Executive Summary/Recommendations

1. Introduction

This document reports the discussion and findings of the Water Infrastructure Adaptation to Climate Change Workshop held at the Institute of Civil Engineers on 12th July 2010. The event was chaired by David Nickols.

The workshop process was organised around the five key questions raised in the briefing document (Appendix 1), commencing with a brainstorming session around the primary concerns and issues before considering options and choices in response to assumed consequences of climate change.

The infrastructure involved with water serves several different functions, reflecting the water cycle, and includes natural and man-made waterways, and flood and coast protection as well the infrastructure required for the storage and delivery of water to domestic, agricultural, industrial and other commercial consumers and the removal, treatment and recycling of waste water.

The nature of the infrastructure is therefore very varied, depending on its function. The adaptation in response to climate change is a product of the rather than the infrastructure *per se*. In addition, much of the infrastructure has other functions, such as environmental and recreational.

Potable water is essential for the continued health of the population, one of the drivers which lead to the development in the 19th century of much of the infrastructure still in use today. This is assumed to meet an ongoing need for the security of society which will continue in the foreseeable future.

In addition, management of water courses, the abstraction of water from the environment, and the return of waste water to the environment present major environmental responsibilities which need to be met in part through the industry’s infrastructure.

Whilst the plumbing within buildings is seen as outside the scope of infrastructure, some of the engineering adaptations to climate change necessarily involve customer-side interventions which are deemed in scope.

Whilst the climate is changing, the water sector will simultaneously face impacts from changing demographics. The population is forecast to grow substantially in the 21st century, and the water infrastructure will also need to meet these challenges. Demand is therefore likely to increase whilst supply decreases, and there may be an increased separation from the geographic location of demand from areas of supply.

2. Impacts and Operational Challenges Arising from Climate Change

It is anticipated that water infrastructure and its use will be materially affected by climate change.

UK climate projections (UKCP09) predict increased summer temperatures, which are expected to increase evaporation from the soil, rivers and reservoirs. Precipitation is expected to change both in volume (with some areas showing increased and others decreased rainfall) and in the pattern of rainfall (with an increase in heavy rainfall and extended, possibly across years, periods of drought expected). There are expected to be rises in sea-level.

These changes may be expected to lead to seasonally reduced supplies from reservoirs and reduced river flows, whilst higher temperatures may lead to higher demand from consumers.

Increased periods of heavy rainfall are likely to stress drainage systems, leading to both an increased likelihood and an increased severity of flooding. Flood events similar to those experienced in England in 2007 are expected with increased frequency. Exceptionally heavy rainfall may see an increase in flash-floods such as effected Cockermouth in 2009. Flooding damages the water supply system and waste removal and treatment facilities.

Extended dry periods may lead to the drying of river and canal banks which, coupled with more frequent and violent flood events, could cause changing patterns of erosion and deposition. These in turn may effect the water flow. This could be a significant impact on navigable waterways.

Rising sea-level could similarly effect coastal erosion and deposition, which could threaten some habitation as well as affect maritime navigation.

Increased wind, fog and rain impact on water-borne transport. Wind and fog can particularly affect maritime transport, whilst low or high rainfall can impair inland waterways which face specific risks from sudden increases in flow or reduced flow.

3. Adaptation Options to Meet Issues and Challenges

The conditions created by climate change are similar to those currently found elsewhere in the world. Hence the technology, skills and knowledge to adapt to these changes are readily available. For instance, Australia has been pioneering “water-sensitive cities”, Singapore has experience in the re-use and recycling of water, USA has been developing urban environment for climate change adaptation, the Netherlands has extensive experience in building on land at risk from flood and Mediterranean countries such as Greece have experience in managing fluctuating, seasonal water supplies.

However, this may well require a changed view from engineers: the adaptations to climate change may not need large scale developments but instead need engineers to focus on economics and social sciences to improve their effectiveness and become solution providers in the broadest sense.

In particular, the paradigm of seeking “clever widget” or “magic bullet” solutions may obscure alternatives. Much of our current infrastructure is based on engineering solutions designed for the 19th century, when conditions were different and believed to be stable. The situation facing England in the 21st century is significantly different, and would benefit from a different outlook to find solutions to the issues faced. Future engineering approaches are likely to benefit from cross-discipline, cross-functional working.

This may require a radical rethinking of engineering education and training, both at university level and continuing professional development. Traditionally, engineers extrapolate from historic data; the changes to climate are likely to be probabilistic and non-linear in nature, with more variation and less certainty. The adaptations to climate change will therefore need to cope with uncertainty, and the engineering response more probabilistic and less deterministic.

A different approach to data may also be needed. Lack of data hinders adequate analysis of the problem. Focussing data collection on those areas most at risk, developing projects on the basis of conceptual rather than hard evidence, collecting data as the project progresses or incorporating data collection into the design and build phases of projects as well as or instead of the feasibility phases may make projects more flexible.

As well as educating engineers, there is a need to educate policy makers, regulators and the public in which engineers as well as other professionals have a role. The public may have expectations regarding the service they receive which will either not be met or will only be able to be met with significantly increased costs. Contributing to a public debate on the nature of services which can be delivered through the infrastructure available, together with government and regulators, could be a central role for engineers in the mid-future. For instance, some communities may be subject to an increase risk of flooding, and it might not be economical to offer them sufficient flood protection. Deciding who pays to protect communities, and what proportion of scarce available finance should be directed towards them, are issues for society to resolve. The role of the insurance industry in managing risk will also be central to the debate.

Cultural changes may also be required to support move from centralised water systems towards distributed storage and treatment systems, which could result in more resilient infrastructure. It is anticipated that within 20 years, much treatment of water will be at the point of consumption rather than in large treatment works. This would enable more economic treatment by treating water to a level fit for its purpose, rather than treating all water until it is potable. Moves to distributed storage could lead to local management of the water cycle and further decentralisation, with the centralised network functioning as a back-up rather than the main supply.

There is an extensive water infrastructure currently is use, a large proportion of it the legacy of earlier generations, such as large reservoirs and the urban sewer systems. Whilst these large assets were built for one purpose, there may be other functions to which they could be put. For instance, adapting the sewer systems to store water might be a more effective use of the infrastructure rather than channel waste water. A creative approach to using the existing infrastructure could yield multiple benefits for society.

Collection and storage systems at a local, community or consumer (agricultural, industrial or residential) level would reduce dependence on water transport systems and make available water directly at the site of consumption, suitable for its intended use. Similarly, greater use of water recycling systems at different scales would improve the effectiveness of water usage, meeting perhaps 20-30% of usage, and reduce reliance on infrastructure.

Developing distributed systems may also enable different benefits at different times or under different conditions. For instance, distributed water storage could be used for hydro power generation, to manage river flows, for agricultural irrigation, for habitat protection and development and for recreation purposes. Realising such multiple benefits may increase the economic value of such schemes and make it more likely to overcome local resistance.

The use of dual water supply to consumers, with one highly treated “potable” water source and another lower grade, would also make the most of the resources available.

The increased seasonal and regional variability in rainfall may also require developing new supplies, through, for instance, new reservoirs or desalination schemes. The use of dual water supply to consumers would also make available more water resources.

As well as providing for new supplies, adaptation may involve improved demand management. It has been suggested that opportunities exist to reduce water removed from environment by 50-60%. The use of low-flow appliances could reduce domestic demand, and more effective use of water in agricultural and industrial processes would also reduce stresses on the water infrastructure.

Consideration of all water use, including the embedded water that consumers use in the products they buy (in the same way that the calculation of an individual’s carbon footprint includes all sources of carbon, direct and indirect), could be a significant lever to influence consumers’ behaviour.

Demand may be reduced through economic incentives such as pricing, as well as educating users to change their behaviour. Smart meters and “intelligent pipework” could be used to support both economic and behavioural incentives and, at time of extreme shortage, may be used restrict access to limited water resources as well as reduce leakage.

Such changes to the water management system would need concurrent changes in consumer expectations as well as regulatory and business processes. This would require extensive education of the public. To support this would require changes to government policies. Moving to a system of service and performance standards for water rather than quality and design standards may benefit the development of adaptation.

Much could be achieved by revising design standards and regulations. For instance, strengthening planning processes to prevent building in areas at high risk of flooding, such as flood plains, would reduce the impact of the increased likelihood of floods. Alternatively, incorporating adaptations to make new buildings and their associated infrastructure more resilient to flooding could achieve the same goal.

Adherence to regulations and standards implies a presumption of a particular way of doing things, with designers, engineers and business models locked into one way of working. Instead, adaptation to climate change may benefit from a fundamental review of the ways in which water infrastructure is utilised.

4. Barriers to Implementing Adaptation Options

The adaptations to climate change identified face variety of barriers to implementation.

Finance is likely to be a central issue: upgrading infrastructure to meet revised standards, particularly in the urban environment, is likely to be costly. The economics is further complicated by allocation of the benefits and the costs to different communities, though this is less of a problem with distributed storage and treatment facilities more closely situated to users.

There may be particular financial issues with any moves to more distributed water systems. In the past, finance has generally been available for large scale capital expenditure projects but not for ongoing maintenance. With distributed systems, the upfront capital cost is likely to be less, but there may be higher ongoing maintenance costs. Reconciling this to the current regulated economic model may be difficult.

Regulation of the water industry can be a barrier as well as a driver for change. Particular ways of working can become fixed within an industry's operating processes to meet regulations, making flexibility and change difficult.

The way the UK approaches its international and national regulations and obligations is, generally, through rigid and strict application. An alternate view suggested that regulations are a manifestation of societal expectations. Society needs to decide what it is willing to pay to meet those expectations, or decide that lower standards (for instance, an interruption to delivery) may be acceptable at a lower price. This will require a programme of education and engagement with the public and policy makers.

The regulatory environment is further complicated by having responsibilities split across several different government departments (eg Defra, DECC, BIS) and regulatory authorities (eg EA, OfWat). Navigating the different authorities can greatly increase the regulatory complexity. Simplifying or "joining up" the regulatory environment may ease the development of adaption strategies, allowing for a greater sharing of data across institutions and bodies and improved, co-ordinated activity.

The regulatory regime itself may need to change. Regulation evolved during a period of apparently stable conditions to maintain society's health and security. As a result of climate change, conditions are likely to be changing significantly in the foreseeable future, and the regulatory regime may not be "fit for purpose". To meet these changing conditions, a flexible and responsive regulatory regime will be required.

Some regulations can have perverse consequences. For instance, current regulations focus on efficiency of energy use in water treatment by measuring the amount of CO_2 emissions per megalitre of water treated, in order to reduce the amount of CO_2 released. This incentivises water companies to maximise through-put, rather than reducing the level of water used by consumers.

Similarly, Defra has an aspiration to reduce the amount of domestic consumption from 150 litres per person per day to 130 litres. It was felt that by taking a more rigorous approach, far larger reductions could be accomplished: Defra was taking the current usage as its starting point, instead of analysing what could be the possible reduction.

Current regulations promote operating efficiency, which drives the industry towards centralisation, possibly at the cost of infrastructure resilience. A move to distributed water systems may lead to decreased efficiency but increased resilience.

It was suggested that the prevailing business model, with its focus on consumers as customers, could also be a barrier to delivering change within the industry. Under the current system, customers can get what they pay for. This may not be the case in the future. A move to distributed – local – infrastructure may not work well within this prevailing model, in which distributed systems with multiple benefits need community engagement.

Existing planning processes were also felt to be potential barriers. It was felt that by allowing central government to overrule local decisions, particularly regarding developments in flood plains, and by incentivising local planning authorities on the number of referrals to central government, the planning process was skewed in favour of projects in areas subject to high risk of flooding.

With an increased likelihood and increased severity of flooding, as well as increased sea-levels, there needs to be a debate about the role of flood and coastal defences. These may be improved to protect areas subject to potential flooding or storm damage, but they become increasingly expensive to maintain in order to protect the population, to the extent that the defences may not in the future be viable. The costs of defences are not necessarily borne by the communities they protect. There may need to be a public debate into the equity of this policy.

The requirement to change engineering education and training in order to be able meet the needs of the adaptation agenda also represents a potential barrier which may be difficult to overcome.

5. Interdependencies

The following inward dependencies were identified:

- energy: water infrastructure is dependent on electricity to power its facilities, particularly pumping and water treatment, and its IT systems
- ICT: water infrastructure is dependent on ICT to run its centralised IT systems and for communication
- transport: there is a dependency on road and rail transport for personnel and supplies to run its facilities

There is an internal dependency on the water infrastructure, in that much of the infrastructure is susceptible to flooding, particularly for treatment works and waste water removal.

Water has significant impacts on other infrastructure:

- energy is dependent on water for cooling power generating and oil and gas processing plant; energy transmission infrastructure and plant is highly susceptible to flood damage
- ICT cables are susceptible to flood damage
- transport systems are also susceptible to flood damage

In addition, any system or process dependent on human intervention is reliant on water for hygiene and drinking: without accessible water, such processes will stop.

Similarly, food production and processing is highly dependent on water.

6. Opportunities Arising from Climate Change

There are considerable opportunities to be gained from adaptation of water infrastructure to climate change. It may be possible to expand the use of water as a renewable energy resource, particularly within a localised, distributed infrastructure for water storage. Similarly, “energy from waste” schemes could form part of a distributed waste treatment system. It might also be possible to expand the development of conventional hydro, wave and tidal energy production as a result of climate change.

Significant opportunities could arise from recreational and tourist use of water systems as a result of climate change and adaptation. The development of wetlands could bring benefits for environmental diversity.

Using adaptation solutions with multiple benefits, especially for local communities, may make it easier for the solution to be support by the community.

Since the conditions the UK is likely to experience as a result of climate change is similar to those currently experienced elsewhere, there is a great opportunity to learn from the steps taken to copes with these conditions in other countries.

Additionally, there is the opportunity to export the UK's learning and expertise as it develops, helping other nations adapt to the issues they face through climate change.

7. Next Steps

References and Bibliography

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http://ukclimateprojections.defra.gov.uk/images/stories/projections_pdfs/UKCP09_Projections_V2.pdf

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Appendices

1. Water Sector discussion paper 12th July

2. Participants