this attenuates flood risk by increasing peak flows. A reduction in the amount of water in fixed channels is an optimum way to reduce flood risk with river re-naturalisation, but is increasingly difficult in urban areas where development borders onto river channels. Un-engineered rivers with vegetated channels slow down flows and increase the channelling of water to natural flood plains avoiding flooding in built up areas[39]. The Environment Agency, Scottish Environmental Protection Agency (SEPA) and the UK Government are now promoting sustainable management of urban watercourses, river restoration schemes and SUDs to assist in cost effective solutions for the reduction and management of flood risk.

Outside of urban areas woodland and forests attenuate flood risk, whilst coastal zone management to retain salt marsh and flood meadow systems act as a natural buffer against coastal erosion and tidal inundation. Making the most of these natural systems can reduce our reliance on hard engineering approaches. Alongside water management, green infrastructure can also act to build resilience to the impacts of climate change and improve biodiversity.

Benefits: using natural processes, added amenity, long term, added resilience, biodiversity benefits

Costs: Difficult to retrofit in some areas, occasional loss of land

2.2.2 Sustainable Drainage Systems (SUDs)

SUDs help to reduce urban diffuse pollution. They minimise surface water runoff with permeable surfaces, filters, storage areas, wetlands and balancing ponds. This helps to protect water quality and provide a habitat for wildlife in urban watercourses[40]. SUDs reduce water treatment costs by improving water quality at the source rather than 'end of pipe'. The collective benefits of SUDs schemes provide a more cost effective solution and offer numerous benefits compared with traditional systems.

Flood risk in urban areas and water quality impacts from urban runoff has traditionally been addressed, if at all, by single measure schemes with ongoing maintenance requirements[41]. With local government expected to take on new powers and responsibilities, which include a lead role in managing local flood risk and looking after SUDs schemes, there will need to be a reworking of relationships with the Environment Agency and other key partners such as Internal Drainage Boards and water companies.

See case studies 5 and 6 in the supporting document on SUDS in Portland USA and the Dŵr Cymru surface water management strategy.

Benefits: reduce flood risk, improve water quality, create habitat, and reduce treatment costs, longer term solution

Costs: difficult to retrofit, upfront costs can be greater than other options, require maintenance

2.2.3 Catchment assessments & catchment mapping

Whilst considering the interconnection with other scales, the catchment scale is arguably the most appropriate for building the necessary collaboration of stakeholders to tackle water management issues in the UK. Studying the physical attributes of the catchment, land management and ownership and the policy and practices behind it through catchment assessments can help to find the most sustainable management options. Mapping of catchments can be used to highlight opportunity areas for multiple benefits that also deliver WFD outcomes.

Mapping needs to take place at an appropriate scale with the maximisation of data sharing between organisations. Land use is likely to be very important and increased detail of land use data could be very valuable. Data is already available for free at a coarse level from the European Environment Agency (the "Corine" data set).

Demonstration Test Catchments projects are underway by DEFRA, WAG, and the EA. These are exploring integrated ways of water and land management at the catchment scale, especially into diffuse water pollution from agriculture. They are based on informed adaptive and participatory principles that incorporate the local scale.

Solving diffuse pollution requires a multi-stakeholder approach due to the complexity of the problem. Where pesticides such as metaldehyde (from slug pellets) and clopyriad (weed killer) are a concern there will need to be cooperation between hydrologists, agronomists, water quality and soils scientists working in partnership with regulators, farmers, pesticide manufacturers, environmentalists and interest groups. Anglian water has approached the problem using catchment scale modelling of diffuse pesticide pollution which will then be used to test different integrated catchment management solutions[42].

Benefits: identifying crossovers and overlaps, indicate priorities

Costs: Resources, culture, multiple pressures on water environment, numerous stakeholders with different drivers and roles, need to be accessible

2.2.4 Making space for water

Water is often managed in terms of how to accelerate it through the catchment i.e. with culverts and channel straightening. Instead catchments needs to be utilised to store excesses of water at different times of year and used to slow down the transport of water.

See case study 11 in the supporting document on Derby's blue corridor.

The Holnicote project in Somerset by the National Trust is a good example of integrated catchment management[43]. This project aims to show how land management can be used to alleviate flood risk and deliver wider benefits including improved biodiversity and water quality, carbon stewardship, public access and landscape quality.

The project considered restoration from source to sea with:

- Restoration of upland peats.
- Regeneration of native woodland on steepsided valleys in the upper reaches.
- Restoration of water meadows and woodland planting in the middle reaches.
- Improved soil husbandry to reduce compaction on farmland.
- River restoration in the lower reaches to restore saltmarsh and improve flood flows through the shingle ridge.

The project is supported by Defra and the Environment Agency and works with tenant farmers throughout the catchments. Land management that actively makes space for water and slows down its transfer thought the catchment has been created through the restoration of moorland wetlands, new woodland creation and the restoration of water meadows. However the benefit in flood terms is very small while the scheme has cost £500,000[44]. A scheme to fully resolve the flooding issues would have cost more and would have involved impact on sensitive habitats[45].

Benefits: increased flood risk management, providing a water resource, habitat protection/creation, low cost

Costs: land ownership and conflicts of interest

2.3 Other water uses

Waterways were once primarily used for freight transport but now other uses of water such as recreation and energy production command a growing share of water use, particularly in the context of potential climate change. Waterways are also an important part of the UK's heritage and serve a wide variety of other uses ranging from land drainage to acting as a catalyst for regeneration[46].

At present, water resource planning concentrates almost entirely on public water supplies, mainly for domestic consumption. There is a need for increased awareness of the need for and benefits of other water uses, and how best to drive forward efficiency and optimise water use within these sectors. CIWEM believes there should be planning on a national and regional scale for meeting all future demands for water, not only public water supply whilst appreciating the range of benefits that these uses provide, and also the impacts they can cause. In the past this has been done at strategic level by the Environment Agency.

2.3.1 Enhancing navigation

There are approximately 5,090kms (3,160 miles) of fully navigable inland waterways in England and Wales, about 445kms of which are tidal[47]. Defra is currently reviewing its inland waterways policies (consulted on in March 2010) whilst British Waterways, (the organisation that cares for 2,200 miles of the country's canals and rivers) is currently transitioning into a mutual.

Many un-navigable and abandoned waterways are being restored to full navigation. There have been a number of significant additions to the navigable network over the past decade including the full restoration of the Kennet and Avon, Huddersfield Narrow and Rochdale Canals and the opening of the Ribble Link and the Liverpool Canal Link[48]. CIWEM supports the restoration of navigation upon historic inland waterways, and the construction of new navigations where this enhances their use, contributes to amenity improvements, mitigates any adverse effects on nature conservation and promotes economic regeneration.

There is much to be gained from incorporating 'heritage' and cultural features in forward planning for flood mitigation, diffuse pollution control and habitat/biodiversity expansion. CIWEM would wish to see a holistic approach to be taken to waterways projects, whatever their primary purpose, seeking to maximise benefits for IWM.

See case study 12 in the supporting document on the Itchen Navigation Heritage Trail.

Benefits: public access, adds value to a community, economic regeneration, flood risk management, habitat enhancement, and heritage conservation

Costs: project costs

2.3.2 Recreation

Recreation provides economic, social, health and environmental benefits to individuals and society alike. On water bodies activities such as swimming, walking, fishing, canoeing, rowing, powered boats and waterside activities such as cycling and horse riding can all impact the water environment. While recreational activity can have some negative impacts, these are often less pervasive and acute than those generated by industry, agriculture and transport.

Some 8% of the major rivers and 3% of the canals in England and Wales are notified as Sites of Special Scientific Interest (SSSIs). Almost 500 enclosed waters of one hectare or more (24% of the total) are notified in part or whole as SSSIs[49]. In some cases, protecting the interests of the environmental designations has frustrated proposals for recreational use of inland waters.

CIWEM considers that the sustainable recreational use of inland water and adjacent land should be protected and increased where it will not adversely impact on existing users and uses, conservation or economic interests now or in the future. Sustainable management and development of watercourses requires closer collaboration between local authorities, public agencies, riparian owners and waterway users.

Benefits: improved health and quality of life for users, adds value to a community

Costs: bank damage, litter, disturbance of wildlife

2.3.3 Hydropower (small scale and micro hydro)

There are strong opinions on both sides of the hydropower argument arising from conflicting local and global environmental impacts. The UK has challenging carbon reduction targets to meet alongside potentially conflicting Directives for environmental protection. These need to be balanced, managed and mitigated through increased stakeholder dialogue, more guidance and decision making on a case-by-case basis. The inclusion of hydropower potential within Water Cycle Studies would allow local authorities to promote specific sites for development and achieve local engagement.

Hydropower offers unique opportunities and challenges: a reliable energy source that produces no waste, but one that can have local detrimental impacts. Poorly designed hydropower schemes can have serious implications for the river environment, particularly on fish populations, such as salmon and trout, and on flood risk for properties downstream of the installation. Every potential hydropower site is different as there are considerable variations in hydrology, terrestrial and aquatic ecology, fisheries and flood risk between different sites. This signifies that a one-size-fits-all approach to managing their impacts is not feasible but a consistent assessment framework is essential.

The potential for hydropower is often missed from catchment studies but as part of the water cycle it is worth considering how it can fit with IWM. The Environment Agency is currently investigating the role of small scale hydropower and has scoped areas of potential development. Work to assess the vulnerability of these sites needs to be undertaken to ensure that the natural and water environment is preserved whilst working towards more strategic aims of securing renewable energy supplies.

Currently 500 sites in England and Wales are being considered by landowners and developers for hydropower, and this figure is likely to increase now that feed-in tariffs are available. Small-scale hydropower is becoming an attractive opportunity especially to communities and the Environment Agency's view is to have 1200 schemes in place by 2020. British Waterways, National Parks, The National Trust and water companies also have many potential sites under consideration. The Environment Agency estimates that there may be a theoretical, unconstrained maximum of 1100MW of energy that could be generated through Hydropower schemes[50]. This would be equivalent to 1.5% of UK electricity needs but would involve developing many tens of thousands of small sites which may be unrealistic.

See case study 13 in the supporting document on hydropower in the Peak District National Park.

Benefits: provides renewable energy, potential for community schemes

Costs: potential implications for flood risk and natural habitats, particularly salmon and other fish which must be excluded from entering the turbines, local objections

3. Summary

3.1 Benefits of IWM

IWM moves our thinking from beyond water to **other agendas** such as energy and carbon, planning, waste, biodiversity, agriculture and ecosystem services.

IWM gives us a chance to re-think managing water from a **wider perspective**. The advantage of looking at the wider water system identifies where an activity in one part of the system may create a benefit (or an unforeseen cost) to another part.

IWM can lead to **cost savings** by creating efficiencies between local and national projects. It can also make 'more effective' use of project costs as using the finances from a variety of organisations tend to create schemes that deliver multiple objectives and multiple benefits.

IWM can be undertaken in ways that work with and ideally **restore ecosystems** and their natural processes, creating multiple and enduring benefits.

IWM allows for **new skills** for managing the environment and new organisational practices.

IWM should encourage greater involvement of all stakeholders, which potentially means options put in place work in the **long term**.

3.2 Conclusion

IWM encapsulates how to manage water as a global resource, along sustainability principles, taking into account the wider requirements of the environment, society and economy in a managed and balanced way. It moves thinking beyond water to other broader, yet interrelated agendas, and in doing so can lead to cost savings, allow for new skills, and produce schemes that deliver multiple objectives and benefits.

The majority of IWM principles are encapsulated by those already established by IWRM, which is an internationally recognised term and concept. Yet the existence of the word "Resource" within the term IWRM carries, in CIWEM's consideration, an association with water volume which arguably distorts the perception of those not fully conversant with its principles away from its true meaning. CIWEM considers that the term "integrated water management" better reflects the wider considerations which are largely already ingrained within IWRM.

Many of the principles of IWM and IWRM have been undertaken by certain parts of the environment sector (particularly in relation to water resources) for some considerable time, but no one has effectively put all of the principles in practice yet – at least on a large geographical and sectoral level.

As this report demonstrates it is impossible to talk of IWM holistically, and to even discuss it, requires it to be broken up into sectors. Integrating the management of the whole water cycle may indeed be an unrealistic ambition, but as the case studies suggest, integrated management of certain sections is entirely possible. Integration between each of these is the next step and as this develops it is essential that we do not lose the sense of the overall system and the connectivity between the parts.

> **"We need a cultural shift towards more holistic water management and essentially co-operation between those who provide water, those who protect water and those who use water."**

IWM principles can be applied to good effect to produce more integrated analysis and solutions that may be more efficient and more effective than traditional reductionist approaches. This paper shows many examples of these principles being applied at different scales with varying ambitions for the degree of integration.

However to achieve ever greater integration and associated benefits may require some significant changes to how we frame problems and how different institutions and sectors work together to achieve common goals. Largely we have found that IWM does not present technical problems, but those that are brought about by governance failures. In general our institutional arrangements tend not to support decision-making made in a cross-sectoral way, with our organisations and regulations having specific and potentially diverging remits which limit the ability to manage the water environment at a wider level.

Another barrier to effective multidisciplinary work is that we have a culture where specialism is most respected, and people prefer to be known as experts, rather than someone who manages and works effectively across areas with an overarching knowledge of different sectors. At present few managers have the skills, tools, training and potentially the time, to develop more systemic approaches to address issues of disjointedness and avoid creating a more bureaucratic system. Some significant changes are required to the way in which problems are framed and how different institutions and sectors work together to achieve common goals.

We will require a shared vision to deliver IWM. This requires a critical perspective and willingness for those involved to step outside their everyday roles and practices. One of the key barriers is institutional permission and the skill sets to do this and imagine doing things differently, rather than doing more of the same. This in itself will require strong leadership within key organisations and appropriate resourcing to ensure effective delivery.

We also need to appreciate that water management is never 'solved'. Managing is an ongoing process which requires skills and awareness to recognise the systemic nature of the situation and its context and then engage in appropriate interventions to bring about the change desired.

> **Where IWM has been successfully achieved there have been high levels of participation.**

The other main conclusion to be drawn is that water and catchment initiatives and projects are context dependent. IWM is not prescriptive and solutions will be largely context specific. The key is being able to understand a complex system to see where the leverage points for improvement are. This takes further time and money than 'off-the-shelf' solutions and requires skilled managers.

There are lessons that we can learn from people and places already doing IWM (Australia, the Netherlands, and Singapore etc.) but these need to be translated to the UK context. Water reuse and water storage are good examples where context is important. There are many demands on the water environment and in some instances where impacts cannot be mitigated; tradeoffs will need to be made.

Thinking through future impacts and choosing the most sustainable option is not always easy. The most sustainable approaches will be those that have taken decisions not only based on water, but on whole life cycle sustainability - energy (operational and embedded), chemical usage, greenhouse gas emissions, economics, environmental services and quality of life.

To achieve IWM, water and land managers must look at the relevant scale (catchments, political regions, water supply regions etc) and consider what can change within sectors, and how solutions can work across sectors to manage the environment and water better in that area. The principles of sustainability must be a key consideration to deliver environmental, social and economically balanced solutions.

3.3 What can be done?

There are clear opportunities ahead. The Coalition's aims for the Big Society can help promote participatory approaches to management. Society can learn and manage together. If there is a main conclusion that can be drawn from this report it is that where IWM has been successfully achieved there have been high levels of participation.

In the UK, we have traditionally worked in a top-down system with limited institutional support for stakeholder engagement. Water and river ecosystems have little identifiable "value" in our society and we have lost the connectivity between people and their environmental surroundings[51]. The positive aspect of community involvement alongside local NGOs and local knowledge for delivery should be seen as critical and not simply token consultation. This is important if innovative approaches are to be adopted, (as seen with the blue corridor example in Derby). Two-way education is also important. There is a long held view that water is plentiful and people's collective memories are short (especially with respect to flooding), this can be overcome with engagement. More local choice is needed within the system, and innovative, cost-effective options in which civil society may play a greater role should be encouraged.

The Government has proposed a role for the third sector in the delivery of water management as a partial replacement for "big government" i.e. centralised action. The third sector is value driven, issue focussed and considered economically efficient due to volunteer engagement and low administrative overheads[52]. However, caution should be noted as this change generates questions for catchment resourcing, governance and regulation. In an age of austerity, there are potentially serious resource issues in terms of funds, personnel, continuity and expertise.

Often there is a lack of importance attributed to the relationships and influences between people and organisations in complex systems. Putting enough emphasis (and money) into effective community engagement programs to communicate information to non-specialist audiences is also a critical part of this.

Moving forward, clear principles are needed. The forthcoming 2011 Natural Environment and Water White Papers would be an ideal opportunity to look at the bigger picture and emphasise integration. Principles such as those highlighted here – using a systems approach, delivering multiple goals through common means, interdisciplinary and multidisciplinary approaches and those that foster sustainability and innovation – ought to be incorporated. This would then enable those delivering projects to justify their approach. Practical measures such as 'integration tests' (similar to climate proofing) could be put at the heart of all water management policy and process design. Incentive structures that reward integration achievements could also encourage more of the same.

Concluding this workstream, it becomes apparent that we need a cultural shift towards more holistic water management and essentially co-operation between those who provide water, those who protect water and those who use water.

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