



Taking Responsibility for Water

United Kingdom Water Research and Innovation Framework 2011 – 2030



Foreword

Research and innovation will play a significant role in achieving a sustainable and secure water resource in future. Science and technology has long been a major driver for UK and global prosperity, and has helped meet the ever increasing demands on the water sector. Deploying new technologies, processes and knowledge that help make the global water sector more innovative and profitable will be even more critical in the future. The UK research and innovation sector needs to respond to these challenges and opportunities.

The UK is a world leader in water research, particularly in the global water cycle and its interaction with climate change. However, UK water research and innovation currently lacks a strategic approach to the highly diverse and interrelated challenges. The intention of the Water Research and Innovation Framework is to highlight key water research and innovation priorities and mechanisms to ensure better coherence and co-ordination of different public funding schemes for water research and innovation, working closely with UK and international organisations in the private and third sector.

The Framework is based on recognition that government, research organisations, academia, NGOs and industry working with other users of water need to provide the evidence to support effective decision-making, joined-up policies, and a co-ordinated coherent approach to the development and dissemination of new knowledge, technologies and skills.

Making changes to the way we manage and use water in the future will need a strong and robust evidence base supported by appropriate research and innovation. Collaboration within the UK, with the EU and its member states, and other international stakeholders will help the UK contribute to future global water security.

I am delighted that the UK Water Research and Innovation Partnership composed of private, public and third sector bodies has been convened to address urgent and important water challenges, and has set out a clear and ambitious framework for the future that builds on existing collaborative actions.

Sir John Beddington

Government Chief Scientific Adviser

Chair of UK Water Research and Innovation Partnership

Executive Summary

Section 1: **Value of Water**

Water is our most vital natural resource. It needs to be valued worldwide if resource efficiency is to be achieved and the opportunities, challenges and complexities of the coming decades are to be taken, met and resolved.

As with many countries, the UK's water footprint relies on global trade in water. The dynamics of water, in all its forms (e.g. freshwater, rain, ice, snow, seas and lakes) and the way it interacts with other parts of the environment needs accounting for in environmental management and in decision making for the future.

Stakeholders engaged in water research and innovation from the public, private and third sectors have agreed to develop a UK Framework to encourage dialogue about water and prioritise areas for action on relevant research and innovation between now and 2030.

Section 2: **A Vision for UK Water Research and Innovation**

A Vision and high level goals to help the UK make its contribution to global water security is set out in the context of the need to develop integrated solutions for water that ensure efficiency of resource use and provide opportunities for growth of the green economy. Integrated solutions are challenging to achieve as they must not only be safe and secure, but also sustainable and resilient to changing environmental conditions, as well as relevant to prevailing social and economic conditions at the location they are applied.

Section 3: **Making it Happen**

Research and Innovation dialogues and actions will be taken forward by members of the UK Water Research and Innovation Partnership to ensure that the right mix of expertise seeks integrated solutions to water challenges. The dialogues and action needed to achieve this will be facilitated by a secretariat from the Living With Environmental Change Partnership, the UK Collaborative on Development Sciences, and the Government Office for Science. Initially, working groups on skills, and pathways to innovation have been established, and another on international development is proposed. Other working groups will be established in the future as appropriate.

The context for research and innovation – a changing environment with an increasing population more vulnerable to water security issues – is set out in brief and a number of topics identified on which the Water Research and Innovation Partnership members could engage in dialogue and action.

Future priorities for research and innovation have been identified through an analysis of many recent reports on different aspects of water and by consultation with the public, private and third sectors. Social and economic topics feature strongly amongst these priorities as well as engineering and environmental ones, however, the need for a systems approach to provide integrated solutions is widely accepted.

Desirable outcomes from research and innovation are provided for each of the priority areas. In addition, a number of options for action are proposed for members of the Water Partnership and other organisations. These include harnessing existing initiatives or those about to be launched, as well as promoting new closer working partnerships between members of the Partnership and other organisations, to contribute to the delivery of the desired outcomes. This will contribute to delivery of the aims of both white papers on the Natural Environment (Natural Choice) and water (Water for Life), and to the development agenda (Millennium Development Goals).

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1. Value of Water

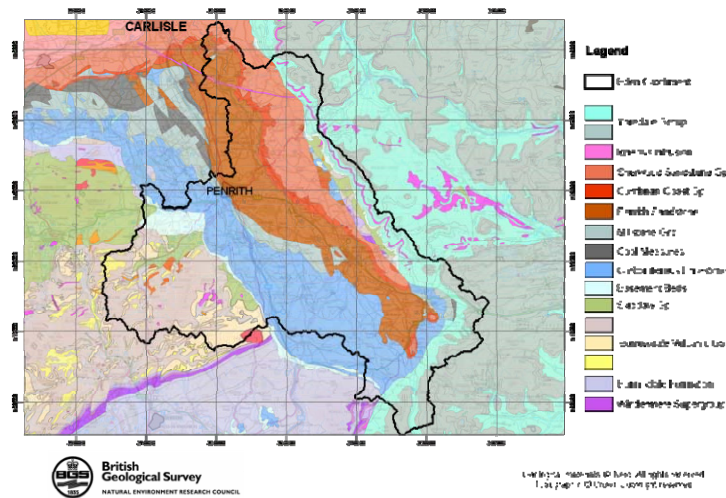
Our health, wealth creation and quality of life depend on water, the most precious natural resource, essential for life. Water needs to be fully valued globally, and more thought given to overall security of water in future decades because water supply, and the quantity and quality of resources underpin many ecosystem services as set out in the National Ecosystem Assessment. In the UK, water may seem to be in such abundance – as supply meets demand – which households and businesses expect access at all times. Other parts of the world are not so fortunate and access to water and services linked to water, such as sanitation, have been and remain difficult daily issues for 100s of millions of people in many parts of the world.

Many of the most important societal and economic challenges involve water because it is central to economic growth, health and social well-being in all nations, businesses and households. It is needed for drinks, effective forms of sanitation, agriculture, food and energy production, cooling power generation plants (both nuclear and fossil-fuel fired), and the manufacture of textiles and many other goods. Water, of the right quality, is essential for freshwater and marine ecosystems. In addition, water provides a range of cultural and recreational services.

In our interconnected world, water cannot be thought of by any one country in isolation. Every country that trades with others draws on the water resources of the countries that it trades with, in the form of embedded water in food and water used in manufacturing. Each country has its water footprint that extends well beyond its borders. Many countries depend on water sources (whether these be rivers, glaciers, lakes or springs) located in other countries, and many will be affected from melting Arctic and Antarctic ice sheets, whose dynamics play major roles in the global water cycle and, in the long term, determine sea level.

The UK needs to use and develop its skills and knowledge of water to make rapid progress towards ensuring that access to water resources can be safe and secure for all people, businesses, other organisations and the environment. This progress can only be made by having strong links between research, business, policy and our international partners. Progress will depend on both a better recognition of the value of water and the benefits derived from water, which are supplied by a range of services delivered through intact ecosystems. In turn, there is a need to learn more about the localised aspects of the global water cycle, and how this influences the amount of rain (or snow) fall; and how to live with the uncertainties and extreme events (storms, floods and droughts), imposed by the natural global water cycles. It will also be important to appreciate how our choices and actions may have an impact on and interact with the complexities in the natural system.

Unless efficiency of water use can be improved, natural freshwater could become a more limited resource, even though there are still freshwater resources to be tapped, and technologies for converting seawater to freshwater are increasingly efficient and available. At such a point, competition for water has complex social and economic effects. For example, as water scarcity intensifies and many of the world's river basins approach "closure" (when water use exceeds the rate at which it is renewed for at least part of the year), competition for water between agriculture and other demands, such as energy generation or growing urban populations, intensifies. Often, it seems, agriculture loses out. To avoid such trade-offs, integrated solutions will need to address local environmental, social and economic conditions.



Box 1: Complex Geology of Cumbria and Impact on Rain Run-off and Flooding.

Some aspects of the geology are much more permeable than others – this influences rates of run-off (e.g. into rivers) and thus the likelihood of flooding.

In order to be resource efficient in water use, account must be taken of the spatial and temporal dynamics of the system through which water passes. As an exemplar, greater appreciation is needed of the fact that precipitation is not the sole water-related determinant of crop growth or flooding. The ability of soil to retain moisture for plant growth, will depend on a whole range of physical and chemical properties of the soil. In designing and managing future crop regimes it will be important to have foresight of soil-moisture dynamics under a range of future climate scenarios at all the locations where a crop needs to be grown.

Likewise for flooding, much depends on the type of land surface on which the rain falls. Variations in local conditions can make a very great difference in the severity and likelihood of flood events. Box 1 shows the variable geology of Cumbria. Exactly where rain falls in such areas determines the nature and speed of run-off of water and therefore influences the likelihood of flooding. In 2009, there was a dramatic flood because heavy rain fell on rocks and soils that did not retain the water, but if the heavy rain had fallen in slightly different places more rainfall may well have been absorbed and many £100Ms in damage costs avoided. This kind of knowledge allows proper management of flood risk.

Such natural, economic and social complexities mean that to better manage global water security (both in terms of water supply and the quality of water in ecosystems), there is a need to join up the skills of many different kinds of experts through research informed dialogues that make the innovation pathway faster. Enabling a UK forum for such dialogue would help the UK deliver the full value of its water skills and knowledge to help grow a green economy, become resource efficient, and reduce costs of damage from extreme climatic events, with many benefits to households and businesses. The key facts in the accompanying box (Box 2) amply illustrate the importance of water, and its role within different sectors of business and society.

Box 2: Water – Selected Key Facts

<u>Water use</u>	<ul style="list-style-type: none"> • Demographic changes and societal trends will place more demand on water resources. • A balanced human diet of 3000 kcal/day calculated at 20% animal and 80% vegetable, requires 3-4 m³ of water per day or 70 times the 50 litres needed per capita for basic daily household water needs. • Heating water is a major use of energy within UK homes.
<u>Water infrastructure</u>	<ul style="list-style-type: none"> • UK has invested over £250 billion in water infrastructure of varying age and condition, managed by the regulated water industry that spend about £8 billion per year on capital and operating costs.
<u>Business and the economy</u>	<ul style="list-style-type: none"> • Floods in 2007 cost the UK approximately £3.5 billion, and flooding events are likely to become more frequent, posing risk to UK infrastructure. • Water industry is worth over £10 billion p.a. in the UK and £500 billion p.a. globally, growing over 10% per annum in some countries. • The drought of 2003 cost the European economy over €8.2 billion and the Barcelona drought in 2007/8 cost the Catalan economy 1% of GDP.
<u>Environment and climate change</u>	<ul style="list-style-type: none"> • Predicting patterns of future rainfall is a major uncertainty in climate models. • Although a prolonged dry spell caused drought in the east of UK in 2011, overall summer rainfall was 18% higher than average. • Most of the worlds freshwater is frozen e.g. in Antarctica and Greenland, and warmer global temperatures mean sea-levels could rise (about 0.5m by the end of the century). • Ocean acidity has increased by about a third since the 19th century, most probably from carbon dioxide dissolving in seawater, and threatens marine ecosystems.
<u>Farming and food</u>	<ul style="list-style-type: none"> • Globally, farming accounts for 70% of the use of all freshwater (blue water) that is abstracted from rivers, lakes and aquifers, compared with 20% for industry, and 10% for municipalities. • Globally, irrigation consumes nearly 1,800 km³ of blue water annually, with rainfed crops consuming an additional 5,000 km³ of green water. • Imported food and fibre account for 62% of the UK's total water footprint. • Amount of water needed to produce one kg of grain-fed beef and poultry is at least 15 m³ and about 5 m³ of water respectively, but grains, pulses, and root crops require less than two m³ /kg.¹
<u>Sanitation and health</u>	<ul style="list-style-type: none"> • The water industry in the UK spends at least £225 million per year to treat potable supplies for pesticides, nutrients, faecal organisms and suspended matter (soil erosion). • 1.1 billion people in the world do not have access to safe drinking water, roughly one-sixth of the world's population. • 2.2 million people in low and medium income countries, mostly children, die each year from diseases associated with lack of access to safe drinking water, inadequate sanitation and poor hygiene. (i.e. diarrhoeal disease).

Sources of information in Annex A.

Broadening understanding of water use would also help achieve resource efficiency. Relatively few people realise that although we each use some 150 litres of water per day in our homes in the UK, other uses (exemplified by water contained in food or used in manufacturing goods) means our real water “footprint” involves drawing on about 3,500 litres per day. Of these 3,500 litres, much of it comes from or is used in other countries that export food and goods to the UK. This means water security failures in other parts of the world (for example, the recent drought in Russia) can have serious consequences for the UK, leading to increased food prices or disrupted business supply chains. There is a need to better understand the concept of water footprints and how the embedded water in products traded globally negatively or positively affects local water resources, ecosystems and livelihoods.¹

Addressing such complex challenges will involve: extending the resource base, new technology, increased customer choices, ensuring access to water, recognising the value of water appropriately, and solutions suited to local environmental, social and economic conditions etc. Such “integrated solutions” can only be achieved by working in close partnerships between those delivering services and those generating the evidence base and innovative approaches to water resources and services.

As a first step, the UK Water Research and Innovation Framework has enabled partner organisations to prioritise the national and global water security challenges that could best be addressed through the evidence generated and impact achieved by UK research and innovation.

The agreed **Purpose of the Framework** is to develop:

- an overall vision on which to focus the UK’s water research and innovation;
- agreed high level goals, cutting across the traditional research boundaries, that might be addressed through research and innovation;
- a list of and justification for prioritised research areas together with an indication of desired outcomes and impacts, based in part on the direction of excellent existing research capability, partnerships and initiatives; and
- the roles of members and how their existing or planned work could address shared interests.

¹ see: <http://www.waterfootprint.org> for accounts of the work of the Water Footprint Network.

2. A Vision for UK Water Research and Innovation

A **vision** for the contribution of the UK to developing and maintaining global water security endorsed by public, private and third sectors is:

By 2030 the UK will be a key contributor in providing integrated solutions in water security and sustainability such that individuals, communities and businesses benefit from productive, equitable water systems and ecosystem services. In consequence, health improves, communities develop, the green economy grows and the environment is protected and enhanced.

In our increasingly interconnected and interdependent world, achieving this vision will only be possible if the UK takes account of its broader economic and societal goals and recognises the role that research and innovation can play in achieving these goals and realising the associated opportunities.

Research and innovation has various roles to play in addressing these national and global challenges for society and the economy, and the **high-level goals** that might be addressed through UK research and innovation actions on water include:

- Embedding responsibility for water in all individual, corporate, economic and policy decisions.
- Enabling access to water and sanitation as these are key factors in human well-being.
- Developing, at appropriate regional and temporal scales, approaches to water safety, security and sustainability that take account of a changing climate, a growing population and competing land use pressures.
- Achieving efficient operation of the human water cycle (abstraction, supply, use and (reuse or) waste water treatment) in response to these pressures whilst minimising energy consumption and providing protection for the water environment.
- Accounting for changes in the frequency and duration of extreme and high impact events (including climatic, natural and human induced events) and improving the management of these events (from prediction and preparedness to recovery).
- Maintaining, valuing and developing ecosystem functions and protecting biodiversity in support of secure and sustainable water resources and the delivery of ecosystem services.

To have impact on society and the economy, outcomes from research must include improved decision making and increased capacity and capability in innovation. Decision makers and innovators need outputs such as the foresight, knowledge and tools needed to help choose between different options. Such outputs strengthen the evidence base and increase opportunities to develop best practice and new products and services.

Likewise, Innovation in water must help deliver (as in Box 3), amongst many other things:

- ***new types of, or, more efficient water services*** that are: a) safe, secure and sustainable; b) resilient to climate and other forms of environmental change; and c) appropriate for the time, place and prevailing social and economic circumstances (e.g. supporting improved access to drinking water and sanitation for the world's poorest).

and

- a **green economy** that: uses resources efficiently and sustainably, is well regulated in a way that does not inhibit innovation and is successfully adapted to forthcoming environmental and demographic changes in ways that provide opportunities for growth.

Box 3: Innovation in Water – Case Study Examples

Innovation in water, from deploying new technologies, processes and knowledge, offers many outcomes, for example, decreasing carbon footprints, and helping to alleviate inequalities in access to water.

Reducing carbon footprints and materials: Anglian Water has worked closely with their supply chain to reduce carbon footprints and material use. Work with new designs of air valves has saved 93% of the embedded carbon and reduced the weight from 25kg to 1kg.

Innovative use of mobile phones in Africa: Oxford University, in partnership with Rural Focus Ltd. (Kenya) and ZamDex (Zambia), have developed a new innovative approach to promoting water security in Africa.



The DFID funded Smart Water System (SWS) initiative, couples mobile banking and smart water metering, offering an opportunity to improve the operational and financial performance of water service utilities by driving down water payment transaction costs and identifying and reducing non-revenue water losses. Moreover, this approach removes the standpipe middlemen that cost the urban poor in Africa an estimated \$650m every year, whilst also generating accurate and reliable data that can enhance water sector accountability and transparency (see <http://owfp.ouce.ox.ac.uk/was/smart-water-systems.php>).

Photo images courtesy of kiwanja.net (www.kiwanja.net/mobilegallery.htm)

3. Making it Happen

It will only be possible to achieve integrated solutions to these challenges if the currently fragmented nature of water research and innovation in the UK can evolve a more co-ordinated and aligned approach where organisations work in partnership in the UK and with international organisations to tackle the challenges. The UKWRIP has been formed to develop a vision, high level goals and a framework for research and innovation as a first step to developing a more strategic approach to UK water research and innovation.

3.1 UK Water Research and Innovation Partnership

The Government Chief Scientific Adviser (GCSA) hosted two stakeholder meetings in November, 2010 and January, 2011 with separate sessions for the UK industry and overseas development stakeholders convened by LWEC², and UKCDS³ respectively. The Water Research and Innovation Partnership (UKWRIP) was then formally established in mid-2011.⁴

The **aims** are to:

- Convene the key UK stakeholders and representatives from linked initiatives concerned with UK and global water security to work together to achieve common goals;
- Develop a UK water research and innovation strategy with a clear vision, activities and deliverables;
- Build on and enhance UK capability in science and engineering in this area which has a high international status and is the foundation of innovation;
- Strengthen and build bridges between academic communities, policy, business and society across the world to maximise knowledge exchange, develop solutions and optimise business growth;
- Provide an international context to the challenges the UK faces so that the UK can contribute to the evidence base to help address both national and international policy goals; and
- Provide, for the first time, an overarching framework and mechanism to commission, prioritise and deliver water research and innovation across the UK.

²The Living With Environmental Change Partnership (LWEC) was launched in 2008 with the specific function of enabling research in areas of society or the economy likely to be affected by environmental change including those linked to population growth.

³ The UK Collaborative on Development Science (UKCDS) was formed to facilitate similar activity in the specific field of development sciences, an area of endeavour that is inherently multi-disciplinary

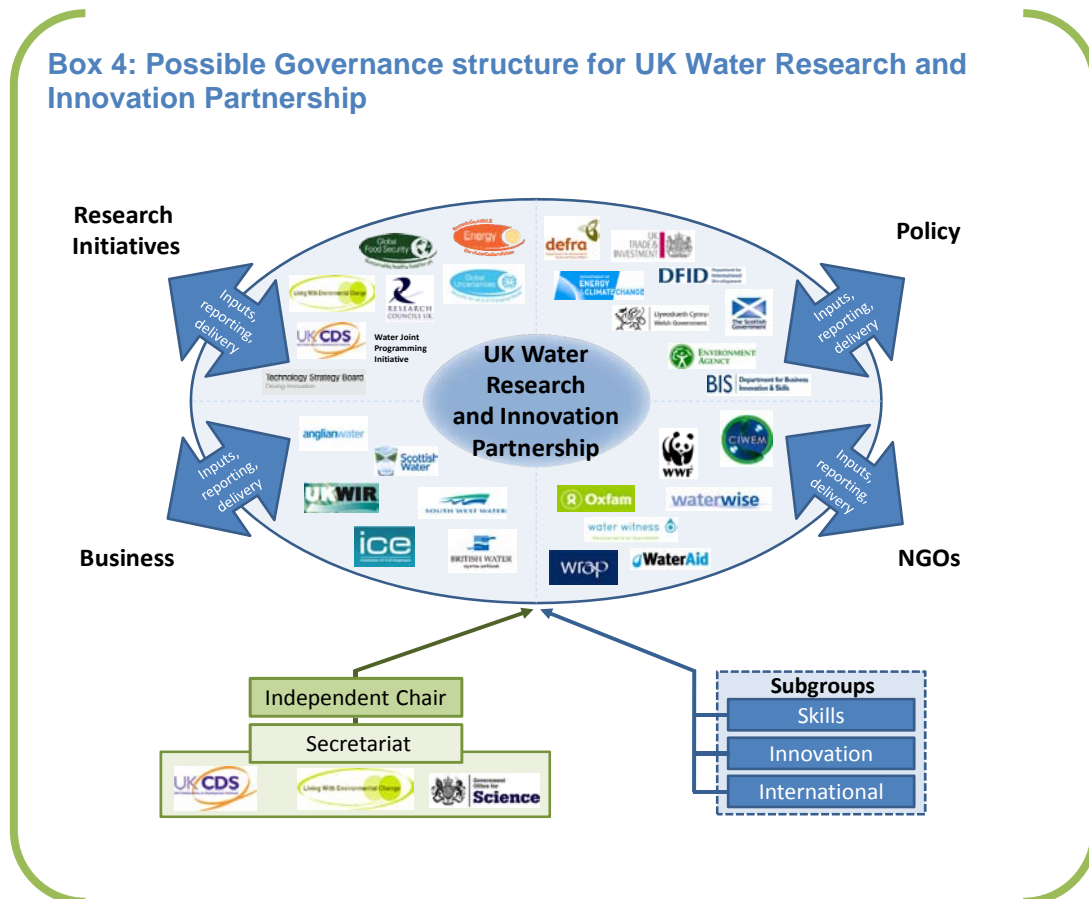
⁴ Facilitated by a joint LWEC, UKCDS, and GO-Science secretariat.

The **objectives** are to:

- **Help balance demands, expectations and well-being of people** with those of the natural systems on which water supplies and other benefits depend;
- **Identify deliverables and activities** that take into account EU and international activity to address challenges at a UK and global level feeding into policy aims across departments to better address both national and international goals;
- **Find innovative approaches** that can address the scale and complexity of the challenges with longer-term, more transformative thinking, beyond the time horizons of some current stakeholders;
- **Develop critical mass for knowledge exchange**, by establishing effective networks of researchers, funders, policy makers and industry so that different parties are clear as to where their capabilities and priorities fit into the UK Strategy;
- **Provide knowledge and foresight on changing pressures** caused by climate, population, food, energy, political instability and changing economic conditions to enable policy and business to develop road maps that optimises the economic and technical management of the water value chain;
- **Develop tools and an integrated evidence base** so that water related policy, and the choices individuals and businesses make about water can benefit from a research informed dialogue about its sustainable supply and use;
- **Facilitate the translation of knowledge, foresight and tools** into use by stakeholders through existing delivery mechanisms and co-ordinating engagement with all stakeholders and the public so that research and evidence based activities can be deployed to meet national and international needs;
- **Promote innovation and business development**, within the UK water supply chain, at home and abroad;
- **Strengthen the evidence base that helps the UK fulfil its obligations under current and future national and European legislation and international commitments** including the EU legislation, Water Framework Directive, Habitats Directive and Nitrates Directive, and the Millennium Development Goals;
- **Reduce or eliminate duplicated or wasted research effort** that might otherwise arise as a consequence of the evolving complexity of water-related research and evidence-gathering activities;
- **Work towards maintaining appropriate research facilities and databases** since these provide the seeds of innovation and a strong evidence base for policy and business decisions;
- **Review skills and evidence needed to deliver integrated water research** in the UK;
- **Review priorities and needs against ongoing research activities and evidence** so that the Strategy can be evaluated and refreshed over time; and
- **Stimulate the Green Economy** through research and evidence informed innovation.

UKWRIP will operate as an open partnership, with membership by invitation from the independent Chair (Box 4). UKWRIP will be facilitated by a dedicated secretariat, led by LWEC, supported by UKCDS and the UK Government Office of Science.

UKWRIP partners will represent existing research initiatives, with policy, industry and NGOs as the primary delivery agents. The partnership aims to foster engagement with broadly relevant water research and innovation challenges within and between existing initiatives and activities, bringing value and connectivity across those endeavours. The attendees to UKWRIP meetings will bring direct relevance to the national and international research agenda, and appropriate expert representation (e.g. from the research base and industry) will also be invited to contribute, as appropriate.



The Partnership will utilise dynamic sub-groups, with flexible membership and resource, to allow partners to contribute relevant expertise and resources to particular focal areas.

Two issues on which the UKWRIP members have focused early attention, have been the impact of the regulatory cycle on the employment opportunities for water experts and the lack of appreciation of the opportunities for innovation in the water sector. Therefore, two multi-stakeholder working parties, chaired by representatives from business and professional bodies, have explored: a) whether the UK skills base in water research and innovation is secure and of sufficient size; and b) whether there is a need for more direct and transparent links between research and innovation in water.

Outcomes from the initial meetings of the working groups on skills and innovation have been:

- *Skills* - a methodology with which to capture the UK water relevant capacity and skills across academia, the private sector and the NGO community. A thematic matrix was developed to be used in conjunction with complementary analyses on public and private sector needs in water to assess capability of the UK in addressing internationally important water security challenges.
- *Innovation* - a series of high level recommendations to help steer innovation priorities for the collaborative water framework. These include:
 - Enhance the understanding of the existing innovation landscape by mapping past, existing and future innovation driven initiatives to provide a foundation on which to base coherent future actions, and identify examples of good practice.
 - Ensure visibility and maximum impact of mechanisms that highlight research opportunities at home and abroad. Analysis of the mechanisms that draw attention to possible funding opportunities for research stakeholders, and evaluation of their scope and sphere of influence.
 - Ensure potential research users - government policy-makers, NGOs and the private sector - are at the centre of defining strategy, as well as development and implementation of research.

Developing priorities for innovation in water will be a major task. One way to achieve this might be to establish groups to consider topics areas and specific innovation, and the knowledge needed to support work on innovation. Another approach is to consider separately, the application and use of new and existing technologies, and the development of new technologies for particular areas.

The uptake of new and existing technologies might be enhanced by outputs such as:

- Educational / society engagement programmes;
- Integrated catchment resource management (i.e. agricultural sector and water sector working more collaboratively);
- Integrated regional planning to facilitate the incremental adoption of appropriate technologies (i.e. focus on regionally sensitive areas and coordinated gradual adoption in new developments, urban renewal schemes etc);
- Adoption of a long term strategy in target urban areas for separation of foul and storm sewers;
- Water storage systems in both rural and urban areas to accommodate seasonal rainfall and river flow;
- Cross-catchment water management; and
- New policy approaches and decision making frameworks.

Whereas in cases where new technologies need to be developed, close working with sectors other than the water sector may stimulate innovation. Such areas would include:

- Innovation in building design for lower water and carbon footprint, rainwater harvesting and water reuse within the building;
- Innovation in low energy use treatment, distribution, waste treatment;
- Innovation in low water use agricultural practices (drip irrigation etc);
- Exploring novel markets / incentives to promote innovation; and
- Approaches to revealing the value of different types of water.

The UKWRIP is now developing an international development subgroup that will assist in developing a focus on water research and innovation that helps to achieve the UK's commitments in the development agenda. Proposed Terms of Reference for this group are provided in Box 5:

Box 5: Aims of International Development Sub-Group

The aim will be to discuss opportunities for UK research and innovation stakeholders to contribute to the wider challenges around water and international development, by considering the:

- water challenges and research needs facing developing countries;
- areas in which the UK research and innovation community can add most value on water and international development;
- existing UK research and innovation landscape and the remit of existing initiatives including the international framework;
- key research providers and user groups with a focus on the role of industry and engagement with NGOs and development practitioners;
- priority topics and/or disciplines;
- priority geographies and how these should be defined; and
- an outline methodology for a UK Water and International Development research and innovation framework involving the UK water industry, NGOs and researchers working together to deliver successful new technology-based products and services and to maximise international development outcomes.

3.2 Context and Role for Research and Innovation

The increased demand for food, energy and water from an increasing global population will need to be supplied in the face of a changing climate and a range of environmental and demographic factors. These will make more people, land and resources vulnerable to uncertainties in the availability of food and water, and the impacts of natural hazards such as major storms, floods and droughts.

Even in the UK, population growth, increased urbanisation, changing lifestyles, and an aging water storage and supply infrastructure will put pressure on water and sanitation services. The impacts of climate change and other environmental changes are likely to make any vulnerability in UK water security more acute and severe as well as urgent to deal with.

In many parts of the world, access to drinking water and water for sanitation is limited and, world-wide, as many as half of hospital beds may be filled by people suffering from water related illness⁵. Middle and low income nations often find it difficult to make progress towards those Millennium Development Goals most dependent on supplies of freshwater. In many areas, the rapid draw-down of fresh-water aquifers – mainly due to the worldwide

⁵ summary figure from <http://blueplanetnetwork.org> that provides a range of tools and approaches to collaborative water work worldwide.

increased use of wells and pumps for irrigation, domestic and industrial water supplies – has reached unsustainable levels since rates of withdrawal can exceed rates of replenishment.

Water use around the world is changing as development proceeds and economic growth lifts people out of poverty. In low-income countries agriculture is normally the dominant user of water, but as development proceeds, the demands of other sectors rise. In high income countries both municipal (encompassing domestic and commercial uses of water) and industrial (including manufacturing, energy generation and other industrial activities) demand for water is predicted to remain relatively constant or decline as water efficiency increases. However, in low or middle income countries, a rapid increase is expected, especially in municipal demand. Industrial water use is expected to peak around 2030 provided that expectations of increased efficiency and the growth of the service economy are met in these developing economies. Unless these expectations can be met then competition between different water uses globally will intensify and may have consequences for the long term sustainability of UK water security.

Efficient use and re-use of water is already a challenge for the UK, with less water available per head of population in the south-east of England than in some parts of North Africa. A large number of rivers and aquifers suffer unsustainable over-abstraction, an imbalance that needs correction to meet the terms of the EU Water Framework Directive. Significant sewage overflow still occurs from some treatment works after only moderate rainfall, a problem that must be addressed to remove risks to health and the environment. Flooding is the most damaging natural hazard the UK faces with significant social disruption and economic loss. Flooding and other high impact weather events associated with water need better management.

The UK needs integrated solutions to deal with these issues, taking account of the interfaces and interactions between the four different parts of the water system shown in Fig 1. The new abstraction regime needed for rivers in England is one example where research will be needed to determine how two subsystems must be more closely related, i.e. water resources in the ecosystems supplied by the global water cycle and the abstractions made to service the human water cycle.

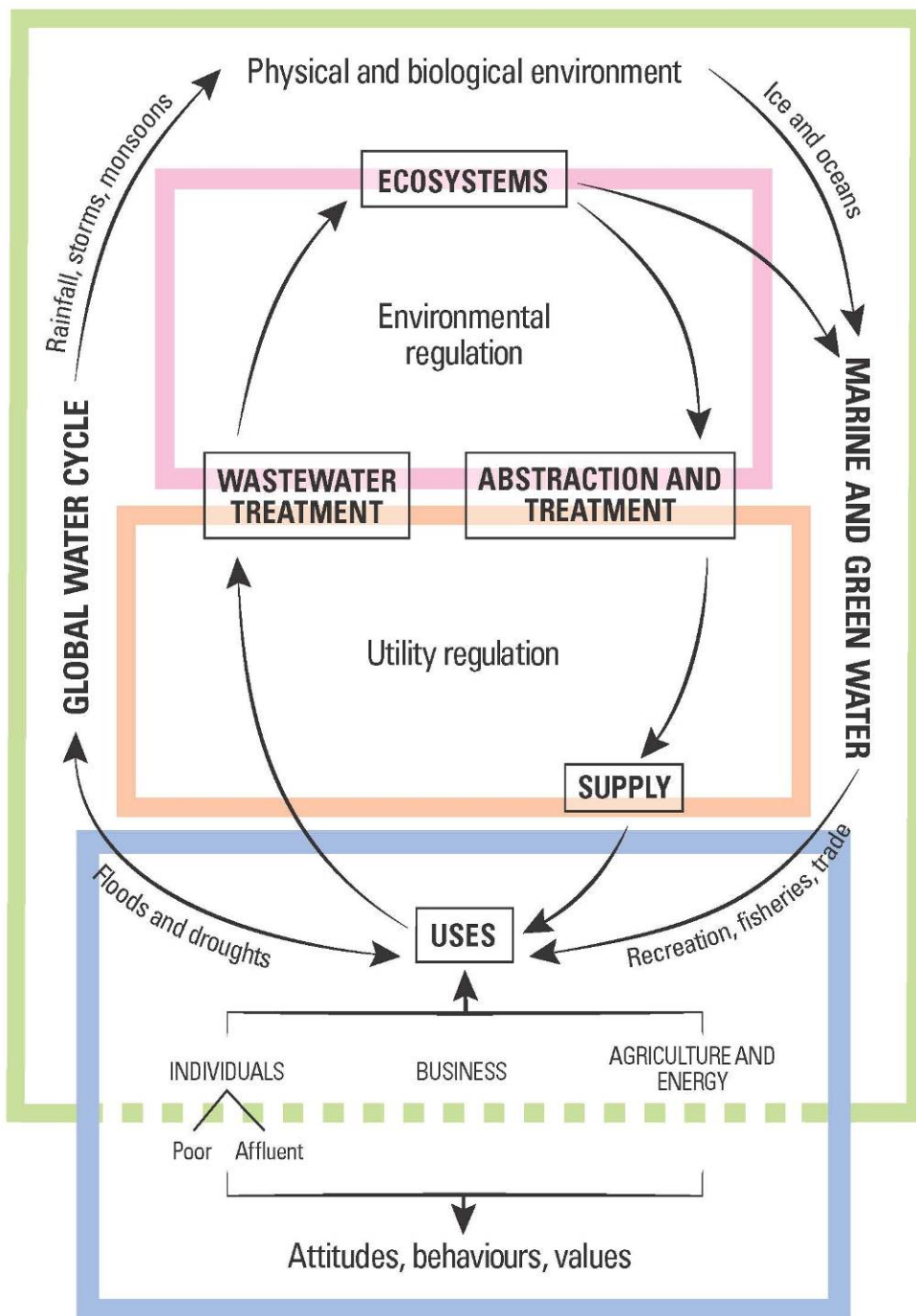


Figure 1. Human Water Cycle embedded within the Global Water Cycle. Often the four elements of the water system are thought about and managed without sufficient regard for the complete water system. Future integrated solutions need to consider (a) the dynamics of water in the global water cycle (outer green box), (b) the ecosystem components like rivers, lakes and groundwater that are the immediate sources of water and that often receive treated water and “waste” water (magenta box), (c) the interactions between ecosystems and the human water cycle (red and blue boxes) and the extent to which these interactions are influenced by local manifestations of the global cycle (e.g. floods or droughts and long term trends affected by interactions between major ecosystems and physical components of the earth system).

Prerequisites to success for UK input to global water security are the presence of a proficient and effective skills base, and a clear pathway to innovation and research priorities that will lead researchers to achieve the outcomes needed by policy, business, consumers and other groups using water. There is also a need to build on previous work and synthesise existing knowledge and expert opinion.

There have been many previous authoritative reports on water. Some of these have made findings or recommendations relevant to research and innovation. Synthesis of this rich, complex and diverse source of information was required. Thus, UKWIR, LWEC and UKCDS funded a group of water experts⁶ to review 90 national and international reports on water and water related topics. The authors have distilled the major common areas where knowledge, foresight or tools were lacking or where impact from research or innovation needed to increase (see Box 6 for the main findings from such a synthesis).

Box 6: Major research and innovation themes in recent water reports and reviews

- **Value of water** needs to be better recognised by stakeholders. It is vital to develop a value framework for water resources from an end-user and environmental ecosystems perspective, as well as encompassing the inextricable link between water and energy. Most of the UK population do not know their domestic water usage or the extent of their much larger water footprint, which includes “virtual” water embedded in food, industrial products and other services that may originate from other countries.
- **Resilience of UK water infrastructure** will need to adapt and requires better understanding. A changing climate and growing population will bring significant challenges to UK and global water infrastructure. Development of a resilient UK water infrastructure requires better understanding of societal behaviours (and their potential for change), as well as acceptable and affordable customer service levels.
- **Water-related natural hazards** including flooding from sewers, storm-water runoff, rivers, coastal surges and groundwaters are likely to have the greatest impact for domestic, industrial (and to a lesser extent, agricultural) property and occupants. Adaptation to climate change will require improved design parameters and predictive models of water availability (water scarcity) and the frequency and scale of extreme events (droughts and floods).
- **Integrated water resources management tools** are essential and must become more dynamic. Integrated river basin or water resource management frameworks should incorporate needs, inputs and outputs from the natural ecosystem, agriculture, industry and urban domestic customer. This includes setting of regulatory goals (EU Water Framework Directive), as well as monitoring and operational management of all aspects of the water cycle within a catchment.
- **Water security in low and middle income countries** needs to be addressed more rigorously, particularly in relation to the Millennium Development Goals. Water is recognised as a “fundamental human right”. Developing countries and external support agencies need to demonstrate greater political commitment to sanitation and drinking water (as well as recognising the role of water security in delivering each of the MDGs) targeting resources to accelerate progress towards meeting identified Millennium Development Goals.

As part of this analysis innovation activity maps were developed for the following topics: valuing water, resilient infrastructure, hazard risk management, integrated resource management, safe water and sanitation for all, and growing the UK water economy. These are intended to provide strategic guidance and research priorities based on reviewed documentation - an exemplar map is illustrated in Figure 2 below:

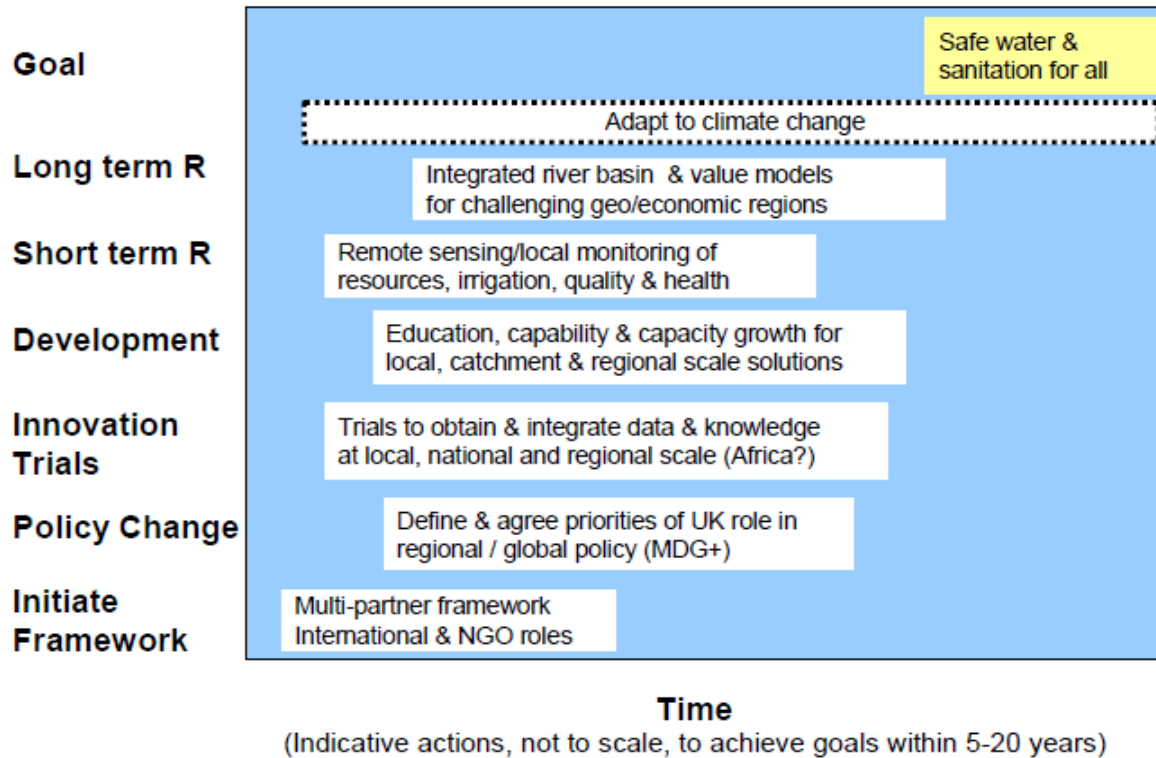


Figure 2: Innovation activity map to achieve water security: Safe water and sanitation for all (UKWIR (2011) Research and Innovation Mapping Study for the UK Water Research and Innovation Framework UKWIR Report Ref. No. 11/RG/10/6. 60pp London, UKWIR).

3.3 Priorities for UK Water Research and Innovation

Drawing on both the synthesis of earlier reports on water, and on the extensive consultations during the development of the Framework, the following priority areas for research and innovation, that should address the vision, high level goals and cross-cutting thematic areas outlined above, have been identified by the Water Research and Innovation Partnership are given in Box 7.

The actions for each of these research priorities are set out under the 15 priority areas for research and innovation within a logical framework below. Based largely on inputs from partner organisations and other key stakeholders, this indicates the priority area and associated outcomes or objectives, and the initiatives that might contribute to meeting these needs. Potential delivery bodies are also identified. This first level log frame will be a basis for discussion of which topics partnership working in research and innovation will have the most effective impact on society and/or the economy.

⁶ UKWIR (2011) Research and Innovation Mapping Study for the UK Water Research and Innovation Framework UKWIR Report Ref. No. 11/RG/10/6. 60pp London, UKWIR, often referred to informally as the Rachwal report.

Box 7: Priorities for UK Water Research and Innovation

Water Use

1. Increasing, through dialogue and educational action, public, business and policy **awareness of water cycles and systems** and how future changes in these might affect life-style and business.
2. Understanding **societal and business behaviours** in relation to efficient operation of the human water cycle and **minimising water footprints**.
3. Developing ways of **valuing water of different qualities** (including that of different salinities).

Water Infrastructure

4. **Increasing the resilience** of our water management systems, buildings, critical infrastructure, and response options – particularly to flood or drought and disaster events such as major industrial accidents.
5. Investigating the **dynamics of energy use** in the management of the human water cycle, the use of water in the energy sector and the generation of energy by the water sector to minimise, cross-sector, water and carbon footprints.

Business and the Economy

6. Developing and assessing the impact of different kinds of water markets on society business and environment.
7. Examining **novel means of regulating water markets** and the quantity and quality of water resources that provide incentives for innovation and the demonstration of new technologies.
8. Adapting business to **achieve resource efficiency in water use** throughout the supplier-customer chain by making knowledge more accessible and models and tools available.

Environment and Climate Change

9. Assessing and mitigating changes in the **quantity and quality of water resources** under different environmental change scenarios.
10. At both catchments, national and international levels, developing **integrated water resource management** so that human and natural water cycles are harmonised.
11. Assessing the **exposure of countries to water security issues** (for example, arising from impacts of the global water cycle on other countries).
12. Determining the benefits (including health benefits), people and business derive from the **ecosystem services delivered by water** and the risks they are exposed to when such services fail.

Farming and Food

13. Developing innovative ways to **adapt agricultural and fisheries systems** to use freshwater, saline water and waste water more efficiently with lower environmental impact.

Sanitation and Health

14. Helping ensure a **sustainable, equitable and affordable supply and treatment of water** for both poor and affluent people and their communities.

Box 8 - First level log frame to take UK Water Research and Innovation Framework forwards – to be progressively developed

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
Household Water Use				
1. Increasing, through dialogue and educational action, public, business and policy awareness of water cycles and systems and how future changes in these might affect life-style and business	<ul style="list-style-type: none"> Increased awareness of how life-styles and business impact upon the water cycle and water system Individual awareness of how much water they use Changing behaviours to reduce water use New approaches to education around water in schools and society 	<ul style="list-style-type: none"> LWEC UK Flood and Coastal Erosion Risk Management (FCERM) Research Strategy UKWIR: Research and Innovation Mapping Study for the UKWRIF EWP's Water Stewardship Programme EWP's European Water Awareness Programme RCUK Water Interest Group (WIG) ESRC's Flood, vulnerability and urban resilience: a real-time study of local recovery following the floods of June 2007 in Hull 	ESRC British Water Defra UK Educational entities ICE Consumer Council for Water	
2. Understanding societal and business behaviours in relation to efficient operation of the human water cycle and minimising water footprints	<ul style="list-style-type: none"> Development of robust water footprint methodologies which include embedded and virtual water Understanding of water footprints by society and business Reduce water footprints per head in the UK (including through less water wastage) Reducing household consumption of water in the UK Businesses to understand their water-related vulnerability Preventing a gap between supply and demand 	<ul style="list-style-type: none"> NERC Water Security Knowledge Exchange Programme UKWIR: Research and Innovation Mapping Study for the UKWRIF Defra's Natural Environment White Paper EWP's Water Stewardship Programme EWP's European Water Awareness Programme RCUK Water Interest Group (WIG) PML's Sea and Society theme EPSRC Sustainable Urban Environment (SUE) Programme EPSRC Sandpit 	NERC ESRC British Water Defra ICE Consumer Council for Water	

⁷ determined from consultation and synthesis of existing reports and knowledge

⁸ existing or planned programmes or activity that might meet the objectives or outcomes

⁹ bodies that might engage in dialogue on meeting outcomes

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
		Project: Transforming Water Scarcity Through Trading <ul style="list-style-type: none"> • Water Futures • NERC's UK Droughts research programme 		
3. Developing ways of valuing water of different qualities (including that of different salinities)	<ul style="list-style-type: none"> • Methods of valuing water • Assigning appropriate value to water • Development of equitable water pricing regimes • Understanding the role of water in ecosystem services and their value 	<ul style="list-style-type: none"> • NERC Water Security Knowledge Exchange Programme • UKWIR: Research and Innovation Mapping Study for the UKWRIF • EPSRC Sandpit Project: Transforming Water Scarcity Through Trading 	NERC British Water	
Water Infrastructure				
4. Increasing the resilience of our water management systems, buildings, critical infrastructure, and response options – particularly to flood and drought	<ul style="list-style-type: none"> • Resilience of the water system to extreme events • Less wastage of water (especially through leaks) • Understanding risk of extreme events – reliable and fit to purpose data and models covering physical, social, environmental and economic domains in light of changes in climate/population/urbanisation • Managing probability of extreme events – supporting design, construction, maintenance, renewal, adaptation, removal, replacement of assets and utilisation of natural features for sustainable protection • Managing consequences – establishment of extreme event resilient communities and properties • Meet requirements of the Flood and Water Management Act • Meet requirements for Sustainable Drainage Systems (SUDS) 	<ul style="list-style-type: none"> • NERC Water Security Knowledge Exchange Programme • Water Challenges for a Changing World • Joint Programming Initiative • Anglian Water's Strategic Direction Strategy 2010-2035 • LWEC UK Flood and Coastal Erosion Risk Management (FCERM) Research Strategy • UKWIR: Research and Innovation Mapping Study for the UKWRIF • Belmont Forum – Freshwater Security • Belmont Forum – Coastal Vulnerabilities • NERC's Flooding from intense rainfall research programme • NERC's UK Droughts research programme • NERC's Changing Water Cycle research programme • NERC/Met Office's Joint Weather and 	NERC EPSRC TSB British Water EPSRC Defra IWA ICE EA SEPA Met Office UKWIR Association of British Insurers (ABI) Construction Industry Research and Information Association (CIRA) Coastal	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
		Climate Research Programme <ul style="list-style-type: none"> • NERC's Storm Risk Mitigation research programme • RCUK Water Interest Group (WIG) • Global Framework for Climate Services • Joint Programme Initiative on Connecting Climate Knowledge for Europe • Defra Multi-Objective Flood Management Demonstration project • EA Flood Risk and Coastal Management (FRCM) Policy Group • Willis Research Network • EWP's Climate Change Adaptation Programme • NERC's Next Generation Weather and Climate Prediction Systems • EPSRC Project: A Risk Based Design of Water Distribution Systems under Uncertainty • EPSRC Project: Assessing Current State of Buried Sewer Systems and Their Remaining Safe Life • EPSRC Strategic Partnership Project: NEPTUNE • Flood Risk Management Research Consortium (FRMRC) • EPSRC Project: General Unifying Concepts for Wastewater Treatment Plant Design • EPSRC Industrial Doctorate Centre: Skills Technology, Research and Management 	Authorities CIWEM Royal Meteorological Society Emergency Planning Society British Hydrological Society MMO DECC	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
		<p>(STREAM) for the UK Water Sector</p> <ul style="list-style-type: none"> • EPSRC Project: Mapping the Underworld • EPSRC Challenging Engineering Fellowship: Pipe Dreams • EPSRC Platform Grant: Earth Systems Engineering • EPSRC Project: Real Time Monitoring and Early Warning of Failure of Potable Water Using Novel Fluorescence Spectroscopy Instrumentation • EPSRC Project: Simplified Dual Drainage Modelling for Flood Risk Assessment in Urban Areas • EPSRC Sandpit Project: A Global Solution to Protect Water by Transforming Waste • EPSRC Project: Contaminant Ingress into Distribution Systems • EPSRC Project: The Use of Probabilistic Climate Scenarios in Decision Making for Adaptation of Building and Property Drainage • EPSRC Project: ARCC-Water 		
<p>5. Investigating the dynamics of energy use in the management of the human water cycle, the use of water in the energy sector and the generation of energy by the water sector to minimise, cross-sector, water and carbon footprints</p>	<ul style="list-style-type: none"> • Optimising the water-energy system • Reducing energy sector water footprints • Reducing the energy sector carbon footprint • Understanding the water vulnerabilities in the energy sector • Low carbon technology for the energy sector • Increase water recycling and re-use 	<ul style="list-style-type: none"> • Anglian Water's Strategic Direction Strategy 2010-2035 • Netherlands Water Partnership (NWP) • UKWIR: Research and Innovation Mapping Study for the UKWRIF • EPSRC Sandpit Project: Bio-desalination: from Cell to Tap • EPSRC Strategic Partnership Project: NEPTUNE • EPSRC Project: 	<p>EPSRC</p> <p>Defra</p> <p>Ofwat</p> <p>DECC</p> <p>UKWIR</p>	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
		Deploying Synthetic Biology in the Water Industry <ul style="list-style-type: none"> • EPSRC Project: General Unifying Concepts for Wastewater Treatment Plant Design • EPSRC Industrial Doctorate Centre: Skills Technology, Research and Management (STREAM) for the UK Water Sector • EPSRC Platform Grant: Pennine Water Group • EPSRC Platform Grant: Earth Systems Engineering • EPSRC Project: Predicting the Acclimatisation of Microbial Wastewater Treatment Communities • EPSRC Project: Real Time Monitoring and Early Warning of Failure of Potable Water Using Novel Fluorescence Spectroscopy Instrumentation 		
Business and the Economy				
6. Developing and assessing the impact of different kinds of water markets on society, business and environment	<ul style="list-style-type: none"> • A modern, sustainable, efficient, effective and risk-based regulatory system which addresses rising demand, pollution and climate change • Reduced water footprints for society and business related to the water markets • A sustainable water market 	<ul style="list-style-type: none"> • Water Challenges for a Changing World • Joint Programming Initiative • Defra's Water Availability and Quality (WAAQ) programme • UKWIR: Research and Innovation Mapping Study for the UKWRIF • Executive MBA Program Water Specialization • EPSRC Sandpit Project: Transforming Water Scarcity Through Trading 	TSB Defra NERC British Water UKWIR ESRC Ofwat EA ICE Water UK	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
			ESRC	
7. Examining novel means of regulating water markets and the quantity and quality of water resources that provide incentives for innovation and the demonstration of new technologies	<ul style="list-style-type: none"> • A modern, sustainable, efficient, effective and risk-based regulatory system which addresses rising demand, pollution and climate change with appropriate competition which allows for innovation and development of technologies, and where long term planning takes place alongside a drive for short-term efficiency savings • Low carbon innovations/new technologies which reduce water use 	<ul style="list-style-type: none"> • Defra's Water Availability and Quality (WAAQ) programme • Netherlands Water Partnership (NWP) • Anglian Water's Strategic Direction Strategy 2010-2035 • EWP's Innowater • Eureka Cluster (Acqueau) • EWP's European Water House • Executive MBA Program Water Specialization • EPSRC Sandpit Project: Transforming Water Scarcity Through Trading 	TSB Defra Ofwat Water UK UKWIR	
8. Adapting business to achieve resource efficiency in water use throughout the supplier-customer chain by making knowledge more accessible and models and tools available	<ul style="list-style-type: none"> • Less wastage of water • Understanding of industrial water footprint and risk management • More 'joined-up' water system • Awareness by customer of supply chain water footprint • Increase water recycling and re-use • Low carbon innovations/new technologies which reduce water use 	<ul style="list-style-type: none"> • NERC Water Security Knowledge Exchange Programme • UKWIR: Research and Innovation Mapping Study for the UKWRIF • Netherlands Water Partnership (NWP) • Anglian Water's Strategic Direction Strategy 2010-2035 • EWP's Innowater • Eureka Cluster (Acqueau) • EWP's European Water House • EU's STREAM project • RCUK Water Interest Group (WIG) – Research Showcase 	NERC Defra	
Environment and Climate Change				
9. Assessing and mitigating changes in the quantity and quality of water resources under different environmental change scenarios	<ul style="list-style-type: none"> • Focus on all types of water bodies, integrate land and water management • Improve understanding of the character of water bodies • Improve understanding of the relationship between multiple pressures and impacts 	<ul style="list-style-type: none"> • NERC Water Security Knowledge Exchange Programme • Water Challenges for a Changing World • Joint Programming Initiative • TSB's Sustainable 	NERC TSB EA Defra LWEC	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
	<ul style="list-style-type: none"> • Increased resilience of water supply under environmental change • Cost-effective land management options which have effective impacts on water quantity and quality and protect and improve the environment • Resilient ecology of catchments under environmental change • Restore and protect nature of all water bodies • Cost-effective management options for macronutrients in urban and rural systems which protect and improve the environment • Cost-effective management options for adaptation and mitigation • Cost-effective management options for chemical and biological pollution events (including reduction of diffuse pollution) which protect and improve the environment • Inform decision making for abstractions, demand management, and license review to produce a cost-effective sustainable abstraction regime which protects and enhances water environments • Develop environmental flow indicators which support abstraction management • Improvement (through remediation and protection of all water environments and water resources (including marine and groundwater) • Models to predict levels of rainfall and river flow • Provide scientific understanding, tools and approaches to meet standards/measures for: WFD (all surface waters at good status by 2015); Bathing Water Directive; Nitrate Directive; Flood & Water Management Act 2010 (including Sustainable Urban Drainage SUDS); Water Act 2003; Water Industry Act 1991; Water Resources Act 1991; Groundwater 	<p>Agriculture and Food Innovation Platform (addressing the challenge of run-off)</p> <ul style="list-style-type: none"> • Defra's Water White Paper • LWEC Resources Challenge • EA's Integrated Catchment Science (ICS) programme • Defra's Water Availability and Quality (WAAQ) programme • PML's Observing marine life • RCUK Water Interest Group (WIG) • NERC's Virtual observatory for water and catchment data • NERC's Ocean Acidification research programme • NERC's Macronutrient Cycle research programme • NERC's UK Droughts research programme • BGS/CEH led soil-water initiative • Scottish and Northern Ireland Forum for Environmental Research (SNIFFER) • Foundation for Water Research (FWR) • Pennine Water Group (PWG) • UK Groundwater Forum • HYDRA – Hydro-sciences Research Association <p>NOC's Coastal Processes Research Group</p> <ul style="list-style-type: none"> • RCUK Water Interest Group (WIG) • NOC's Ocean Biogeochemistry & Ecosystems (OBE) 	<p>OFWAT</p> <p>UKWIR</p> <p>Natural England CEFAS</p> <p>UKTAG</p> <p>CEH</p> <p>BGS</p> <p>Wallingford Hydrosolutions</p> <p>DWI</p> <p>Water Companies</p> <p>FC</p> <p>SEPA</p> <p>NI EA</p> <p>ADAS</p> <p>SNIFFER</p> <p>WG</p> <p>CCW</p> <p>NE</p> <p>MMO</p> <p>River Trusts</p>	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
	Directive; Priority Substances Directive; Freshwater Fish Directive; Shellfish Waters Directive; Urban Waste Water Directive; Sewage Sludge Directive; Habitats Directive; Soils Directive; Waste Directive; and Marine Framework Directive	Research Group <ul style="list-style-type: none"> • PML's Sea and Society theme • PML's Marine Life Supports Systems theme • Flood Risk Management Research Consortium (FRMRC) • EPSRC Platform Grant: Earth Systems Engineering • EPSRC Project: Simplified Dual Drainage Modelling for Flood Risk Assessment in Urban Areas • EPSRC Project: URSULA • EPSRC Project: ARCC-Water 		
10. At both catchment and UK levels, developing integrated water resource management so that human and natural water cycles are harmonised	<ul style="list-style-type: none"> • Manage catchments in a more integrated, efficient and cost-effective way • Incorporated adaptation strategies • Strengthen the scientific evidence base, provide analysis and visualisation tools and decision support systems for integrated solutions for the management of water resources • Deliver sustainable improvements to those who live in this environment • Reducing water footprint per head in the UK • Resilience of the water system to extreme events • Optimising the water-food-energy system • Help protect and enhance the environment and ecosystem services • Improve the operational delivery of our statutory objectives • Better catchment planning with clear objectives and priorities, focussed on integrating land and water management to promote sustainable development • Ensure sustainable delivery 	<ul style="list-style-type: none"> • EA's Integrated Catchment Science (ICS) programme • Belmont Forum – Freshwater Security • United Utilities Sustainable Catchment Management Programme (SCaMP) • Defra/ EA Demonstration Test Catchments Research Platform • RCUK Water Interest Group (WIG) • NERC's Virtual observatory for water and catchment data • NERC's UK Droughts research programme • BGS/CEH led soil-water initiative • Scottish and Northern Ireland Forum for Environmental Research (SNIFFER) • Foundation for Water Research 	Global water partnership EA SEPA DFID CIWEM ICE NERC Defra NE River Trusts	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
	of secure water supplies and promote sustainable use of water resources	(FWR) <ul style="list-style-type: none"> • Pennine Water Group (PWG) • UK Groundwater Forum • HYDRA - Hydrosciences Research Association NOC's Coastal Processes Research Group <ul style="list-style-type: none"> • PML's Sea and Society theme • EPSRC Project: A Risk Based Design of Water Distribution Systems under Uncertainty • EPSRC Strategic Partnership Project: NEPTUNE • Flood Risk Management Research Consortium (FRMRC) • EPSRC Platform Grant: Earth Systems Engineering • EPSRC Project: Simplified Dual Drainage Modelling for Flood Risk Assessment in Urban Areas • EPSRC Project: The Use of Probabilistic Climate Scenarios in Decision Making for Adaptation of Building and Property Drainage • EPSRC Project: URSULA 		
11. Assessing the exposure of countries to water security issues (e.g. arising from impacts of the global water cycle on other countries)	<ul style="list-style-type: none"> • Preventing a gap between supply and demand • Businesses, investors, regulators and government agencies to understand their water-related vulnerability 	<ul style="list-style-type: none"> • NERC Water Security Knowledge Exchange Programme • Belmont Forum – Freshwater Security • UKWIR: Research and Innovation Mapping Study for the UKWRIF • NERC's UK Droughts research programme 	NERC	
12. Determining the benefits	<ul style="list-style-type: none"> • Understanding the role of water in ecosystem 	<ul style="list-style-type: none"> • NERC Water Security Knowledge 	NERC	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
(including health benefits), people and business derive from the ecosystem services delivered by water and the risks they are exposed to when such services fail	<p>services and their value including the economic costs of allowing deterioration</p> <ul style="list-style-type: none"> • Methods and tools for valuing ecosystem services for all water (including rivers, streams, lakes, ponds, groundwater, coastal waters) • Maximising and sustaining ecosystems services 	<p>Exchange Programme</p> <ul style="list-style-type: none"> • LWEC Resources Challenge • UK National Ecosystem Assessment (UK-NEA) • Defra's Natural Environment White Paper • Belmont Forum – Ecosystem Services • DFID/NERC/ESRC Ecosystem Services for Poverty Alleviation research programme • NERC's UK Droughts research programme 	<p>Defra</p> <p>EA</p>	
Farming and Food				
13. Developing innovative ways to adapt agricultural and fisheries systems to use freshwater, saline water and waste water more efficiently with lower environmental impact	<ul style="list-style-type: none"> • Reduced water use in agriculture • Less water pollution, improved biodiversity, more resilient system • Maximising and sustaining ecosystems services • Optimising the water-food system • Increased productivity to meet population needs • Sustainable, secure and healthy food supplies • Support British farming and UK fisheries • Implement a new marine licensing regime that is easier for everyone to use with clearer, simpler and quicker licensing decisions which protect the environment and biodiversity • Increase water recycling and re-use 	<ul style="list-style-type: none"> • Water Challenges for a Changing World • Joint Programming Initiative • LWEC Resource Challenge • Foresight Project on Global Food and • Farming Futures. Synthesis Report C2: Changing pressures on food production systems • PML's Algal bloom early warning system • EWP's Desiras • PML's Marine Life Supports Systems theme • The Rural Economy and Land Use programme funded by ESRC, BBSRC and NERC 	<p>BBSRC</p> <p>NERC</p> <p>TSB</p> <p>NFU</p> <p>Defra</p> <p>EA</p> <p>NE</p> <p>MMO</p> <p>CEFAS</p> <p>FERA</p>	
Sanitation and Health				
14. Helping ensure a sustainable, equitable and affordable supply and treatment of water for both poor	<ul style="list-style-type: none"> • Increased access to clean drinking water and sanitation whatever the prevailing circumstance • Reducing domestic water demand per head in the UK • Appropriate low carbon 	<ul style="list-style-type: none"> • Water Challenges for a Changing World • Joint Programming Initiative • Defra's Drinking Water Quality and 	<p>TSB</p> <p>DFID</p> <p>UKCDS</p>	

Priority for research or innovation ⁷	Objective/Outcome wanted	Action/ Mechanisms ⁸	Potential Delivery partners ⁹	Potential Timing
and affluent people and their communities	technology <ul style="list-style-type: none"> • Meet regulations for the EC Drinking Water Directive • Implement fair, affordable and cost reflective water charges that incentivise environmentally responsible behaviour while protecting vulnerable groups • Ensure new risks to drinking water quality are identified and assessed and where appropriate to develop national standards or guidance to protect drinking water quality and consequently public health • Meet Millennium Development Goals 	Health (DWQH) programme <ul style="list-style-type: none"> • Anglian Water's Strategic Direction Strategy 2010-2035 • UKWIR: Research and Innovation Mapping Study for the UKWRIF • World Bank - Water • The Organisation for Economic Co-operation and Development (OECD) • EC's Water supply and sanitation technology platform (WssTP) • World Health Organisation Water Sanitation Health • EPSRC Project: Water Quality Measurement in Regions of Poor Sanitation 	OFWAT EPSRC CIWEM WHO DFID HPA EA Defra UKWIR Drinking Water Inspectorate, sponsored by Water, Floods, Environmental Risks & Regulation Directorate (WaFERR) WG DWI Water UK	
15. Controlling water borne diseases	<ul style="list-style-type: none"> • Reduce number of hospitalised people from water borne diseases • Reduce number of deaths from water borne diseases • Surveillance and prevention of outbreaks of water borne disease 	<ul style="list-style-type: none"> • EA's Integrated Catchment Science (ICS) programme • World Health Organisation Water Sanitation Health • UKWIR: Research and Innovation Mapping Study for the UKWRIF • EPSRC Challenging Engineering Fellowship: Pipe Dreams 	British Water MRC WHO DFID HPA Wellcome Trust	

3.4 Harnessing Existing and New Initiatives

Improved co-ordination of water research and innovation requires not just the simple transfer of knowledge between related sectors but, more fundamentally, placing research in a wider context. There are clear benefits of a more holistic and integrated approach including to:

- **support joined up, evidence based policies and delivery of coherent outcomes** (e.g. economic growth, mitigation of the climate change and its impacts) by developing a stronger and more coherent evidence base to tackle system and interface issues; and avoiding policies/interventions that could impact detrimentally in other areas;
- **promote the development of a research base** providing the multidisciplinary evidence needed to support more coherent policy/innovation; and improving the effectiveness and value of horizon scanning, in identifying emerging scientific, technical, market, regulatory and other issues;
- **make more efficient use of overall resources** – both within and between public, private and third sector funders, and in the research base; to address research gaps and avoid overlaps, while reducing the risk of duplication;
- **build a more integrated community of researchers and users** extending across disciplines, organisations and sectors; which facilitates shared views and strategies – e.g. on institutional aspects of innovation and the continuum of research (from basic to applied) and the infrastructure requirements;
- **identify opportunities to capitalise on the UK's infrastructure and capacity** to improve buy-in and exploitation of research and provide a platform for closer collaboration with the private and third sector, to maximise global impact and influence of UK research and UK research agencies;
- **provide a more coherent UK approach linking research priorities and outcomes** to the EU water security agenda, international development agenda, G8 commitments and Millennium Development Goals.

3.4.1 UK

The UKWRIP aims to provide a facilitative framework within which to strengthen collaboration in areas where there is added value for this approach. There is already much good practice on which to build, with examples including:

- **Water Stakeholder Forum** - The emerging Environment Agency/Defra water initiative currently being discussed with UKWRIP partners and other water stakeholders.
- **UK Flood and Coastal Erosion Risk Management (FCERM) Research Strategy** - commissioning a new programme on flood risk and mitigation and adaptation, including development of real time flood management models to deliver reduced costs of flooding to the UK's government, population and local authorities by understanding the true cost of flooding and value of flood alleviation and management, and filling knowledge gaps (for example, soil water dynamics are a key missing link in the ability to predict flood risk).

- **Innovation in Water** - a Technology Strategy Board (TSB) led competition to allow the transfer of research into the product development cycle of the UK water sector, addressing the lack of innovation identified by the Cave Review, through establishment of close relationships with industry to de-risk the process and produce financially viable solutions to strategic problems in the water sector.
- **Water Security Knowledge Exchange Programme** – a NERC funded programme to build links between business and research, and improve links between research and innovation.
- **Water Innovation Leadership Group** – established by Defra, Ofwat, and the Technology Strategy Board to stimulate closer working partnerships across the water sector with strong linkages to the Environment Agency and the Drinking Water Inspectorate.
- **RCUK Water Interest Group** - to consider forthcoming research strategies and the renewal of a range of research priorities across the Research Councils.
- **Engineering and Water** – an EPSRC activity to shape future research in water in the engineering and physical sciences domain and stimulate new collaborations.
- **Living with Environmental Change** - to better integrate existing programmes with delivery agencies and policy teams.

3.4.2 European Union

A recent major new EU research funder's initiative is the Joint Programme Initiative on 'Water Challenges for a Changing World' that is led by Spain.

The vision document sets out the challenge of *“Achieving sustainable water systems for a sustainable economy in Europe and Abroad.”* Whilst the research agenda is currently under development the specific challenges that have been identified include:

- Bio-based economy: prevention of the negative effects of the bio-based economy on the water system;
- Sustainable Ecosystems: Searching for sustainable balance of ecosystem services;
- Healthier water systems for a healthier society: managing threats to water quality and societal wellbeing from new contaminants such as viruses and hormones; and
- Closing the water cycle – closed water systems in arid regions.

To most effectively contribute to this agenda a highly coherent and well-joined up UK research and innovation community is necessary. Current reporting from the JPI progress can be found at http://www.era.gv.at/attach/WaterJPI_Maturity_Template20110420.pdf.

3.4.3 Wider International Opportunities

International Research: The Belmont Forum

The Belmont Forum are major funders from UK, USA, France, Germany, Australia, Brazil, India, and China committed to ensuring greater alignment of future international research agendas and to add value through collaboration. The forum is scoping opportunities for an international Collaborative Research Action (CRA) on both Coastal Vulnerability and Freshwaters.

International Development: Department for International Development

The Department for International Development (DFID) Research & Evidence Division (RED) is developing a pipeline of research in water security in consultation with low and middle income countries, other development partners and the research community active on water security, including those based in the UK. Many of these players are already involved in existing international networks focussing on this area (e.g. Global Water Partnership, EU Water Initiative, etc.). Any new water security research portfolio will probably address critical research questions at multiple levels; from the basin and national level, to communities and households - and could focus on three areas: water security and water supply services; growth and climate change; agriculture and food security. RED is also strengthening its capacity in this area by recruiting a new water research adviser, whose focus will be on water security.

International business: UK Trade and Investment

UKTI Strategy

UK Trade & Investment's (UKTI's) new strategy, 'Britain open for Business' launched in May 2011, is at the heart of the Government's drive to promote growth through trade and investment. The strategy lays out four pathways to balanced growth:

- Targeting services at innovative and high growth SMEs to encourage more companies to export, and help existing exporters reach more high growth and emerging markets;
- Winning high value opportunities in overseas markets for UK businesses of all sizes;
- Delivering high quality inward investment, with a drive to market large British infrastructure and regeneration projects to foreign investors;
- Building strategic relationships at the highest levels with the most significant inward investors, including overseas institutions such as Sovereign Wealth Funds, and with the UK's top exporters and major overseas buyers.

Included in the UKTI strategy are a range of actions to help secure a strong, sustainable and open economy that benefits business both domestically and internationally: strengthening the multilateral trading system, enabling low and middle income countries to benefit from trade and investment; maximising and realising the opportunities for UK businesses to trade and invest. To help achieve this, UKTI works collaboratively across government. UKTI, with its partners', aims to support UK companies and organisations to realise export potential.

Delivery of support is based on consideration of a number of external factors:

- UK Government and other Governments around the world are committed to tackling environmental challenges particularly within the context of addressing climate change and carbon reduction. Many countries have committed to environmental investment in economic stimulus packages;
- The UK's dynamic business environment fosters innovation and collaboration which places the UK in a good position to help global markets /countries address challenges such as climate change adaptation and mitigation. Building on its rich history of invention, entrepreneurship and academic excellence, UK innovation is driving green and low carbon solutions for a new greener low carbon world.
- The current global economic downturn creates additional challenges including a need for Governments in particular to reinforce efforts to promote environmental solutions in terms of their contribution to business competitiveness and to help businesses respond to the opportunities on the other side of the downturn. Smaller businesses which predominate in this sector are likely, given the current exchange rate situation, to seek growth through international markets supported by recent UK Government schemes specifically structured for SMEs;
- The UK has a global reputation for world-leading capabilities and outstanding solutions and services in the water sector. Its unique combination of traditional industrial expertise and scientific excellence with strong, innovative approaches to technology, policy and regulation has ensured a global competitive advantage;
- International opportunities are significant. However other countries share the UK's capacity to exploit the future potential of the global opportunities. The UK needs to ensure it retains its position at the forefront of water research and innovation, and that UK companies and organisations realise their full potential in both domestic and international markets.

UK Water Sector's Unique Selling Position

The UK water sector's Unique Selling Position is the capability to offer a business model which includes privatised water services, strong regulation and respect for environment and social needs.

The UK's water management and planning successes in world markets are recognised globally. The UK has capability and capacity in reducing carbon footprints, lowering water consumption, water re-use, leakage control, sewers and pipe repair, environmental factors, managing water wisely, and a range of conservation practices.

The UK is well placed to share its skills and knowledge with the rest of the world. UK companies involved with the water sector such as utilities, contractors, consultants, equipment manufacturers, lawyers and financiers, have a long history of working successfully in world markets and between them generate over £3bn of business annually overseas. They will continue actively to seek opportunities abroad and are keen to play their part to help the global community meet the UN's Sustainable Development Targets for water.

From an inward investment perspective, most of the interest in the sector comes from the water recycling technologies and more recently in the effluent treatment plant which can utilise the waste material to produce energy through various methods.

Annex 1 – Sample of Existing Water Initiatives

Anglian Water's Strategic Direction Strategy 2010-2035

This report outlines the strategy that Anglian Water will adopt for the next 25 years to ensure that they deliver a reliable supply of safe, clean water and effective wastewater services to customers. It includes details of innovation required in the water industry.

<http://www.anglianwater.co.uk/assets/media/strategic-direction-statement.pdf>

Belmont Forum

The Belmont Forum is a high level group of the world's major and emerging funders of global environmental change research and international science councils.

Since its establishment in 2009, the Belmont Forum has developed a collective 'funders' vision of the priorities for global environmental change research needed to accelerate the provision of this knowledge. This vision is articulated as the "Belmont Challenge": To deliver knowledge needed for action to mitigate and adapt to detrimental environmental change including extreme hazardous events. With priority foci are **Coastal Vulnerability**; **Freshwater Security**; **Ecosystem Services**; Carbon Budgets; and Most Vulnerable Societies.

The Belmont Forum funding agencies are collaborating to plan three new 'pilot' actions. These will provide opportunities for the international research and innovation community to add value to existing investments of national funding agencies, by forming innovative international and trans-disciplinary partnerships to address sustainability challenges. These actions will focus on: **Freshwater Security**; **Coastal Vulnerability**; and A 'bottom-up' Belmont Forum International Opportunities Fund.

<http://igfagcr.org/index.php/belmont-forum>

Defra Multi-Objective Flood project

The social, economic and environmental costs of flooding are significant and increasing. With this in mind, the Defra Multi-Objective Flood Management Demonstration Project hopes to provide robust catchment scale evidence of the influence of land management change on flood risk. Driven by Defra and supported by the Environment Agency and National Trust, the project hopes to demonstrate that by looking at whole catchments and strategically targeting shifts in agricultural practice, sustainable, cost-effective support to flood management may be achieved.

<http://www.pennyanderson.com/case-studies/defra-multi-objective-flood-management-demonstration-project>

Defra/ EA Demonstration Test Catchments Research Platform

The Demonstration Test Catchments will develop an evidence-base for wider application to the management of river catchments across England and Wales. The £8M project will initially set up three instrumented catchments with an integrative data infrastructure to provide a shared-use network as the framework for collaborative analysis. Research and mitigation actions in other catchments will also be drawn in and supported where relevant, to enhance the developing evidence base.

<http://www.lwec.org.uk/activities/demonstration-test-catchments>

Defra's Drinking Water Quality and Health (DWQH) programme

This research programme allows Defra and the Welsh Assembly Government (WAG) to discharge their obligations in respect of ensuring the safety of drinking water based on credible scientific evidence. Defra funds this research because of the UK Government's responsibility as the designated competent authority for implementation of the Drinking Water Directive. In this respect, Defra funds only the research needed to guide the execution and delivery of drinking water policy (in particular by the independent regulator) and to address issues on which Ministers may need to take decisions in future. Thus the research programme also supports regulation of the water industry in England and Wales and assesses risks to health in relation to emerging issues, new technology and processes.

<http://www.defra.gov.uk/>

Defra's Natural Environment White Paper - 'The Natural Choice'

The Natural Environment White Paper is a bold and ambitious statement outlining the Government's vision for the natural environment over the next 50 years, backed up with practical action to deliver that ambition. Nature is sometimes taken for granted and undervalued. But people cannot flourish without the benefits and services our natural environment provides. A healthy, properly functioning natural environment is the foundation of sustained economic growth, prospering communities and personal wellbeing.

<http://www.defra.gov.uk/environment/natural/whitepaper/>

Defra's Water Availability and Quality (WAAQ) programme

This programme delivers the Government's policy priorities in the areas of water quality and water supply - including water industry reform, supporting all three departmental priorities in the Defra Business Plan, namely to:

- Support British farming and encourage sustainable food production
- Enhance the environment and biodiversity to improve quality of life
- Support a strong and sustainable green economy, resilient to climate change

<http://www.defra.gov.uk/>

Defra's Water White Paper 'Water for Life'

The White paper sets out a vision for future water management in which the water sector is resilient, water companies are more efficient and customer focused, and water is valued as a precious resource.

The White Paper includes several proposals for deregulating and simplifying legislation, to reduce burdens and stimulate growth. Ofwat's proposals for reducing its regulatory burdens complement these. The Government's Red Tape Challenge will offer another opportunity to identify areas where regulation can be simplified or removed. The White Paper explains how Government will encourage and incentivize water efficiency measures, some of which are being supported under the Green Deal; and sets out how it will encourage voluntary water efficiency labeling to enable customers to choose more efficient products. It also aims to introduce over the long-term, a reformed water abstraction regime, as signaled in the [Natural](#)

[Environment White Paper](#), and sets out changes to deal with the legacy of over-abstraction of rivers.

<http://www.defra.gov.uk/environment/quality/water/legislation/whitepaper/>

EA Flood Risk and Coastal Management (FRCM) Policy Group

This group undertakes the National Planning and investment Strategy for FRCM and negotiates the national priorities and work programme with Defra. They have produced a long-term investment strategy which sets out the Environment Agency's evidence and views on the choices that the people of England face concerning the amount of investment needed to manage the risk of flooding and coastal erosion between 2010 and 2035.

<http://publications.environment-agency.gov.uk/PDF/GEHO0609BQDF-E-E.pdf>

EA's Integrated Catchment Science (ICS) programme

The overall aim of this programme is to help the Environment Agency, along with its partners, to deliver sustainable improvements to the environment and thus help to improve people's quality of life. This will be achieved by developing the scientific understanding, approaches and tools that will enable river catchments to be managed in a more integrated and cost effective way.

<http://publications.environment-agency.gov.uk/dispay.php?name=SCHO0508BOCP-E-E>

Ecosystem Services for Poverty Alleviation (ESPA) research programme

This £40.5M programme funded by NERC, ESRC, Defra and DFID will address key environmental vulnerabilities in areas of the world where poverty is worst. The aim is to find ways in which poverty can be reduced by accounting for regional variations in climate, weather patterns and land use without causing or worsening enduring environmental problems.

<http://www.espa.ac.uk/>

EC's Water supply and sanitation technology platform (WssTP)

WssTP is the Water supply and sanitation Technology Platform. It was initiated by the European Commission in 2004 to promote coordination and collaboration of Research and Technology Development in the water industry. Through the Strategic Research Agenda they provide strategic answers for the water research future challenges. It has 61 members and 210 contributors from Industries, Academics, Research, Policy Makers and Water Utilities.

<http://www.wsstp.eu/site/online/home>

Environmental Science to Service Partnership (ESSP)

This is a partnership comprising NERC (including CEH and BGS), Met Office, Ordnance Survey, Environment Agency and Defra, and the aim of the partnership is to work together to develop a service relating to water availability based on data from all of the partner organisations that would address a stakeholder need, such as a policy requirement or to

inform business decisions. Stakeholder needs have been gathered through a workshop, and a service relating to hydrological forecasts is being explored as a pilot project for the partnership.

ESRC's Flood, vulnerability and urban resilience: a real-time study of local recovery following the floods of June 2007 in Hull

This £0.22M research funded by ESRC, EPSRC and the Environment Agency used diaries, interviews and group discussions to follow the recovery experiences of people across Hull after the floods of June 2007 which affected over 8,600 households across the city. It had the following objectives:

- To identify and document key dimensions of the longer term experience of flood impact and flood recovery, including health, economic and social aspects.
- To examine how resilience and vulnerability were manifest in the interaction between everyday strategies of adaptation during the flood recovery process, and modes of institutional support and the management of infrastructure and the built environment.
- To explore to what extent the recovery process entailed the development of new forms of resilience and to identify the implications for developing local level resilience for flood recovery in the future.
- To develop an archive that will be accessible for future research into other aspects of flood recovery

<http://www.esrc.ac.uk/my-esrc/grants/RES-177-25-0004/read> and
http://www.lec.lancs.ac.uk/cswm/Hull%20Floods%20Project/HFP_home.php

EU's STREAM project

In 2000 the EU Water framework directive has set up a truly integrated Community policy. Today water scarcity and waste water management are two of the most relevant challenges that Europe has to face in the field of water crisis. In this context STREAM project aims to raise awareness of state of the art water technology research. This will be brought to the interest of policy makers and potential up-takers through a diversified series of dissemination and communication actions tailored to the needs of the different categories of stakeholders: researchers, policy makers, industry and SMEs.

<http://www.stream-project.eu/>

Eureka Cluster (Acqueau)

ACQUEAU is an industry driven EUREKA Cluster dedicated to water related technologies and innovation. It aims to promote innovation and market driven solutions to develop new technologies in the European water sector. ACQUEAU is an initiative to boost growth and innovation in the water sector.

<http://www.acqueau.eu/>

The European Water Partnership (EWP) Climate Change Adaptation Programme

EWP, together with its partners, have set up a European Dialogue on Climate Change Adaptation and Water. This Dialogue will focus on raising awareness, exchanging experiences and best practices between all stakeholders and the set up of concrete projects to help make sure Europe is safe of climate change. It will be a focal point for coordination in Europe, as well as towards the outside world. They operate a number of relevant activities.

<http://www.ewp.eu/activities/water-and-energy-climate-cca/>

EWP's Desiras

The DESIRAS project pilot tests an innovative technology to reduce water use in irrigation on three farms in Spain and Cyprus. Testing is executed within the framework of the Water Stewardship Program, which allows for an objective and inclusive evaluation of the impact of the technologies. DESIRAS runs from 1 January 2010 – 31 March 2011 and is supported by DG Environment

<http://www.ewp.eu/activities/desiras/>

EWP's European Water Awareness Programme

This programme directs to introduce a water saving and water efficient culture among political decision makers, key stakeholders and inhabitants within Europe. The basic tool to implement awareness on sustainable water use on all social and geographical levels is to make information available for everybody. Improved information creates transparency on the water situation and ensures a realistic and objective decision making process. In that way the program ensures the change of behavior, practices and habits and supports an efficient policy making process.

<http://www.ewp.eu/activities/water-awareness/>

EWP's European Water House

The European Water House project aims at demonstrating the vast potential of appropriate water technology and its practical applications. The European Water House is being established to make the Water Vision for Europe visible and applicable, to demonstrate that working together with private and public structures, local, regional, national and European institutions may turn these principles into a coherent reality for a sustainable future.

<http://www.ewp.eu/activities/water-house-structure/>

EWP's Innowater

This is a public-private partnership coordinated by the European Water Partnership, and supported by the European Commission – DG Enterprise. It consists of 15 public innovation agencies, water associations, technology specialists, innovation experts and eco-innovative cluster organisations from Belgium, Denmark, Cyprus, Spain, the UK and the Netherlands aspiring to develop and test new and better innovation support tools for innovative SME's and first user industries in the water sector to promote the market uptake of new technologies. INNOWATER started on 1 February 2010 and will run for three years.

<http://www.ewp.eu/activities/innowater/>

EWP's Water Stewardship Programme

In December 2008, within the frame of the EWP program "Aquawareness" and based on the Water Vision for Europe, the EWP Stewardship program has been launched with a strategic workshop of stakeholders from various parts and parties of the water sector. The aim of this project is to provide a tool to communicate and award responsible water users through the development of a common framework for assessing, implementing and communicating Sustainable Water Management (SWM).

Due to the high motivation and pro-active engagement of the project participants, this Stewardship initiative quickly found its recognition within the European water sector and within the global Water Stewardship process where it represents the "Regional Water Stewardship Initiative for Europe".

<http://www.ewp.eu/activities/water-stewardship/>

Executive MBA Program Water Specialization

The Rotterdam School of Management, Erasmus University (RSM), Wetsus, the European Water Partnership (EWP) and seven further founding partners joined their expertise and launched a new Executive MBA program that focuses on the water business. The program started in January 2011 and offers a higher management education to companies in the water business. The program is tailored to international oriented and talented business people who wish to develop their activities in the global water business. With a strong emphasis on leadership development in an international environment, the aim of the EMBA Water Specialization program is to reflect and further expand on issues related to water quality, distribution and availability. Moreover, the goal is to provide insights into state-of-the-art technological and managerial aspects of operating successfully in the industry.

<http://www.ewp.eu/activities/water-mba/>

Foundation for Water Research (FWR)

Foundation for Water Research (FWR) is an independent, membership based charity dedicated to education and information exchange. It is based in Marlow, Buckinghamshire, UK. It was founded in 1989 and its mission is to advance the education of the public in science, engineering and management of water through specialist forums, reviews of current knowledge, publishing and information support.

http://www.euwfd.com/html/about_us.html

Global Framework for Climate Services

The Global Framework for Climate Services will boost the availability of climate information needed by policy-makers and people to plan ahead and to take decisions that are sustainable in a changing climate. The World Meteorological Congress, which met from 16 May to 3 June 2011, decided that the Global Framework will be one of the top five priorities of the World Meteorological Organization (WMO) in the next four years.

Its primary goal is to ensure greater availability of, access to, and use of climate services for all countries. It will serve as a permanent platform for dialogue between providers of climate services (essentially National Meteorological and Hydrological Services) and users ranging from policy-makers to farmers and fishermen.

http://www.wmo.int/pages/qfcs/qfcs_en.html

HYDRA - Hydrosociences Research Association

This association is for strategic multi-disciplinary research in water science, policy and management. Membership comprises the leading UK water science research groups in SE England and is also open to stakeholders and policymakers with interests in water science and management. Their vision is to integrate this science excellence across the hydrosociences disciplines to provide the best in evidence based policy for UK environmental management, and to do this in an integrative and inclusive research environment involving both scientists and policymakers.

<http://www.hydra.uk.net/>

Joint Programme Initiative (JPI)

In 2008 the EC called together member states to form Joint Programming. The aim of Joint Programming is to pool national research efforts in order to make better use of Europe's precious public R&D resources and to tackle common European challenges more effectively in a few key areas. It follows a structured strategic process whereby Member States agree common visions and strategic research agendas to address major societal challenges.

http://ec.europa.eu/research/era/areas/programming/joint_programming_en.htm

JPI on Connecting Climate Knowledge for Europe

This JPI, known as JPI Climate, as has a focus on coordination of climate research funding. They consider 'climate knowledge' in the broad sense, including all kinds of scientific knowledge on causes and consequences, on cost, risks and benefits of climate change as well as possible responses. JPI Climate intends to contribute to a highly coordinated knowledge development by not only improving the scientific expertise on climate change risks and adaptation options, but also by connecting that knowledge with decision-making on safety and major investments in climate-vulnerable sectors in Europe.

<http://www.jpi-climate.eu/>

JPI on Water Challenges for a Changing World

The "grand challenge" is to achieve sustainable water systems for a sustainable economy in Europe and more widely. This JPI will mobilise existing RDI programmes to harmonise their research agendas and infrastructures, defining common research needs and developing synergistic joint activities that increase their efficiency by avoiding duplications. The JPI vision is structured through a set of objectives and a set of research questions being addressed.

<ftp://155.210.150.22/Main%20documents/Vision%20Document/Vision%20Document.pdf>

LWEC Resources Challenge

Living With Environmental Change (LWEC) has six challenges, one of which is the Resources Challenge. The aim of the challenge is to promote human well-being, alleviate poverty and minimise waste by ensuring a sustainable supply of water, food and other

biological resources. This challenge has a steering group that will ensure that the UK gets the tools, knowledge and foresight needed to address the aim.

<http://www.lwec.org.uk/node/83>

UK Flood and Coastal Erosion Risk Management (FCERM) Research Strategy

This strategy outlines how the Living With Environmental Change (LWEC) partnership (principally Defra, EA and the Research Councils) will make a significant difference in meeting the scientific and practical challenges that FCERM presents. The strategy will facilitate the delivery of high-quality, outcome focused research, to underpin UK-wide and local FCERM strategies, to enable evidence-based policy decisions, to improve operational efficiency and effectiveness and to develop new innovative tools and techniques to improve FCERM delivery. It aims to secure the finances and expertise to deliver the identified research needs, building upon a solid base of past experience and lessons learnt; and to develop and sustain this over the next 20 years.

<http://www.lwec.org.uk/sites/default/files/UK%20Flood%20Research%20Strategy%20Draft%20for%20Consultation.pdf>

The **Natural Environment Research Council (NERC)** funds several relevant research programmes, national capability in science, and other activities, often supported financially and in kind by other bodies, including:

NERC Water Security Knowledge Exchange Programme

The NERC Water Security Knowledge Exchange Programme (WSKEP) is a three year (2011-2014), £1.8 million programme that will improve the delivery of NERC research to the user community. The programme will establish a community of researchers and science users to develop networks for effective knowledge exchange. It will:

- Work with policy-makers, industry and civil society organisations to identify priority areas for accelerating knowledge exchange activities.
- Offer a first point of contact for information about water security related research.
- Facilitate a range of knowledge exchange events, bringing together key researchers and users.
- Help users communicate their needs to shape the development of new NERC research programmes.

<http://www.nerc.ac.uk/using/keprog/water.asp>

Changing Water Cycle research programme

This programme will develop an integrated, quantitative understanding of the changes taking place in the global water cycle, involving all components of the earth system. It will address the urgent needs to understand the changes taking place now; predict changes that will take place over the next few decades; and, through LWEC, work with partners to build resilience, mitigate problems, and develop adaptive solutions. The Environment Agency, Met Office and Defra have all been involved in the development stages of the programme. The current funding level is £10.1M, which is likely to increase once contributions from other stakeholders are confirmed.

<http://www.nerc.ac.uk/research/programmes/cwc/>

UK Droughts research programme

This newly commissioned NERC programme has £6.5M funding to identify and predict the interrelationships between multiple drivers and impacts of UK droughts - over daily to multi-annual timescales and on spatial scales from metres to 500 km - to inform adaptation and management decisions before, during and after drought events.

<http://www.nerc.ac.uk/research/themes/tap/tap-phase3.asp#drought>

Flooding from intense rainfall research programme

This newly commissioned NERC programme has £5.2M funding. This UK-focused programme will reduce the risks of damage and loss of life caused by surface water and flash floods through improved identification, characterisation and prediction of interacting meteorological, hydrological and hydro-morphological processes that contribute to flooding associated with high-intensity rainfall events.

<http://www.nerc.ac.uk/research/themes/tap/tap-phase3.asp#flooding>

NERC/Met Office's Joint Weather and Climate Research Programme

The overarching aim of the JWCRP is to ensure that, in areas of common interest to the Met Office and NERC, the UK maintains and strengthens its leading international position in climate science, and hence in climate forecasting and provision of advice for climate policy. The programme (£13.6M) was launched in April 2009.

<http://www.jwcrp.org.uk/>

Macronutrient Cycle research programme

This is a major £9.5M programme that aims to understand the interactions between Carbon, Nitrogen and Phosphorus Cycles in the environment. The research will assess the fate and distribution of these nutrients and the likely changes due to man-made impacts such as climate change, land use change, population changes and changing pollution gradients across the UK and Europe. It has contributions from the Environment Agency, Defra, Scottish Government and Welsh Assembly Government.

<http://www.nerc.ac.uk/research/programmes/macronutrient/>

Next Generation Weather and Climate Prediction Systems

Technical developments in computing and in global scale observations create an environment of enormous opportunity for improving capabilities for weather and climate prediction, but there are major scientific and technical barriers to realizing this potential. This £4.4M programme co-developed with the Met Office and the Science and Technology Facilities Council (STFC) aims to address two key areas where scientific and technological advances offer opportunities to maintain UK leadership in environmental prediction:

- Goal A - Resolution of small scale weather systems in the atmosphere and ocean

- Goal B - Use of observations to initialise climate predictions

<http://www.nerc.ac.uk/research/programmes/ngwcp/>

Ocean Acidification research programme

The overall aim of this £12.4M (funding from NERC, Defra and DECC) Research Programme, is to provide a greater understanding of the implications of ocean acidification (as a result of the absorption of anthropogenic carbon dioxide) and its risks to ocean biogeochemistry, biodiversity and the whole Earth System. Scottish Government and Welsh Assembly Government have also been consulted in the design phase of the programme. There is close alignment with other international programmes in the USA and the EU.

<http://www.nerc.ac.uk/research/programmes/oceanacidification/>

Storm Risk Mitigation research programme

Storms have had an increasing social and economic cost over recent years and are likely to be a main cause of loss of life or assets in the UK over the next few decades. The objective of this ~£5M collaborative programme between NERC, the Met Office and the Environment Agency is to improve short (0-48 hours) and longer term (decades) forecasting of storms and their impacts on catchments and coasts.

<http://www.nerc.ac.uk/research/programmes/stormrisk/>

NERC's Virtual observatory for water and catchment data

The pilot Environmental Virtual Observatory (EVOp) is a proof of concept project designed to demonstrate that linking data, models and expert knowledge will provide cost effective answers to vital wide-ranging environmental issues (initially in the soil - water system). The project will exploit cloud computing to develop new applications for accessing, filtering and synthesising data to develop new knowledge and evaluation tools. It will investigate possible structures for the cloud environment and develop exemplars at a local and national scale of how the Environmental Virtual Observatory (EVO) could make environmental monitoring and decision making more efficient, effective and transparent to the whole community. Novel visualisation tools will promote cross-disciplinary communication and illustrate the effects of alternative strategies and solutions from 'townhall to Whitehall'.

<http://www.environmentalvirtualobservatory.org/> and
<http://www.nerc.ac.uk/research/programmes/virtualobservatory/>

The Expert forum for practitioners implementing the Water Framework Directive (WFD) aims (a) to create an expert forum to collate and share knowledge and skills between practitioners from industry, business, academia and policy, to increase compliance with the WFD by 2015 and (b) to establish what initiatives and research is available and ongoing on at a national level to inform implementation of WFD. The Forum aims to compile national activities which inform what needs to be done to comply with the WFD, assist in Knowledge exchange and shape future work.

<http://www.waterratleeds.org/water-framework-directive.php>

Information on **NERC's national capability programmes** can be found at:

British Antarctic Survey <http://www.bas.ac.uk>

British Geological Survey <http://www.bgs.ac.uk>

Centre for Ecology and Hydrology <http://www.ceh.ac.uk>

National Oceanography Centre <http://www.noc.ac.uk>

Netherlands Water Partnership (NWP)

This is an independent body set up by the Dutch private and public sectors in the Netherlands to act as a national coordination and information centre for water-related issues abroad. The principal aims of the NWP are to harmonise the activities and initiatives of the Dutch water sector abroad and to promote Dutch expertise in water worldwide. The NWP is the channel through which government bodies, NGOs, knowledge institutes and private organisations in the water sector share information on their activities and services. The NWP has over 180 members.

<http://www.waterland.net/index.cfm/site/Netherlands%20Water%20Partnership/pageid/371DE44E-0574-FFD6-90D1C1585AD5A258/index.cfm>

Pennine Water Group (PWG)

The Pennine Water Group (PWG) is an EPSRC funded Platform Grant centre dedicated to research into water and wastewater and based at the Universities of Sheffield and Bradford. The PWG aims to advance engineering and scientific knowledge across all aspects of potable water, stormwater and wastewater service provision, and management of associated assets.

<http://www.shef.ac.uk/penninewatergroup>

PML's Sea and Society theme

This Plymouth Marine Laboratory theme covers environment, human health, bio-discovery and socio-economics of the marine environment. PML's mission is to develop and apply world-leading integrated scientific understanding of interactions between the marine environment and society, in order to sustain coastal and upper ocean ecosystems and their services under conditions of global change. These values have been fundamental to the organisation for over 30 years and this area of science is essential in delivering this promise.

http://www.pml.ac.uk/science_areas/sea_and_society.aspx

Within this theme, PML have produced an **Algal bloom early warning system**.

PML's Marine Life Supports Systems theme

This Plymouth Marine Laboratory theme covers biodiversity, marine ecology and molecular science. PML has a depth of expertise in understanding and valuing marine biodiversity, which is vital in developing tools and strategies for preserving the ocean's vast biological diversity and, therefore, the goods and services provided by the ocean. To increase the value of this knowledge to society, PML is at the forefront of UK, European and international biodiversity networks, which enables the sharing of species and distribution data to researchers, industry, stakeholders and the general public across the world.

http://www.pml.ac.uk/science_areas/marine_life_support_systems.aspx

UKWIR: Research and Innovation Mapping Study for the UKWRIF

As part of work towards the UKWRIF, UK water experts were asked to carry out a high level overview and synthesis of recommendations from key policy and research reports relevant to the UK's potential contribution to UK and global water security. This was to be in the form of a mapping study under 11 agreed key priority themes related to water security.

<http://ukwir.forefront-library.com/report/90055/Regulatory/91293/Innovation-in-Water/94138/Research-and-Innovation-Mapping-Study-for-the-UK-Water-Research-and-Innovation-Framework>

UK Water Industry Research Ltd.

UKWIR was established in 1993 to undertake single voice research on behalf of the UK water industry. It shapes and leads the future research agenda for the industry by identifying and responding to current and future challenges. Membership comprises of UK water companies who participate in project steering groups to guide the high value independent collaborative research undertaken, both nationally and internationally. Research undertaken provides robust and reliable evidence on behalf of the membership, enables informed interaction with regulators, and delivers financial savings. A key role is encouraging the sharing of best practice and continuous improvement.

RCUK Water Interest Group (WIG)

This was set up in Autumn 2009, consisting of RC representatives and with LWEC and TSB representatives, to consider research opportunities, including EU dimensions, with a particular focus on the potential to develop interdisciplinarity. The WIG has initiated a mapping exercise for the RCs to understand better what they are doing of relevance to water research and innovation.

RCUK Water Interest Group – Research Showcase

The WIG intends to organise a RCUK Water Research Showcase to showcase the breadth and variety of water related research supported by the Research Councils; to align research demonstrations to the priority areas highlighted by the UKWRIF; to engage water stakeholders and experts with the academic activities in order to encourage knowledge exchange; and to gather input from stakeholders and experts on the quality and importance of the research supported by Research Councils and to identify any gaps in research capability in the UK.

Scottish and Northern Ireland Forum for Environmental Research (SNIFFER)

SNIFFER is a company limited by guarantee and a registered charity. They provide a service to members and partners to manage and deliver knowledge relating to the environment and quality of life. SNIFFER provide three main types of service: horizon scanning, research management and knowledge exchange. They have six areas of interest: Sustainable Land Use and Water Management; Sustainable Places; Environmental Regulation; Climate Change; European Involvement; and Emerging Issues.

<http://www.sniffer.org.uk/>

SHARE (Sanitation and Hygiene Applied Research for Equity)

SHARE is a consortium of five organisations that have come together to generate rigorous and relevant research for use in the field of sanitation and hygiene. It is a five year initiative (2010-2015) funded by the UK Department for International Development. It is led by the London School of Hygiene and Tropical Medicine and includes the following partners: the International Centre for Diarrhoeal Disease Control, Bangladesh; the International Institute for Environment and Development; Slum/Shack Dwellers International; and, WaterAid. The purpose of SHARE is to join together the energy and resources of the five partners in order to make a real difference to the lives of people all over the world who struggle with the realities of poor sanitation and hygiene. It aims to generate the knowledge that is needed to improve sector performance and drive progress on sanitation.

<http://www.sharesearch.org/>

The Organisation for Economic Co-operation and Development (OECD)

The mission of OECD is to promote policies that will improve the economic and social well-being of people around the world. The OECD provides a forum in which governments can work together to share experiences and seek solutions to common problems. Their work covers the environment.

http://www.oecd.org/home/0,3675,en_2649_201185_1_1_1_1_1,00.html

Technology Strategy Board's Sustainable Agriculture and Food Innovation Platform

This platform, launched in October 2009, aims to stimulate the development and adoption of new technologies to help improve the productivity of the UK food and farming industries, while decreasing their impact on the environment. It is in partnership with Defra and BBSRC. Over the next five years, they will invest up to £90m in projects to develop new technologies. Investments will be made jointly with industry and other funders in projects to develop innovative solutions to these challenges. They include in their work the challenge of addressing agricultural run-off.

http://www.innovateuk.org/_assets/pdf/corporate-publications/sustainableagriculturefood%20ip-final.pdf

Technology Strategy Board Innovation Competition in Water Security

A £3.5 m innovation competition in water security will be launched by TSB in March 2012, jointly funded by Defra, NERC and TSB for step change solutions to potentially recover 1,000 megalitres per day from the blue water cycle. All aspects of the water cycle will be included; from resource management, through demand management to wastewater treatment and recycling. The plan is to support both technical and commercial feasibility studies, and practical demonstration of solutions in use.

UK Groundwater Forum

The aims of this forum are to raise the awareness of groundwater and the role it plays in supporting the environment and in water supply; provide information on groundwater, targeted at specific groups such as decision makers, policy makers and schoolchildren; improve groundwater education in schools by providing educational resources, or links to existing resources; promote careers in groundwater-related professions; produce and disseminate information and facilitate discussion on topical groundwater issues within the

water and environment community; and provide a means for those in the water and environment community to share information.

<http://www.groundwateruk.org/>

The UK National Ecosystem Assessment (UK-NEA)

This world-leading, £1.2M initiative has produced the world's first national assessment of its kind. Following the Millennium Ecosystem Assessment it will provide an assessment of the current state of all of the ecosystems in the UK. The study will provide the evidence foundation of the ecosystems approach to policy that Defra are leading across Whitehall, identifying both threats and opportunities.

<http://uknea.unep-wcmc.org/Home/tabid/38/Default.aspx>

United Utilities Sustainable Catchment Management Programme (SCaMP)

Much of United Utilities land is home to nationally significant habitats for animals and plants, with around 30% designated as Sites of Special Scientific Interest (SSSI). The Sustainable Catchment Management Programme (SCaMP), which has been developed in association with the RSPB, aims to apply an integrated approach to catchment management in two key areas of United Utilities land, Bowland and the Peak District area.

<http://www.unitedutilities.com/scamp.aspx>

World Health Organisation Water Sanitation Health

WHO works on aspects of water, sanitation and hygiene where the health burden is high, where interventions could make a major difference and where the present state of knowledge is poor. Their work is divided into six core activities: Drinking-water quality management; Water supply and sanitation monitoring; Cholera surveillance and prevention; Water and sanitation in different settings; Water resources management; and Miscellaneous activities (including Economic aspects, Climate change, and the Millennium Development Goals).

http://www.who.int/water_sanitation_health/en/index.html

Willis Research Network

The WRN supports open academic research and the development of new risk models and applications. Their ethos is to provide an open forum for the advancement of the science of extreme events through close collaboration between universities, insurers, reinsurers, catastrophe modelling companies, government research institutions and non-governmental organisations. The WRN's research programme is primarily focussed on the key issues related to climate and weather risks, including storms, floods and other extremes.

<http://www.willisresearchnetwork.com/default.aspx>

World Bank – Water

The World Bank is a vital source of financial and technical assistance to developing countries around the world. Its mission is to fight poverty with passion and professionalism for lasting results and to help people help themselves and their environment by providing resources, sharing knowledge, building capacity and forging partnerships in the public and

private sectors. The World Bank is a key financier of water projects in developing countries and holds and needs water and environmental expertise to further its aims.

<http://water.worldbank.org/water/>

Annex 2 – Selected Key Facts: Sample Information Sources

These references have been chosen to reflect the breadth of research and synthesis material that is widely available to both the general and specialist reader. Many other sources of information and reports on water are available and many of the most important are given in: UKWIR (2011) Research and Innovation Mapping Study for the UK Water Research and Innovation Framework UKWIR Report Ref. No. 11/RG/10/6. 60pp London, UKWIR. Sources of information on which the selected key facts are based are, by section:

Water Use

2030 Water Resources Group (2009). - Charting our Water Future, Economic frameworks to inform decision making – Executive Summary 30pp full report from McKinsey at: www.mckinsey.com/water.
Royal Commission on Environmental Pollution (2011) *Demographic Change and the Environment* Twenty-ninth Report. Cm 8001, 128pp. London, The Stationery Office
SIWI, IFPRI, IUCN, IWMI. (2005). "Let it Reign: The New Water Paradigm for Global Food Security." Final Report to CSD-13. 40pp Stockholm, Stockholm International Water Institute.
DTI (2002 onward) Energy Consumption in the UK. London, DTI with updated tables and data available from the Department of Energy and Climate Change at <http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx>

Water Infrastructure

Ofwat (2009). Future water and sewerage charges 2010-15: Final determinations.
Ofwat (2010). Financial performance and expenditure of the water companies in England and Wales 2009-10.

Business and the Economy

Environment Agency (2010). The costs of the Summer 2007 floods in England. Project: SC070039/R1. Environment Agency, Bristol.
EU (2007). Water scarcity & droughts In-depth assessment. Second Interim Report 93pp.
Wild, D. Francke, C-J. Menzli, P and Schön, U (2007). Water: a Market of the Future 32pp Zurich, Sustainable Asset Management AG.
Martin-Ortega, J. and Markandya, A. (2009). The costs of drought: The exceptional 2007-2008 case of Barcelona. BC3 Working paper series 2009-09 32pp. Bilbao, Basque Centre for Climate Change.

Environment and Climate Change

<http://ukclimateprojections.defra.gov.uk> provides a wealth of information relevant to many aspects of climate change, including information on taking account of uncertainties in future projections.
Met Office data for 2010 and 2011 and earlier years allows trend and average information to be supplied to the public e.g. as at <http://www.metoffice.gov.uk/climate/uk/2011/summer.html>
IPCC (2007). Climate Change 2007 The Fourth Assessment Report – note exact estimates of sea level rise depend on scenarios used.
Natural England (2009). Ocean acidification: the facts. A special introductory guide for policy advisers and decision makers. Commissioned Report NECR034 16pp. London, The Stationery Office.

Food and Farming

UNESCO (2003). Water for People, Water for Life. The United Nations World Water Development Report, Executive Summary 36pp. Paris, UNESCO.
FAO (2006). World agriculture: towards 2030/2050 Interim report; Prospects for food, nutrition, agriculture and major commodity groups. 71pp Rome, FAO and data in the AQUASTAT Database.
FAO (2007). The world's mangroves 1980-2005. FAO Forestry Paper 153. Rome: Italy. Molden, D. ed. (2007). Comprehensive Assessment of Water Management in Agriculture. 2007. Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. London: Earthscan, and Colombo: International Water Management Institute.
Foresight "Global Food and Farming Futures" Synthesis Report C2: External pressures on the food system.
Chapagain, A. K. & S. Orr (2008). UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources 48pp WWF-UK.
SIWI, IFPRI, IUCN, IWMI. (2005). Let it Reign: The New Water Paradigm for Global Food Security. Final Report to CSD-13. 40pp Stockholm, Stockholm International Water Institute.

Health and Sanitation

Wildlife Link (2004). Diffuse Water Pollution from Agriculture: a proposed solution quoting Defra 2002 this being 'The Potential Cost and Effectiveness of Voluntary Measures in Reducing the Environmental Impact of Pesticides', report prepared by EFTEC, CSERGE and ENTEC.
WHO/UNICEF (2004). Joint Monitoring Programme for Water Supply and Sanitation: Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress, 34pp Geneva World Health Organization.
WHO (2000). [Global Water Supply and Sanitation Assessment](http://www.who.int/water_sanitation_health/assessment/). Geneva, World Health Organization.