Title:	**Report AR1206 Annex C** **Scenario framework**		
Project no.:	2287	Date:	26th April 2018
Author(s):	Rob Lawson – Artesia Consulting Bruce Horton – Environmental Policy Consulting	email:	rob@artesia-consulting.co.uk

This document is one of five technical annexes that accompany the main report "The long term potential for deep reductions in household water demand" produced for Ofwat by Artesia Consulting.

1. Introduction

The research conducted in this project illustrates the complex links between stakeholders and activities associated with water demand and demand management. This complexity could present challenges for scenario development; in terms of what factors to consider, the end goal to be achieved and the likely effectiveness of different demand reduction measures. Therefore we have developed five scenarios to reflect the impact from a range of drivers and pressures. The scenarios each result in a different level of ambition in terms of PCC reduction in 50 years' time. These scenarios provide a range of uncertainties and risks, and help identify opportunities for resilient responses.

The scenarios have been developed using a 'DPSIR' framework to identify and assess how the scenarios perform in terms of Drivers, Pressures, States, Impacts and Responses.

The background to the DPSIR model is described in section 2. Section 3 describes the approach to scenario development and the scenarios themselves. Section 3 also provides an evaluation of the scenarios, which is summarised in the main report.

2. The use of a DPSIR model for context and assessment of scenarios

One way to address this complexity is to apply a model to the subject in order to better classify and understand the various inter-relationships at play. One of the most common analytical frameworks is the Driver, Pressure, State, Impact, and Response (DPSIR) model that more explicitly depicts how socioeconomic development impacts the environment[1]. The DPSIR scheme is a flexible framework that can be used to assist decision-makers in many steps of the decision process. DPSIR was initially developed by the Organisation for Economic Co-operation and Development (OECD 1994) and has been used by the United Nations (UNEP 1994; UNEP 2007) and European Environmental Agency (Dutch National Institute for Public Health and the Environment 1995; Pierce 1998; EEA 1999) to relate human activities to the state of the environment.[2]

The DPSIR model describes a general chain which triggers environmental issues between the origin and the results. This chain indicates that societal, economic and population development act as drivers (D) on the environment, thus producing pressure (P) on it, which gives rise to a change in its status (S) and thus affects it.

[1] Kelble CR, Loomis DK, Lovelace S, Nuttle WK, Ortner PB, Fletcher P, et al. (2013) The EBM-DPSER Conceptual Model: Integrating Ecosystem Services into the DPSIR Framework. PLoS ONE 8(8): e70766. https://doi.org/10.1371/journal.pone.0070766

[2] https://archive.epa.gov/ged/tutorial/web/pdf/dpsir_module_2.pdf

All of these effects then either urge humans to respond (R) to the environmental status (S), changing the complex systems which consists of society, economics and population, or directly act on environmental pressure (P), status (S) and influence (I).[3]

We have adapted this framework for this project so that the 'drivers' are the Ofwat key themes for PR19, as described in section 1.1. Population growth and climate change are regarded as 'pressures' as described in section 1.2, and the 'state' (i.e. the desired state that the scenarios should achieve) is 'resilience'. We felt these modifications enabled impacts and responses to be evaluated more effectively against the long term goals of Ofwat and the wider water sector, in the face of pressures from population growth and climate change, which are taken as given.

Whilst there has been criticism of the DPSIR model for being too linear and not being able to account for 'many-to-many' relationships between factors, it is considered an appropriate tool for this study because of the way it has been adapted and applied..

2.1. Drivers

At the highest level, this project is driven by the challenge of sustaining an effective system for water provision in England and Wales. This is exemplified in Ofwat's four key themes for the PR19 price review, which for the purpose of this study will be used to define the drivers in the DPSIR model:

- Customer service. Ofwat wants to see an improvement in the services customers receive.
- Affordable bills which offer value for money and are clear, fair and as low as they can be while ensuring there is the right amount of investment for the future.
- Innovation and new ways of working. Water companies should do more to test themselves to improve and innovate.
- Long term resilience in the round, including resilient supplies that recover quickly from problems like bursts and floods, resilient companies with sound governance and resilience for the environment. It also means tackling issues that could compromise resilience – like leakage, wasting water, and bad debt.

Meeting the objectives set out by these drivers will result in sustainable and resilient water sector and these drivers are therefore considered an appropriate starting point for the DPSIR model.

2.2. Pressures

The main pressures on water provision in England are Wales are the demand for water and climate change. The demand for water is driven by population growth and how individual consumers use water – i.e. water consumption. This project is focused on water use in households, i.e. household consumption.

In this project we have assumed that climate change and the forecast growth in population (as well as the uncertainties associated with these pressures) are a given and therefore the responses we consider have to take account of these pressures but cannot influence them.

This project considers how household water consumption (i.e. the third of the pressures identified) can be modified to ensure an effective system for water provision, that meet Ofwat's four key themes for PR19.

[3] Shikun Sun,Yubao Wang,Jing Liu,Huanjie Cai,Pute Wu,Qingling Geng,Lijun Xu (2016) Sustainability assessment of regional water resources under the DPSIR framework. Journal of Hydrology Volume 532, January 2016, Pages 140-148. https://doi.org/10.1016/j.jhydrol.2015.11.028

2.3. State

For this project we have taken resilience, as defined by Ofwat in their Resilience in the Round document to be the desired state for water resource and supply systems:

"Resilience is the ability to cope with, and recover from, disruption and anticipate trends and variability in order to maintain services for people and protect the natural environment now and in the future."[4]

This resilient state is then taken to be the long-term goal of the water sector in England and Wales. The scenarios that we have developed will be assessed qualitatively in terms of their performance against this goal. This will be done by qualitatively evaluating their performance against some simple metrics, described as 'impacts' in the following section.

2.4. Impacts

The impacts of the scenarios will be evaluated qualitatively based on the following factors:

- The ability to deliver the reductions in household consumption necessary to maintain environmental resilience whilst meeting the needs of society and consumers.
- Levels of service – the likely frequency and duration of supply interruptions such as temporary use bans due to an imbalance between supply and demand.
- The cost of water services to customers in proportion to the investment required to deliver the resilience required – in other words how effective and efficient is the scenario at delivering resilience.
- The level of innovation delivered by water service providers in terms of how they work with customers and other stakeholders to deliver the resilience required.
- The extent of institutional change required and the ability of water service providers to effectively govern and fund themselves.

2.5. Responses

The response measures identified in Annex B and section 4 of the main report will be organised into the scenarios. They can be categorised as response measures which:

Affect consumer choice in water using practices. These are measures which will drive change in water using behaviour. Examples include financially-based measures such as charging methods and pricing, including metering, tariffs, rebates, penalties and innovative contracts (c.f. mobile phones). Measures based on behavioural science (including social science and behavioural economics) include personalised bills, targeted promotion of social norms, the use of technology to deliver smarter water using products, apps and home automation. Home visits and retrofits.

Deliver greater efficiency. New technology will reduce the amount of water used without compromising on the utility provided. Examples include ultra-low flush toilets, recycling showers, waterless toilets, washing machines and dishwashers.

Change public perceptions about water. This is regarded as a precursor to ensure many of the other response measures are successful and deliver the greatest possible benefit. Many of the response measures (e.g. water labelling, charging methods) will help to change perceptions about water, therefore clear planning and co-ordination of all the response measures will be necessary.

[4] https://www.ofwat.gov.uk/publication/resilience-in-the-round/

Affect consumer choice in purchasing decisions. Measures in this category include encouraging the purchase of new water using product designs and technologies via water labels, tighter building regulations or policies which promote efficient retrofit choices such as 'Green Deal' type schemes or a 'Water Performance Certificates'. Choices could also be influenced by planning policies to deliver new developments where buildings or communities use water in different ways, such as rainwater harvesting.

Reduce water wastage. Address the problem of leaky loos and the complex ownership, policy and regulation issues associated with customer supply pipes. New technology will provide alarms for leaks in homes and on supply pipes. Smart technology will prevent wastage in end uses.

Affect resource provision. Reducing the supply of water e.g. through abstraction reform will increase the value of water to service providers and require innovative responses to ensure a scarcer resource can meet demand effectively. This is a second order response which could drive the first order responses above.

Affect the governance, funding or regulation of water service providers. This category focuses on changing the way that water services are managed and or regulated. This is a third order response which could drive the first and second order responses above. Outcomes are less certain.

3. Scenario development

3.1. Why develop scenarios?

Scenarios may be defined as an internally consistent picture of a sequence of events, or situation, based on certain assumptions and factors (variables) chosen by its creator. Scenarios are used in estimating the probable effects of one or more variables, and are an integral part of situation analysis and long-range planning. In particular they can:

- Take better account of uncontrolled/random events than single predicted future;
- Can be assessed consistently to identify potential future impacts of demand management initiatives;
- Be a useful decision support tool;
- Provide an understanding of uncertainty and risks; and
- Identify opportunities for resilient responses.

3.2. Defining scenarios for this project

For this project, scenarios can be used to systematically investigate future uncertainties around water demand, and set out how coherent and plausible alternative futures could affect future water use.

In developing these scenarios we have also identified a range of scenario-based studies from the literature review which are relevant to water demand as presented in Table 1.

Table 1 Relevant previous scenarios

Scenario	Authors and Date	Features	Comments
Foresight scenarios	Defra, 2004, updated 2008	Axes are: Autonomy (local/national vs international) and Social values (consumerist vs community)	Designed to consider future flood risk. Dated, but still useful
EA 2050 scenarios	Futures Company 2012	Based on 2 axes representing 'most critical' uncertainties: Consumption patterns & Governance system	Used to inform water resource strategies, the Water White Paper (Defra, 2011) and sustainable abstraction policies
EA	with Cranfield and HR Wallingford, 2015	DPSIR approach	Evaluating EA scenarios in relation to RBMPs up to 2050
Climate futures: responses to climate change in 2030	Forum for the Future (2008)	Focused on the social, political, economic and psychological aspects of climate change	Useful for big picture
Future proofing the UK water sector	Atkins (2013)	Axes: societal value placed on resources; and energy price & availability	'No regrets' pathways include: Data/ knowledge management; customer; enhanced skills/workforce; innovation
The Future of Water UK Timeline	Imperial College (2017)	Considers how technology, society, the environment, the economy and new policies will shape water consumption	Each impact classified as 'present' (up to 2020), 'probable' (>50% prob. by 2030) or 'possible' (could occur by 2040)
The Long View	Yorkshire Water/pwc (2016)	Six credible scenarios	Possibly overly tied to current agenda? E.g. takes market reform as a 'given' but renationalisation "not considered a credible option"

3.3. Scenario development

We have developed five scenarios taking account of the following research and inputs to this project:

- The response measures identified in section 2.5 (and described more fully in Technical Annex B); and
- The approaches and evidence from the previous water-related scenario-based studies, summarised in section 3.2.

We have developed five scenarios of plausible futures for the water sector in fifty years' time. These scenarios reflect a range of responses that may be taken to deal with pressures on water provision in England and Wales, as described in section 2. They take the current 'landscape' of the water sector in 2018 as a starting point. Based on the response measures identified in Technical Annex B, the current landscape can be characterised as presented in Table 2.

Table 2 Current landscape for water services in England and Wales

Response	Current situation
Change public perceptions about water	There is a general perception, based on stakeholder feedback, that public perceptions about water in England and Wales are insufficient to enable significant change in water using practices.
Affect consumer choice in purchasing decisions	At present there is a voluntary labelling scheme for water using bathroom products[5]. However, one of the most common stakeholder feedback responses was that this was not sufficient, and that mandatory labelling was required. Anecdotal evidence suggests a lack of choice in levels of water efficiency for products such as toilets and showers.
Affect consumer choice in water using practices	Recent trends in household consumption suggest a small but notable decrease in household consumption which is likely to have included some changes in water using practice. There is also evidence of a wide range in practice with a proportion of properties showing either profligate water use or water wastage.
Reduce water wastage	The introduction of drop valve toilet cisterns (instead of siphon-based cisterns) has led to an increase in water wastage when these mechanisms become faulty. This is likely to be a growing problem as more of these devices reach the end of their design life. The complex and confusing ownership and water accounting issues around customer supply pipes is also a constraint on reducing water wastage.
Deliver greater efficiency	The drivers for delivering greater efficiency in water using products is limited. Building regulations for toilets mean that the remaining larger flush toilets will be replaced by maximum six litre flush models in the next 10-15 years. Increased energy efficiency for washing machines and (to a lesser extent) dishwashers will also have an effect. There are no obvious drivers for efficiency in showers or taps.
Affect resource provision	Defra announced a new 'Water abstraction plan' in December 2017[6]. This includes abstraction reform, based on a new catchment focus, and continued effort to reduce unsustainable abstraction. The effects of these changes on water availability are as yet unknown.
Affect the governance, funding or regulation of water service providers	The model of water service provision, by privately owned water companies, is attracting increased criticism, with the current Labour Party opposition calling for renationalisation[7]. Water companies have also been criticised for their approach to executive remuneration and levels of debt they carry in proportion to their assets by the current Government[8]. Company resilience is under review following the challenging operational conditions of the freeze-thaw event in early March 2018[9].

[5] http://www.europeanwaterlabel.eu/
[6] https://www.gov.uk/government/publications/water-abstraction-plan-2017/water-abstraction-plan
[7] https://labour.org.uk/wp-content/uploads/2017/10/labour-manifesto-2017.pdf. Page 19
[8] https://www.gov.uk/government/speeches/a-water-industry-that-works-for-everyone
[9] https://www.ofwat.gov.uk/pn-11-18-ofwat-review-water-sectors-handling-recent-supply-interruptions/

In developing these scenarios we assume the following are constant for all four scenarios:

- **Population and demographic forecasts.** Water companies use common guidance to estimate population and property forecasts in their supply areas based on projections from the Office for National Statistics and local authorities. Population and property numbers are generally forecast to increase across England and Wales. These projections are embedded in the scenario forecasts presented in section 5 of the main report (and also described in further detail in Technical Annex D). Variations in these forecasts will have an impact on the future demand for water, but will not affect how scenarios characterise future water consumption by individuals and households.

- **The effect of climate change on water resource availability and demand.** Water companies take account of climate change impacts and the associated uncertainties in their forecasts of supply and demand. In general, climate change is expected to reduce water resource availability, though the impact and extent of this is variable depending on water resource systems. Climate change is also expected to increase the peak demand for water, though this impact is smaller than the effect on resources. Variations in climate change impacts will affect the future balance between supply and demand, but will not affect how scenarios characterise future water consumption by individuals and households.

- **Macro-economic conditions**. The national economic situation will affect consumer behaviour in terms of how often people move house, when people refurbish kitchens and bathrooms, or buy new water using products. This in turn will affect how and when the response measures summarised in section 2.5 will be implemented, and whether additional effort or cost is required (e.g. in the form of rebates) to promote demand reduction. Macro-economic conditions will therefore affect the performance of the scenarios described below in different ways, depending on how they aim to deliver reductions in water demand. This is accounted for in the uncertainties associated with scenario forecasts presented in section 5 of the main report.

- **Levels of household metering**. Water companies forecast the number of households that will be charged for water services using a meter in their plans. These forecasts are part of the scenario forecasts presented in section 5 of the main report. Metering is a response measure to reduce water consumption and enables other measures such as tariffs. It is possible that water companies could change their metering strategies and forecasts in the future. Therefore the scenario forecasts presented in section 5 of the main report account for a range of future levels of household metering.

We have developed five scenarios for future water demand which take account of a range of factors, as described in Table 3.

Table 3 Scenario descriptions

Scenario name	Description
S-0. Current ambition	There is progress regarding public awareness of future water scarcity issues (via planning control) and there is also reasonable progress to increase the efficiency of water using devices and deliver behaviour change via increased metering, voluntary water labels, and stricter product regulation.
S-1. Unfocused frugality	The public do not perceive water scarcity as a problem and there is limited regulatory intervention or organisational innovation to limit resource availability or constrain water use. Technology fails to deliver efficiency or reduce wastage and as a result households need to conserve water.
S-2. Localised sustainability	Water scarcity is widely recognised as an important issue. Markets in water resources and water services results in widespread competition and local providers delivering integrated water services. This positively influences consumer behaviour in purchasing and use of water using devices.
S-3. Technology and service innovation	Market-driven high-tech solutions drive very high levels of water efficiency and reduces water wastage, e.g. through home automation and waterless fixtures and fittings. A new focus blurs the lines between regulated utilities and home services, including smarter tariffs and pay-per-use.
S-4. Regulation and compliance	Water service providers do not adapt to water scarcity, despite increased public awareness of the issue. Regulators apply strict controls on water availability and usage via punitive controls for companies. Variable tariffs and other behavioural measures are used to limit water use.

3.4. Assessment and review of draft scenarios

The scenarios look a long way into the future and in this context it is difficult to define exactly how the water sector might move from the current situation to those illustrated in the scenarios. To move beyond 'business as usual' and start to deliver the kind of reductions in household water demand that will be required under any of the scenarios, a number of actions are needed. These are presented in Section 7 of the main report as the first steps to delivering these deep reductions, and will allow a broad range of stakeholders to contribute towards this ambition.

Table 4 assesses how each of the scenarios performs against the impacts identified in section 2. Note: there is no Scenario S – 0 in Table 4, this is because this scenario is simply a projection forward in time of the average rate of household consumption reduction (PCC) observed and forecast from 2015 to 2025 by water companies in England and Wales.

Table 5 presents a qualitative assessment of the likelihood that current developments in the water sector in England and Wales will contribute to the four main scenarios. This assessment, derived by the authors, uses the descriptions of the scenarios presented in Table 3 and a subjective consideration of the likely role of the five actual and/or potential developments currently 'at play'. To illustrate, upstream competition is considered most likely to have a role in the 'localised sustainability' scenario, and least likely to factor in the 'regulation and compliance' scenario. Also, the 'technology and service innovation' scenario is most likely to feature retail separation; likely to include upstream competition; but least likely to include renationalisation or natural capital accounting.

Table 4 Performance of the scenarios against impacts in the DPSIR model

Impact	Unfocused frugality	Localised sustainability	Technology and service innovation	Regulation and compliance
The ability to deliver the reductions in household consumption necessary to maintain environmental resilience whilst meeting the needs of society and consumers.	Low – the levels of conservation required in this scenario could mean that the needs of society and consumers are not fully met.	Moderate – consumer behaviour in the purchasing and use of water using devices is positively influenced.	High – this scenario delivers high levels of water efficiency via technology and new water service provision models.	High – regulation achieves reductions in water use and constrains water availability, thus ensuring environmental resilience.
Levels of service – the likely frequency and duration of supply interruptions such as temporary use bans due to an imbalance between supply and demand.	High – the lack of regulatory intervention and need for conservation means that levels of service will be affected.	Moderate – levels of service are a driver for competition and local service delivery. However this new service model may be riskier than the current system.	Low – A new focus on home services means that providers compete for customers with levels of service a key differentiator and performance measure.	Moderate – water use is limited via regulation, tariffs and behavioural measures but strict controls on water availability may affect levels of service.
The cost of water services to customers in proportion to the investment required to deliver the resilience required – in other words how effective and efficient is the scenario at delivering resilience.	Low – lack of investment or regulation means this is not a resilient scenario. There is an indirect cost to consumers because they have to conserve water.	Moderate – creating an integrated local system has a high-set-up cost but lower operational costs. Reduced demand increases resilience.	Moderate – A competitive market is good for prices overall but this scenario requires the use of potentially high cost devices	Moderate – sophisticated tariffs are used to limit water use. These could be cost neutral overall, but winners and losers are likely.
The level of innovation delivered by water service providers in terms of how they work with customers and other stakeholders to deliver the resilience required.	Low – technology fails to deliver efficiency or reduce water wastage and there is limited organisational innovation.	High – water service providers have a greater community role and deliver resilience by working with other providers.	Moderate – there is innovation and closer working with consumers but resilience depends on markets working effectively.	Low –service providers do not adapt to water scarcity initially. Punitive controls are required to deliver resilience.
The extent of institutional change required and the ability of water service providers to effectively govern and fund themselves.	Low – There is limited institutional change and governance and funding structures are assumed to be relatively unchanged.	High – service providers integrate local water supply with drainage and flood mitigation. New funding and governance systems are needed.	High – the lines between regulated utilities and home service providers is blurred. New funding and governance systems are needed.	Low – There is limited institutional change and governance and funding structures are assumed to be relatively unchanged.

The table below presents how likely five key emerging issues are under the four scenarios.

Table 5 Likelihood of various developments in the water sector contributing to the four scenarios

Development	Unfocused frugality	Localised sustainability	Technology and service innovation	Regulation and compliance
Upstream competition	Less likely	Most likely	Likely	Least likely
Retail separation	Less likely	Likely	Most likely	Least likely
Increased role of NAVs	Less likely	Most likely	Likely	Least likely
Sector renationalisation	Most likely	Less likely	Least likely	Less likely
Natural capital accounting	Least likely	Most likely	Less likely	Likely