ZOFNASS PROGRAM
FOR SUSTAINABLE INFRASTRUCTURE
Business Case for Sustainable Infrastructure

The Business Case for Sustainable Infrastructure

Water Infrastructure

Thames Water Utility Limited Water Resources Management Plan 2019 and Projects

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ACRONYMS – GLOSSARY

AMP	*Asset management plan (for a 5-year cycle)*
BP20-25	*Thames Water Business Plan 2020–2025*
CAP	*Competitively appointed provider*
Capex	*Capital expenditure (cost)*
CCWater	*Consumer Council for Water (a statutory consumer body for water and wastewater consumers in England and Wales)*
DEFRA	*Department of Environment, Food and Rural Affairs (UK Government department responsible for the water sector)*
DMA	*District metered area*
DPC	*Direct procurement for customers*
DWI	*Drinking Water Inspectorate*
EA	*Environment Agency (regulator for the natural environment in England)*
EIA	*Environmental impact assessment*
ELL	Economic Level of Leakage
Ml/d	*Megaliters per day*
NPV	*Net present value*
NIC	*National Infrastructure Commission*
Opex	*Operating expenditure (cost)*
PCC	*Per capita consumption (= total consumption / total population)*
PR19	*Price Review 2019 (price controls for the period 2020–2025)*
RCV	*Regulatory capital value*
SE	*South East region of England*
SEA	*Strategic environmental assessment*
SELL	Sustainable Economic Level of Leakage
SESRO	*South East Strategic Reservoir Option*
ST	*Severn Trent Water Company*
STT	*Severn-Thames Transfer*
SWA	*Slough, Wycombe and Aylesbury water resource zone*
SWOX	*Swindon and Oxfordshire water resource zone*
Totex	*Total expenditure (Capex + Opex)*
TW	*Thames Water Utilities Limited (statutory water and wastewater company responsible for the public water supply and wastewater networks in Greater London and the Thames Valley)*
UU	*United Utilities Water Company*
WRZ	*Water resource zone (the largest possible zone in which all water resources, excluding external transfers, can be shared, hence the zone in which all customers experience the same risk of supply failure from a resource shortfall)*
WRMP	*Water resources management plan (a water company's long-term plan for managing its supply-demand balance; it has been placed on a statutory basis, which allows each water company to set out how it will meet water demand up to 2035 and deal with factors such as changes in climate and population)*
WRPG	*Water Resources Planning Guideline*
WW	*Welsh Water Company*

ABSTRACT

Resilient planning, integrated regional considerations, trust and legitimacy with customers, as well as the engagement of stakeholders constitute the main commitments of Thames Water Utilities Ltd (TW) to respond to its users while protecting the environment. This case study presents TW's plans to meet its public commitments and its regulatory requirements, with the planning alternatives for meeting the increased demand and the expected reduced supply while ensuring resilience and sustainability. Part I focuses on the draft Water Resources Management Plan 2019 and its planning options; Part II presents the demand management schemes; Part III describes two strategic long-term water supply options.

Prof. S.N. Pollalis prepared this case study with researchers at The Zofnass Program as the basis for research and class discussion rather than to illustrate either effective or ineffective handling of the design, the construction, or an administrative situation.

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1. INTRODUCTION

1.1 Thames Water Utilities Ltd (TW)

TW is a privately owned utility company, the largest water service provider in the UK, serving almost 25% of the population of England and Wales. It supplies 2.7 Mm^3/day of potable water and treats 4.4 Mm^3/day of sewage.[1] TW's area of operation is the Thames Valley[2] that sits mostly within the Thames River Basin, which represents almost 10% of the area of England and Wales. Due to its area of service, which includes London, TW plays a decisive role in the UK's water industry, coping with population growth in addition to climate change.

1.2 Water supply

According to the National Infrastructure Commission (NIC), the UK faces serious risks of future water shortages, especially in the drier south and east. In February 2008, Hilary Benn, Secretary of State for Environment, Food and Rural Affairs, stated: "The Southeast and East of England already face increasing demand on a finite water supply. The drought of 2004–06 was only managed through controls on what we could use water for. This was not a one-off; indeed, droughts are likely to be more common. By 2080, some long-term climate projections forecast half as much rainfall in summer (nothing like fully offset by 30% more rainfall in winter) in the South East. We need to plan and each of us needs to play our part."[3]

NIC states that the government should ensure increased drought resilience[4] by enhancing the capacity of the water supply system.[5] The new requirement for "Resilience in the Water Industry," already agreed by the regulators and the Government, asks for resilience for a 100-year drought condition. NIC calculated future water balances considering a range of droughts. The analysis assumed no further action beyond those listed in the previous Water Resources Management Plan[6] for 2014 (WRMP14). The baseline demand was assumed to be the "business as usual" scenario to calculate the supply/demand balance for each water company.[7]

1 These figures correspond to 600 Mgd (Megagallons per day) of fresh water and 1,000 Mgd of sewage.

2 See Appendix A for information regarding the Thames Valley.

3 DEFRA and HM Government, "Future Water: The Government's Water Strategy for England," Ministerial Foreword, p. 6.

4 In the United Kingdom, a prolonged period of abnormally low rainfall is defined as 15 consecutive days with daily precipitation totals of less than 0.2mm (TW Trading and Procurement Code, V1, May 2016).

5 National Infrastructure Commission, "Preparing for a Drier Future: England's Water Infrastructure Needs," April 2018, p. 3.

6 A Water Resources Management Plan is a water company's long-term plan for managing its supply-demand balance. It has been placed on a statutory basis, which allows each water company to set out how it will meet water demand for the next 25 years and deal with factors such as changes in climate and population.

7 The analysis showed that six water companies, serving almost 40% of the English population, would experience water deficits during a drought that has a one in four chance of occurring at least once between now and 2050, as would ten companies (serving almost 60% of households) during a drought with a one in seven chance of occurring between now and 2050 (National Infrastructure Commission, "Preparing for a Drier Future," p. 18).

1.3 Regulatory context

Water companies are regulated by (a) the Water Services Regulation Authority (Ofwat),[8] (b) the Environment Agency (EA),[9] and (c) the Drinking Water Inspectorate (DWI).[10]

In recent years, resilient and sustainable planning have been required by the regulators. As NIC stated in 2018: "The impact of losing access to clean, fresh water for even a short period is unimaginable for many people and, while the risks can never be reduced to zero, much more can and should be done to address them."[11] The public and legal expectations have changed how water companies invest, the timeline, and their planning approach for the next 100–200 years, with an impact on cost-benefit for resilience versus customer charges.

There is a statutory requirement for the UK's water utility companies to prepare a WRMP and a drought plan every five years. EA gives utility companies specific Water Resources Planning Guidelines to follow, signed off in collaboration with Ofwat and DWI. The guidelines request measures to meet climate change,[12] population growth, and "sustainability reductions,"[13] referring to reducing/stopping abstraction of water[14] where the environment is deteriorating.

TW's Water Resources Department is responsible for the technical plan that meets the regulators' requirements.[15] As suggested by NIC, TW follows the "twin-track"[16,17] approach to increase resilience. Both tracks are presented in the WRMP19:

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8 The Water Services Regulation Authority is the economic regulator for the water sector in England and Wales. It sets limits on the charges that the water companies make for their services.

9 The Environment Agency seeks to maintain and improve the quality of "untreated" water in England and Wales. It is concerned with the quality of fresh surface and underground water along with marine and estuarial waters, and strives to prevent/reduce the threat of water contamination.

10 The Drinking Water Inspectorate is a regulator that acts on behalf of the Secretary of State for DEFRA and the National Assembly of Wales. It assesses the wholesomeness of water supplies and undertakes technical audits of water suppliers to examine all aspects of water quality, treatment, and monitoring. The DWI requires each water supplier to submit quality data on a monthly basis for scrutiny. Where necessary, the DWI can require a company to implement schemes to improve water quality and will monitor their progress.

11 National Infrastructure Commission, "Preparing for a Drier Future," p. 13.

12 UK Water Industry Research (UKWIR) was set up in 1993 by the UK water industry (UKWI) to provide a framework for the procurement of a common research program for the UK's water operators on "one voice" issues. The research program is currently divided into the following topic areas: climate change; customers; drinking water quality and health; environmental quality; program management; regulation; sewerage; sludge and waste management; toxicology; wastewater treatment; water mains and services; leakage; and water resources (https://ukwir.org/page/$HOzG1n0!/~undefined).

13 These are reductions in licensed abstraction that are required by the EA to provide environmental improvements. EA together with DEFRA have set a target for 90% of surface water bodies and 77% of groundwater bodies to be in good ecological status by 2021, as a result of water resources (DEFRA, "Regulation of the Water Industry, Eighth Report of Session 2017–19," p. 8).

14 Abstraction is the licensed removal of water from the natural environment. It is regulated by the EA, which provides licenses to anyone taking or transferring more than 20,000 lt/day. There are approximately 19,000 abstraction licenses in the UK of which 1,400 are for public water supply. The rest are for agriculture (1%), industries, and electricity production (70%) (DEFRA, "Regulation of the Water Industry, Eighth Report of Session 2017–19," p. 7).

15 For a diagrammatic view of TW's progress in planning for climate change, see Appendix B. TW has actively supported research by UKWIR into the implications of climate change for water and wastewater treatment and then applied these methodologies to assess the risks, determine thresholds, and plan monitoring strategies to improve the resilience of its water and wastewater systems.

- manage water demand: install water meters, reduce leakage, and increase efficiency,
- provide additional infrastructure for new water supply.

2. WATER RESOURCES MANAGEMENT PLAN 2019

TW's draft Water Resources Management Plan of 2019 (dWRMP19) addresses the growing water needs[18] by adopting a regional perspective taking into consideration options to transfer water from across the region and beyond the UK's borders. TW has coordinated with other water companies[19] across England and Wales, towards planning for resilience for a best value for money.

The dWRMP19 is based on customers' preferences, regulators' requirements, and the scrutiny of the Customer Challenge Group.[20] It has been developed in accordance with:

- The Water Resources Planning Guideline (WRPG) and the more recent guidance set by Government in its Strategic Policy Statement,
- DEFRA's Guiding Principles,[21]
- The recommendations of the NIC report "Preparing for a Drier Future,"[22]
- The Thames River Basin Management Plan,[23]
- The Thames Water Drought Plan,[24]

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16 The Commission concluded that a twin-track approach is required that combines demand management (including leakage reduction) with long-term investment in supply infrastructure.

17 The "twin-track approach" to water strategy was found in 2005–06 to be the best way to strike an appropriate balance between water resource development and demand management in England and Wales. According to the Secretary of State's principal guidance to Ofwat, as part of PR04: "the Government's twin-track approach for water supply requires demand management options, such as fostering behavioral change, use of new technologies and controlling leakage, to be fully deployed before new supply side measures are adopted." According to the EA, the Twin-Track Approach takes a balanced view, seeking the efficient use of water while bringing forward timely proposals for resources development where and when appropriate" (Water Management, 8th Report of Session 2005–06, Volume I: Report. House of Lords, Science and Technology Committee, pp. 26–28).

18 According to Antony Owen, TW Head of Water Resources, Supply & Demand Agent, "The UK Climate Projections 2018 (UKCP18) report confirms the scenarios by TW on climate change and population variation and all evidenced that the options proposed in the WRMP19 are resilient to these changes."

19 Some of the neighboring companies have asked TW to provide water to them in the future, which their customers would pay for, so their needs have been taken under consideration as well.

20 The Thames Water Customer Challenge Group (CCG) is a group that is independent of Thames Water. All water companies in England and Wales have similar groups drawn from a cross section of customers, regulators, and other groups that play a part in the life of the region. The Thames Water CCG has two main roles. The first is to monitor whether Thames Water is meeting its commitments and reports to Thames Water customers, the wider public and Ofwat what progress it finds on an annual basis. The second is to consider whether Thames Water's future plans reflect what customers need and want and reports on its findings to Ofwat.

21 The 25-year Environmental Plan from DEFRA sets out the long-term approach to protecting and enhancing natural landscapes and habitats in England for the next generation ("A Green Future: Our 25 Year Plan to Improve the Environment," DEFRA, January 2018).

22 The NIC "Preparing for a Drier Future" report sets out a range of measures which NIC believes Government, water companies, and regulators should undertake to increase investment in supply infrastructure and encourage more efficient use of water.

23 This plan provides an environmental framework for the WRMP. Environment Agency, Thames River Basin District (RBMP) 2015.

- The Thames Water PR19/Business Plan 2020–2025,
- Population and housing data from local authorities.

The regulators asked for a comprehensive program for the engagement of key stakeholders and the community. In February 2018, TW published the dWRMP19 and the public consultation started. Ending on April 29, 2018, TW revised[25] its dWRMP19 plan based on the public and regulatory feedback and issued it again for public consultation in October 2018. The second consultation ended on November 28, 2018. With the new feedback, analyzed in the Statement of Response (Winter 2019), the updated addendum to the revised dWRMP19 was issued in Spring 2019.[26] It also included updates of the Strategic Environmental Assessment, the Habitats Regulation Assessment, and additional assessments to ensure compliance with the Water Framework Directive.

The plan includes TW's projected investments up to 2024 and presents a "Preferred Plan" for new water supply schemes for the period 2020–2100.[27] TW also produced a Fine Screening Report (FSR)[28] to propose a set of water supply options.

2.1 The planning process

Advanced decision support tools were used for a thorough analysis of the demand and supply planning challenges and multiple feasible investment programs for TW's planning proposals. Sustainability measures, such as reduction of abstraction, were also taken under consideration, as required by the EA. TW concluded its planning proposals with:

- A request for proposals for water resources in the Official Journal of the European Union (OJEU), initiated in 2011,
- Bilateral discussions with other water companies and other companies that hold abstraction licenses (e.g., Npower RWE at Didcot),
- Active engagement with regional water resource planning groups, including the WRSE Group,[29] the Water Resources East Group, and the River Severn Working Group.

Preferred planning water management programs have been valued by the company for each Water Resource Zone (WRZ),[30] taking into account "the need to address and resolve the predicted water supply/demand deficit in the planning period. Factors considered were affordability and sharing of costs (capex & opex), customers' preferences, impacts on the environment (loss of land & recreational opportunities), the need for flexibility in managing

24 Thames Water revised draft Drought Plan, 2018.

25 TW was forced to set more ambitious leakage targets and revise its population projections for 2100 to a predicted population for the South East of only 13.9 million.

26 https://www.thameswater.co.uk/sitecore/content/Corporate/Corporate/About-us/our-strategies-and-plans/water-resources

27 New government guidelines support more long-term planning by water companies.

28 The FSR was put out for public consultation, which ended on October 31, 2016.

29 The group was created 20 years ago. It is a regional partnership of the six South East water companies, the EA, Ofwat, Consumer Council for Water, Natural England, and DEFRA to develop long-term plans for securing water supplies in the South East. The water companies are: Affinity Water, Portsmouth Water, SES Water, South East Water, Southern Water, and Thames Water. (More information: http://www.wrse.org.uk/)

30 See Appendix A.

a range of resiliency risks, such as a 200 year drought,[31] adaptability to future changes, best value planning of water supply in SE England and its uncertainties, and the need to facilitate, where possible, sustainable development."[32]

Alternative plans were evaluated, showing higher and lower costs and risks. The final preferred plan is towards the lower end of the cost range while achieving sustainable water resource management. The plan has a different risk profile from previous water resource plans and strikes the most appropriate water management balance throughout the planning period. TW has ranked affordability in providing an economical system of water supply as a main factor in deriving the preferred plan, which included (a) reduction of leakage, (b) installation of water meters, (c) increased water efficiency (short-term), and (d) new water resources (long-term).

The appraisal of the demand management options

This process developed a range of demand management programs that have been subsequently assessed in the preferred plan preparation. The appraisal included three stages: screening, evaluation, and optimization. Each option was linked to costs, benefits, delivery constraints, and the different demand scenarios. Screening led to the identification of 135 generic options, which were reduced to 47 feasible options at the evaluation stage. The 47 options were classified by whether they could reduce leakage or usage and at what cost. Finally, the optimization stage involved comparative assessment of the feasible options using the model of integrated demand management (IDM)[33] to produce the range of deliverable and cost-efficient demand management programs.

The appraisal of supply/resource options

The appraisal process included the identification of constrained and unconstrained resource options through a phased approach and according to the principles of the Water Resource Planning Guideline (WRPG) issued by the EA and Natural Resources Wales.[34] Throughout the resources appraisal process,[35] TW worked closely with stakeholders through frequent technical meetings.[36]

"The four-phase approach [was] comprised of reviewing and screening, detailed investigations, program appraisal and design and planning."[37] The first phase reviewed a generic list of resource options that were presented in WRMP14, focusing on uncertainties

[31] Severe droughts leading to severe restrictions of water would disrupt customers by having a damaging effect on the environment and could cost London's economy alone up to £330m per day. (September 2018. BP20-25, Appendix 4, p. 6).

[32] dWRMP19, Section 11, p. 2.

[33] See Appendix C for the IDM process diagram and an overview of the demand management appraisal process.

[34] In collaboration with DEFRA, the Welsh Government, and Ofwat.

[35] See Appendix D for an overview of the new resources appraisal process.

[36] Technical meetings were held in September 2014, January 2015, March 2015, May 2015, July 2015, November 2015, December 2015, May 2016, October 2016, February 2017, April 2017, June 2017, and January 2018 (dWRMP19, Section 7, p. 5).

[37] dWRMP19, Section 7, pp. 2–3.

and risks. This stage led to screening reports for several larger and smaller possible interventions. Detailed investigations were then undertaken, such as feasibility assessments and cross option studies that determined the best value options. All new options[38] were considered, and phase 2 resulted in a Fine Screening Report, which included the constrained list of 40 new water resource options to be assessed in phase 3 (conceptual design and program appraisal).[39] To understand their impact on the environment, each option was the subject of an SEA as required by the WRPG. For each of the constrained options, conceptual design reports[40] were completed, costs were updated, and bottom-up risk assessments were undertaken for options larger than 50 Ml/d. Then the optimum best value program was determined, ensuring that supply balances demand. After the confirmation of the preferred program, phase 4 will produce the scheme to be submitted, with outlined planning and design.

2.2 Preferred plan

The preferred plan adopts NIC's twin-track approach to ensure resilience and robustness: (a) demand management measures and (b) new water resources. According to dWRMP19, "in the long term, when demand management of water use can no longer keep pace with the increasing deficit, the plan turns to strategic resource development for the SE region."[41]

Demand Management Alternatives

TW has set a target to reduce water consumption from 142 to 136 liters/person/day by:

- The installation of smart meters and sharing the data with customers, and
- water efficiency measures, such as the Smart Home Visits Program.

Demand management is favored by customers. However, "demand management measures alone will not guarantee uninterrupted water supply."[42] According to NIC, "even with ambitious actions to reduce demand, additional supply infrastructure will be needed."

In addition to the above, the company committed to a material reduction in network leakage.[43]

38 "New" as contrasted with those already presented in WRMP14.

39 Constrained options (see Appendix E) include effluent reuse, effluent transfer, desalination, river abstractions, intercompany transfers, innovative groundwater schemes, and a reservoir.

40 These reports provide information on the location of the works, engineering and land requirements, construction impacts, environmental and social mitigation, program assumptions, and risks. The reports are the basis for developing estimates of cost for each option, building a risk register, and completing the Strategic Environmental Assessment (SEA). Today, the options for Thames Water's WMRP are in the conceptual design stage.

41 dWRMP19, Section 11, p. 1.

42 DEFRA and HM Government, "Future Water: The Government's Water Strategy for England," Ministerial Foreword, p. 9.

43 Around 2,900 Ml/day (20%) of water put into the public supply is lost through leakage (National Infrastructure Commission, "Preparing for a Drier Future," p. 11).

Strategic water resource alternatives

The plan proposes a combination of short-term and long-term new water supply options. TW started off with 140 different options. After discussions and assessments, the company ended up with the following short-term schemes:

- Combination of groundwater development and small resource schemes:
  1. desalination (already existing),
  2. water reuse treatment plants, and
  3. direct river abstractions by putting effluent in downstream and then taking water out upstream.
- Water trading with external organizations:[44]
  4. a water trading[45] agreement with RWE Npower – 18 Ml/d from 2020,
  5. new sustainable groundwater sources – approx. 13 Ml/d by 2024,[46]
  6. multiple transfer opportunities from outside Thames Valley, both pipeline and canal options, to transfer untreated water to River Thames.

For the long term, two alternatives were proposed:

1. the South East Strategic Reservoir Option (SESRO), a regional storage and transfer hub;
2. the Severn-Thames Transfer (STT) to bring water from the Midlands via the Oxford Canal, together with an innovative water reuse plant north of London.

Phasing

The plan proposes three phases:

1. Up to 2030: demand management with a combination of groundwater solutions, the Deephams reuse scheme (45 Ml/d), and the Oxford canal untreated water transfer (15 Ml/d) by 2030.
2. 2035–45: the reservoir (SESRO) gradually providing 294 Ml/d, including 100 Ml/d to Affinity Water. It is projected to be operational by 2037–38.
3. 2050s onward: staged development of the STT (to become operational in the 2080s), in order to maintain sufficient resilience for London and the SE to the end of the planning period in 2100.[47]

"Should demand management not deliver the expected savings or should underlying demand from population growth or PCC increase, further groundwater schemes would be able to cope with minor variability until SESRO is delivered in 2037. In the medium-term, if SESRO is not available, the STT option would start earlier. The long-term proposal for a major new reservoir will allow the transfer of surplus winter rainfall from the wetter west of the TW region to the drier east, and benefit customers of several companies in London and

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44 To trade and share water, TW is working with United Utilities (UU), Severn Trent (ST), Welsh Water (WW), the regulator, the EA, and Natural Resources Wales (NRW) to look at the potential for an intraregional untreated water transfer.

45 Water transfer between two water companies.

46 WRMP Phase 4 Workshop slides V4 (material received by Thames Water).

47 dWRMP19, Section 11, p. 1.

the SE. This also provides the required support for further environmental protection to chalk streams and water courses within our region."[48]

- Reduce leakage – 15% reduction
- Continue to install smart meters – 700,000 meters
- Help customers use less water – over 400,000 smart home visits
- Develop new groundwater sources in London
- Buy surplus water from other organizations
- Plan a new water transfer via Oxford Canal for use from 2030
- Plan to develop Deephams reuse plant by 2030 and initiate work on SESRO

Short-term proposals summary (5-year plan), according to the dWRMP19

- Ongoing program of leakage reduction and promotion of water efficiency
- SESRO in Oxfordshire by 2037
- Extension of trading agreement with Essex and Suffolk Water
- Severn-Thames transfer in the 2080s

Long-term proposals summary (80-year plan), according to the dWRMP19

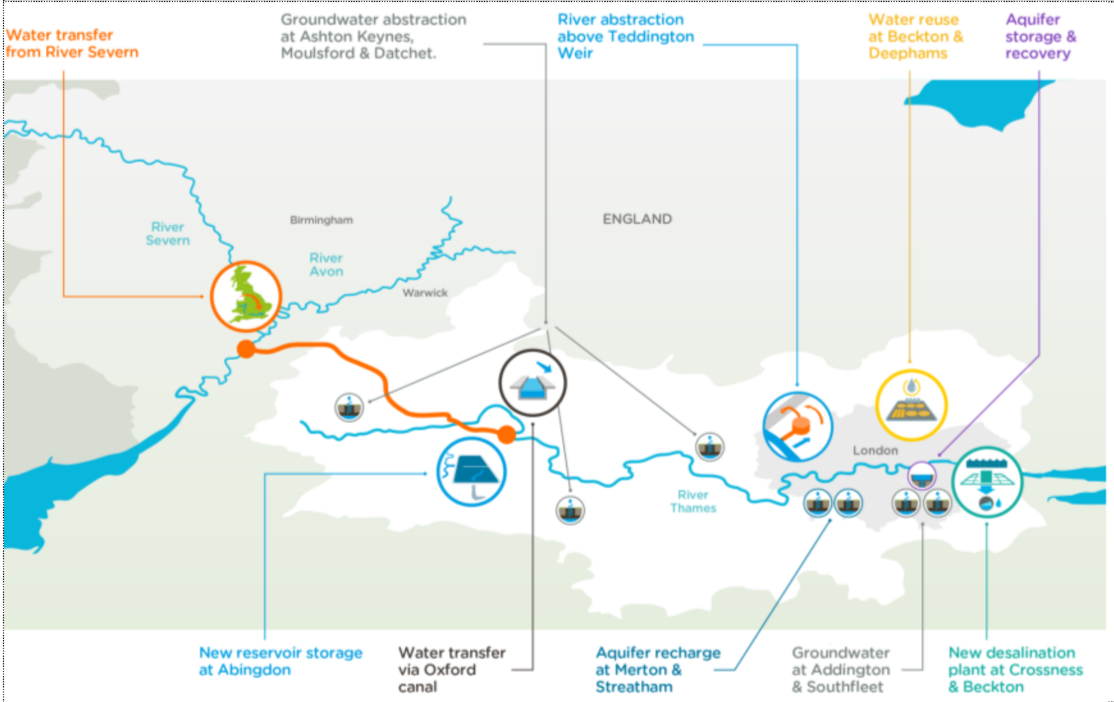

Fig.1: *Overview of all the additional water supply options*

[48] dWRMP19, Section 0, p. 46.

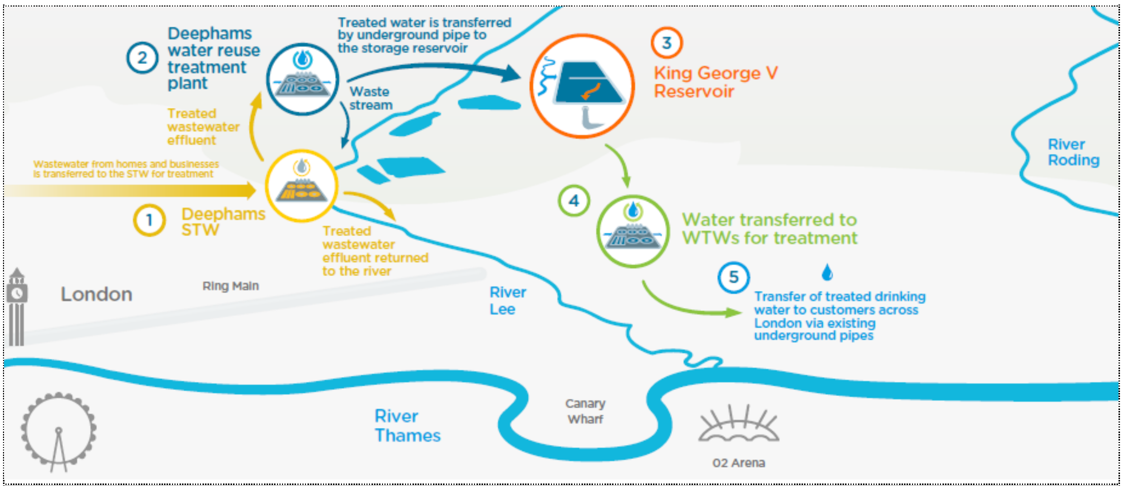

Fig.2: *Water reuse scheme – effluent reuse plant at Deephams*

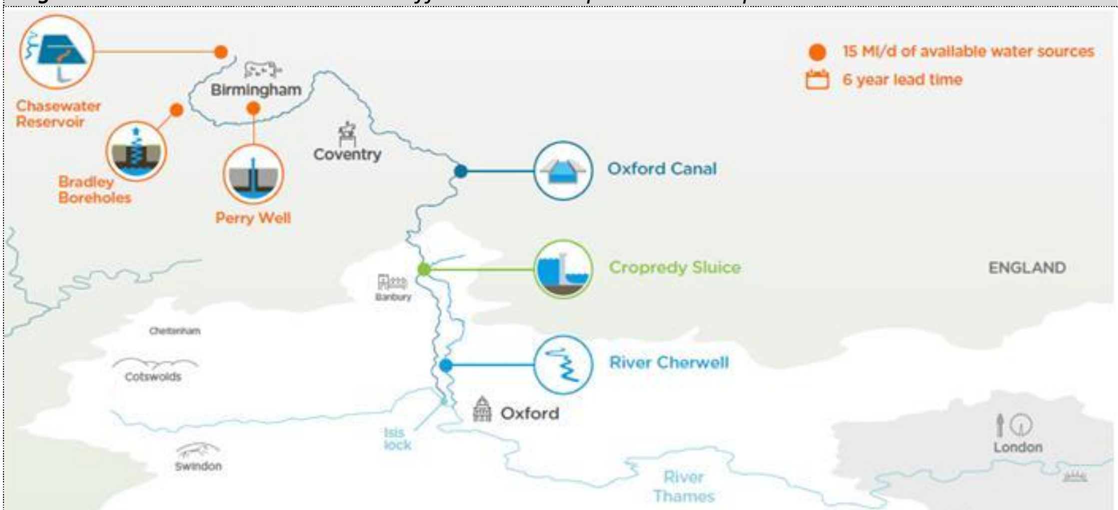

Fig.3: *Local water schemes and transfers*

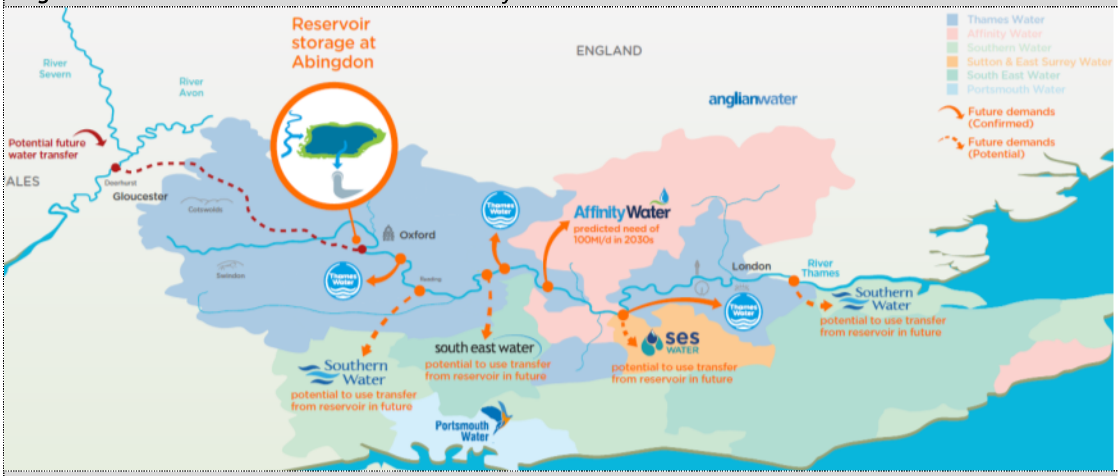

Fig.4: *Intercompany trading*

3. DEMAND MANAGEMENT MEASURES

There is a moral duty to reduce per capita consumption. Thus water companies may increase water prices, requiring those who waste water to pay more. For a given 5-year period, each water company's revenue is determined by Ofwat in real terms at the beginning of the period. Company revenues are linked to required level of investment and efficient costs to operate the business and not to water consumption. In case of over/underspending, companies' revenues are corrected in the following period, in line with Ofwat methodologies.

3.1 Smart metering

A Governmental guidance with pressing targets for water demand reduction is on the way. Smart customer metering is at the heart of reducing demand, in multiple ways. It helps in identifying leaks and it facilitates water efficiency. Smart customer metering, combined with district metering (DM), captures real-time flow data.[49] TW invests in additional measures, such as improving customers' understanding of their contribution to leakage, then testing/fixing pipes/appliances in domestic/commercial properties.

DEFRA should "amend regulations requiring all water companies to consider systematic roll out of smart meters, even in non-water stressed areas."[50] Antony Owen, TW Head of Water Resources, Supply & Demand Agent, mentions: "If our customers decide to use increasing volumes of water, then we can work with each household to try and achieve reductions. But this is not in our direct control, and customers can decide to continue using greater volumes. Whereas, with the leakage within our own pipe network, there is something that we can directly do about that. So there is this difference between customer usage and sustainable network leakage reductions that we can discuss with the regulators as they set the targets with us. … As seen in the last 10 years, metering reduces domestic water usage by 17%.[51] Today TW continues to increase metering coverage, with approximately 40% of domestic properties metered, and with a growing number using smart meters."

Costs and benefits of metering

Smart metering of private networks (households, apartments, businesses) leads to changes in the water charging system from rateable-based to volume-based. Thereafter, according to NIC, there is strong evidence that charging by volume leads to more efficient water use,[52]

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49 "This can result in finding customer demand we did not know about, correcting our understanding of our pipe network, or finding a long-standing leak on a customer supply pipe which couldn't be detected with conventional leak detection techniques" (dWRMP19, Appendix M: Leakage, p. 3).

50 National Infrastructure Commission, "Preparing for a Drier Future," p. 12.

51 According to the NIC, conventional metering can reduce demand by around 15%, and smart meters are expected to increase this to about 17% and help identify leaks (National Infrastructure Commission, "Preparing for a Drier Future," p. 12).

52 According to DEFRA's "Future Water" report (p. 12): "The current system of charging for water, based on rateable values from the 1970s, is increasingly indefensible, particularly in water stressed areas. As less than one third of customers have a water meter, this means that for most customers water bills bear no relation to water use. Metering is increasing, predominantly through customers' own choice. Households that stand

reducing the average household demand.[53] "Overall, customers and stakeholders have a generally positive attitude towards metering, as observed by the Consumer Council for Water research."[54]

The Commission has analyzed potential benefits of systematic smart metering (it helps identify leakages, reduce energy used for treating and pumping, reduce household energy use, and offers volume-based charging), as well as its costs (installation, O&M, replacement), compared to a baseline of continuing the current conventional metering. The results suggest that smart metering should save important amounts of water and with no increase in cost.[55] The Government has allowed water companies in areas of serious water stress to use their WRMPs to make metering compulsory for household customers.[56]

TW's approach to smart metering

Smart metering was one of TW's projects as part of the Green Bond framework[57]. The company started a compulsory smart metering program[58] for all the properties it serves, and is installing a radio network[59] using advanced meter infrastructure and advanced meter readers technology.[60] The company spends annually £70 million on smart metering including upfront engagement costs.[61]

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to save money tend to opt for meters, which has an impact on those households left behind without meters, including large families in properties with a low rateable value. As a consequence, these households could be faced with higher bills as bills for unmetered customers grow faster than metered ones.
"Metering is a fair way to pay for water, in that customers pay for what they use, and it introduces a financial incentive to save water. Metering can therefore stimulate water efficiency. Evidence shows that fitting a meter reduces household water consumption by about 10%. On its own, or combined with innovative tariffs and other technologies, it increases the range and flexibility of measures to address water availability issues. However, installing, reading and maintaining meters adds to water company costs and customers' bills, which in turn are determined by the timescale over which change occurs."

53 On average, households that have a smart meter reduce their water use by 15–20% (dWRMP19, Overview, p. 20).

54 National Infrastructure Commission, "Preparing for a Drier Future," p. 24.

55 See Appendix F for NIC analysis for costs and benefits of metering policies.

56 DEFRA and HM Government, "Future Water: The Government's Water Strategy for England," Ministerial Foreword, p. 77.

57 The framework under which TW and its subsidiaries can issue Green Bonds. The Green Bond Framework ("the Framework") supports the financing of the company's water and wastewater recycling projects related to the environmentally sustainable management of natural resources and land use, as well as climate adaptation. (https://corporate.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/HWDB/Case-studies/Our-Green-Bond-Framework.pdf)

58 TW services a designated water-stressed area and has the right to compulsory metering. Totex approval by the regulator is a legal requirement. Customers ultimately will pay for smart metering, but TW's capital investment program allows it not to charge for the installation of the meter itself.

59 The network is split into district metered areas (DMAs), which is an added benefit.

60 As of 4 years ago, 35% of TW's customers were measured using either dump meters or advanced meter readers. The company was used to dealing with about 2.5 million meter reads per year: one or two reads per customer per year purely for billing purposes. Now, with about 340,000 smart meters that TW has installed in the last 3 years, they are receiving over 7 million meter reads per day.

61 Engagement costs are greater than the meter itself. (Mostly in London where the meters have to be installed inside each property (mostly flats), there is a lot engagement work to be done upfront to get customers to take time off from their work and let TW staff into the property.)

At the beginning of this investment period, TW had 34% of its customers on a metered supply. TW plans for data capturing with a frequency of 24 reads/day that will allow for almost real-time analysis of water use. This will allow the company to identify how much water is consumed, where, and how much is lost because of leaks. Through the installation of 300,000 smart meters by 2020, and a total of 700,000 by 2025,[62] TW expects to reach 75–80% coverage[63] of properties.

Installing meters and making the metering data available helps the customers understand how their habits are reflected in water savings and help the company monitor water flow and identify leaks. As Mark Cooper, TW metering manager,[64] points out: "Normally you have high consumption levels in the morning when everyone is waking up, and [they] drop down, sometimes to 0, if there is no one in the house. Then people start getting home and you see these spikes. What we can see with the hourly data is that these properties (normal households) never go to 0 flow. That means that they have leaks, which could be in the supply pipe or a leaky toilet or dripping tap, etc. The leak in the toilet can cause an enormous spike in your water usage, and that transfers to moving the water bill up from the usual £400–£500. The average size increase in a bill from a leaky toilet is around £800, but we regularly identify leaking toilets that have a greater impact, increasing bills by £3,000 to £5,000 per year. By having smart meter data TW can monitor and fix that."

3.2 Leakage reduction

The EA indicated that water companies should invest in infrastructure to address leakage instead of increasing abstraction to respond to rising water demand. Furthermore, the performance of a water company in managing leakage can have an impact on its customers' attitude to water savings, as well as their perception of the company itself. The Consumer Council for Water (CCWater) stated that "consumers are discouraged from becoming more water efficient because they believe that companies should be doing more to tackle levels of leakage."[65] NIC also supports that "an ambitious long-term strategy to reduce leakage would help encourage action by customers and incentivise technological innovation, which in turn should drive down the costs of managing leaks"[66]

Costs and benefits of leakage reduction

NIC points out that "analysis by water companies and Ofwat suggest that it would be cheaper to use more water than to reduce leakage further." Reducing leakage is expensive,

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[62] BP20-25, Section 8, p. 65.

[63] Universal metering would reduce average water bills, but some customers would end up paying more than they do now. Large families might be worse off with a meter, but this is consistent with the fact that they consume more water. More than half of households likely to have a lower income saw a reduction in their bill (partly related to reductions in consumption). However, the average (mean) bill for households likely to have a lower income rose by around £10 per year. This implies that losses for those households that did pay more outweighed savings among the households that paid less, even though there were more of the latter group. Assistance for lower-income households that might be worse off with metering is therefore likely to be most effective if it is well targeted. (National Infrastructure Commission, "Preparing for a Drier Future," p. 23.)

[64] Officially, "Head of Customer Programmes."

[65] DEFRA, "Regulation of the Water Industry, Eighth Report of Session 2017–19," September 2018, p. 11.

[66] National Infrastructure Commission, "Preparing for a Drier Future," p. 11.

and "fewer than 1/3 of the water companies have included a 15% leakage reduction by 2025 in their draft planning tables."[67] Leakage reduction costs are uncertain as long as the condition of the distribution network is unknown, and the points/times of leakage are not easily spotted.[68]

Each water company has its own Economic Level of Leakage (ELL), the level at which the cost to the company, and therefore to its customers, of further reducing leakage exceeds the cost of supplying water. ELL is not constant. As water resources become scarce, the cost of developing new water supplies increases, resulting in a lower ELL. Operating at ELL means that the total cost to the customer of supplying water is optimal and the company operates efficiently. Ofwat requires water companies to fix leaks, as long as the cost of doing so is less than the cost of not fixing them.[69] This approach is called Sustainable Economic Level of Leakage (SELL).[70]

TW's approach to leakage (per September 2018 Business Plan)

Reducing leakage is a priority for TW customers, making it a strong commitment for the company. TW takes a holistic approach to leakage management, with an eye to affordability and maintaining balance between additional costs of locating and repairing leaks and the impact on customers' bills.

Having missed the leakage target in 2015–16 and 2016–17, the company has put out a detailed recovery plan committing additional funding for activities including leakage reduction and repair, advanced detection technologies, pressure management, and more investment in improving understanding and accounting for water use by installing more smart meters. The company has set the required target of a 15% reduction (97 Ml/d)[71] in its AMP7 within the next 5 years (2020–2025).[72] Then, according to the dWRMP19, the company is planning to reduce leakage by 50% by 2050 (around c270 Ml/d).[73,74]

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67 National Infrastructure Commission, "Preparing for a Drier Future," p. 26.

68 Water companies are required to consider systematic rollout of universal smart metering to identify and address leakage.

69 The cost of not fixing leaks includes environmental damage and the cost of developing new water resources to compensate for water lost through leaks.

70 The ELL is the strict financial level where it becomes more expensive to reduce leakage than to develop new water supply schemes. As leakage is reduced, further reduction becomes increasingly expensive because cheaper methods of leakage control (e.g., pressure management) are exhausted first, leaving the more expensive options (e.g., mains replacement) to achieve further reductions. The SELL makes a further allowance for reducing leakage, by considering the amount that customers would be willing to pay for further leakage reduction beyond the strict economic level of leakage. For example, customers may be prepared to pay an extra £5 on their annual bill to see leakage reduced by an additional 20 Ml/d beyond the ELL.

71 dWRMP19, Section 0, p.48

72 "Due to missing the target in 2016/17 with leakage increasing over the year and each future year's target being more challenging, this recovery plan does not see us meeting our WRMP14 leakage targets fully until 2019/20. However, this plan will ensure we are back on track for AMP7, and it forms a key part of the base plan for the draft WRMP19." (dWRMP19, Appendix M: Leakage, p. 5.)

73 dWRMP19, Section 0, p.48

74 The company is "committed to a package of measures in relation to managing and communicating our leakage reduction performance as part of our undertaking to Ofwat for the purpose of section 19 WIA 1991." https://www.ofwat.gov.uk/investigation-thames-waters-failure-meet-leakage-performance-commitments

	Minimising leak occurrence (consistently)	Understanding where leakage is (quickly and accurately)	Locating leaks (quickly, accurately and efficiently)	Repairing leaks (quickly, efficiently, to quality, with minimal interruption to supply)
Maintaining leakage level	Pumping regimes	Network meter verification	Reactive and recovery leakage surveys	Capacity planning, job planning and dispatch
	Surge vessels	Maintain customer meters	Run step tests	Wastage fixes
	Variable speed pumps	Maintain District Metered Area (DMA) meters	Correlation survey and sound	Valve maintenance
	Managing commercial customer demand	Install loggers on new customers	Gas detection	Traffic management and streetworks
	Pressure Management Valve (PRV) and Pressure Management Area (PMA) maintenance work	Maintain DMAs and Flow Monitoring Zone (FMZ) bounaries and function sets	Sahara surveys and lekage investigations	Repairs on visible leaks, active leaks and customer side leaks and fast reinstatements
	Network reconfiguratin to meet new customer demand	Network meter repair and replacement	Seepage investigations	Special focus on fast repair of visible leaks
	Mains replacement to offset deterioration	Maintain commercial loggers	Maintain waste areas and meters	Trunk main repairs
Reducing leakage	New PMA schemes	Improve network metering	Special surveys	Reduce repair times
	Network reconfiguration to reduce pressures	Improve DMA operability as part of DMA Enhancement	Campaigns management and burst sectorisation	
	Mains replacement to enhance asset	Sub- divide DMAs as part of DMA Enhancement	Join up acoustic logger data with DMA flows	
		Integrate use of smart meters		

Fig.5: *TW's holistic approach to leakage management (dWRMP19, Appendix M)*

Leakage reduction will be achieved through better detection of leaks both on the customers' side and in the company's network.[75] The TW network is, on average, 80 years old, with 34% of it over 100 years old, and is characterized by high levels of leakage compared to other water companies. 67% of the leaks are under London, making them challenging, costly, and disruptive to access and repair.[76] As Steve Robertson, TW CEO, stated: "TW has a massive network that is very dense, particularly in London. Every time there is a connection in the water network, there is an opportunity for a leak to happen. 98% of leakage is underground." Replacement and refurbish of mains will reduce leakage and stop deterioration. The company also invests heavily in innovative new leak detection technologies such as satellite detection,[77] drones,[78] and acoustic loggers.[79] These technologies combined with increased smart metering will help TW manage leakage recurrence efficiently and drive leakage below current levels.

75 Approximately one quarter of leakage is estimated to be from leaks on customers' own supply pipes/appliances (dWRMP19, Appendix M: Leakage, p. 5).

76 BP20-25, Appendix 4, p. 5.

77 "Satellite leakage detection uses thermal and infrared imaging signatures from satellites to identify areas where the ground temperature is significantly different to the surrounding area to indicate the potential location of a leak" (dWRMP19, Appendix M: Leakage, p. 10).

78 "Aircraft and drone technology is similar to satellite leak detection, in that it uses thermal and infrared imaging techniques to identify the possible location of a leak, but with the difference that it can be targeted to a specific main, in real time. This approach is primarily being tested on trunk mains." (dWRMP19, Appendix M: Leakage, p. 10.)

79 These listen to the water going through the pipe and help narrow down the area where the leak may be.

3.3 Water efficiency

Increasing water efficiency can save considerable amounts of water. Customer behavior as well as low-flow fixtures and water appliances are crucial. Campaigning, public engagement, and water labeling allow customers to make informed decisions.

TW's approach to water efficiency

TW plans to work with its customers to save approximately 40 Mlt/d of water by 2020, through new water efficiency measures. The company will support its 400,000 domestic customers and 34,000 business customers[80] through the Smart Home/Business Visits program associated with smart metering, providing customers with tailored advice and installation of free water efficiency devices, and through incentives and rewards that the company will create for both households (e.g., rewards for customers who use less water) and developers (e.g., install non-potable water systems for toilet flushing). TW customers will save water, money, and energy for heating water.

Through the cooperation of TW with the Government, measures were adopted for new and existing buildings to promote non-potable water consumption, such as through reuse of shower water. The company works with developers and pressure groups towards incorporating the new water standards into the building standards.[81]

For existing properties, measures are taken to continuously nudge customers, via letters and emails, to go to the TW website and check their usage or educate themselves on water use patterns and charges and what they can do to use water efficiently. TW is providing new taps, shower timers, and efficient toilet systems that use less water.[82] Additionally, in the Smart Home/Business Visits context, once the TW analytics department detects a continuous water flow or high usage, TW staff visits the property (household or business) to inform the customer and check the appliances. They provide assistance to each property primarily by assessing water use, the efficiency of the water machines,[83] and the usage patterns.[84] As water is cheap compared to energy, TW relates water to energy usage to

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80 BP20-25, Section 8, p. 65

81 From 2008: "The joint Communities and Local Government department (CLG) and Defra policy statement on water efficiency in new buildings announced that the Government will amend the Building Regulations to include a requirement for a minimum standard of water efficiency in new homes. The requirement will be in the form of a calculated whole building performance standard set at 125 liters per day (l/p/d). This will ensure that all new homes have fittings with a good standard of water efficiency, while retaining flexibility in the way overall performance is achieved. New requirements on water efficiency will be introduced into Building Regulations at the same time as any changes to improve the safety of hot water systems and to update the supporting technical guidance." CLG has also issued the Code for Sustainable Homes, a national voluntary standard for the sustainable design and construction of new homes. (DEFRA and HM Government, "Future Water: The Government's Water Strategy for England," Ministerial Foreword, p. 25.)

82 According to DEFREA's 2008 report "Future Water" (p. 31): "All water companies offer water efficient devices either free of charge or at a subsidized rate. These include Cistern Displacement Devices (e.g. Hippos, Save-a-Flush), Water butts, Trigger hose attachments, Domestic/commercial water audits, Free supply pipe repair/replacement (in most cases). In addition, all water companies have water saving information on their websites, along with information in bills and literature."

83 If they find a number of leaking taps, toilets, etc., then the company will send a plumber to fix them.

84 For example, if the customer is having incredibly long showers which puts the electricity and power bills up.

persuade its customers to reduce water consumption.[85] According to Mark Cooper: “We are really trying to demonstrate how much the customers will save in their water and energy bills. We link the smart visit of ours to talk to them about their water consumption in terms of energy. For example, if the user is having 4-minute showers as we recommend, instead of 20-minute ones, then their bill can drop down at least £250. Then if you link in how much energy you are saving without heating all that water, that meter became cost neutral.”

4. NEW WATER SUPPLY OPTIONS

NIC has assessed the additional capacity needed by the UK’s water system[86] and proposes a combination of options: reservoirs, transfers, reuse, desalination. Ofwat’s assessment on TW’s Business Plan for 2020–2025 allows £151 million in funding “to facilitate the development of strategic water resources options for the south and southeast of England to ensure that appropriate regional solutions can be taken forward in future investment plans.” The regulator also stated that water companies should work together to undertake detailed feasibility studies and planning.

4.1 The reservoir supply option

The South East Strategic Reservoir Option is one of the two alternative options for long-term resilience of the Thames Valley water supply. SESRO could make affordable water available year-round, supporting the reduction/abortion of abstraction from vulnerable chalk streams. In 2006, TW proposed a new four-square-mile reservoir[87] in the Abingdon area, which was rejected by the EA in 2011.

In 2018, TW submitted a new proposal for the reservoir, to be built by 2037. The new proposed location is southwest of Abingdon, Oxfordshire, west of London. The proposed clean water reservoir would capture and store water from the wetter west of the SE region to meet the growing needs of Swindon and Oxford and, using the River Thames as a natural, efficient water transfer system, would supply customers in the London, Slough, Wycombe, and Aylesbury areas, under TW jurisdiction. This strategic project is promoted for joint ownership by TW and Affinity Water.[88] It would supply the WRSE untreated water needs of Affinity Water (100 Ml/d in 2037) and potentially of South East Water. Both companies have existing intakes on the River Thames. TW’s Business Plan 2020–2025 includes £31 million for

[85] The second biggest thing in your home that consumes energy is water heating.

[86] “The government should ensure that plans are in place to deliver additional supply and demand reduction of at least 4,000 Mlt/day. […] According to the projections the costs to maintain current levels of resilience relying on emergency measures for droughts are between £25b–£40b, whereas for proactive long-term resilience improvements, it ranges between £18b–£21b. […] Whilst the costs of proactive long-term resilience improvements roughly scale with additional capacity, the costs of emergency measures rise more dramatically for the most extreme events.” (National Infrastructure Commission, “Preparing for a Drier Future,” pp. 7–9.)

[87] https://www.bbc.com/news/uk-england-oxfordshire-12651131

[88] Affinity Water is the company supplying water to Hertfordshire, Kent, and Essex.

planning the SESRO, as part of a planned £203 million investment in increasing water resources and the capacity of distribution systems.[89]

Project conceptual design

Siting: TW identified several reservoir sites within the River Thames catchment area through a four-stage evaluation process. In the first stage, 55 potential sites were identified through negative screening and the initial constraints relating to permeable strata, built environment, infrastructure, and the distance from rivers with sufficient flows to refill the reservoir. During the second evaluation stage, the performance of the remaining sites was assessed against four absolute constrains[90] and sustainability measures. In the third stage, technical and planning appraisals were conducted, concept designs were developed for six different sizes and three function scenarios,[91] and these were further cost-checked and assessed against further sustainability criteria. Finally, a short list of sites continued to the final verification stage.[92] The company is licensed to acquire the site that will be chosen through the Development Consent Order.[93]

Design features: The proposed site is close to the point where the proposed Deerhurst Pipeline, carrying water from the River Severn, would meet the Thames. During winter, when the Thames is full and quite often overflows to its floodplains, the reservoir will be fed through a large conduit from the river, acting as a balance tank for water throughout the year.[94] The largest option proposed is for a reservoir capacity of 150,000 Ml. The capacity of the existing reservoirs around Heathrow airport is 210,000 Ml of water, so the new reservoir will almost double the installed base.

89 BP20-25, Appendix 4, p. 7.

90 The four absolute constraints were: (1) the site could not be part of an international/national nature conservation area, (2) it could not contain an international/national heritage site, (3) it could not be within 3 km of an airfield, and (4) any clay strata had to be of thickness 10 m or less.

91 The minimum site area was set at 200 hectares, which could accommodate a reservoir with minimum volume capacity 30,000 Ml, and the maximum site area was set at 1,400 hectares with volume capacity of 150,000 Ml of water. The three function scenarios were those of direct supply, regulating, and dual.

92 According to the Reservoir Site Selection Study Report of September 2006, prepared by Arup, the overall siting findings (reservoir size and preferred site) are: 30,000 Ml (direct supply) → Longworth, Abingdon, Marsh Gibbon, or Quainton; 50,000 Ml (both direct supply and regulation) → Abingdon; 75,000 Ml (dual)→ Abingdon; 100,000 Ml (dual) → Abingdon; 125,000 Ml (dual) →Abingdon; 150,000 Ml (dual) →Abingdon.

93 It is a significant asset application for planning which gets Secretary of State approval.

94 According to Antony Owen (TW Head of Water Resources, Supply & Demand Agent): “The water is there. We have done all the climate change reviews, we’ve looked at how things will change in the future, so the expectation is that winters are becoming wetter and summers are becoming drier with more tropical style rainfall, so we have a requirement to capture that water from our existing catchment region through a reservoir.”

Fig.6: *Concept design for the South East Strategic Reservoir Option (2009)*

Project implementation

Construction: The main disadvantages of the reservoir option relate to the loss of agricultural land and the displacement of households and businesses currently on the site.[95] There is also a risk of overlying an archaeological site. "The construction period will be approximately eight years and during this time there is a need to use large volumes of materials. During this period there is the potential to cause disruption and adverse effects on heritage assets as well as adverse impacts on the visual amenities of nearby residents, in particular, the inhabitants of the villages of Steventon, Drayton, Marcham and East Hanney. Such construction activities including the routing of construction traffic would need to be carefully managed with mitigation measures put in place."[96]

Operation: "Over the longer term and once the reservoir landscaping is complete, the scheme has the potential to offer recreation, compensatory habitat provision as well as reducing abstraction from environmentally sensitive chalk streams in the River Thames catchment."[97]

Risks: Risks and challenges of the reservoir option are being reviewed. Environmentally, the lower water temperature that flows from the reservoir back to the river may affect fish. The

95 The site contains 28–30 houses, some of which are for sale and 5 already owned by TW.
96 dWRMP19, Section 11, p. 17.
97 dWRMP19, Section 11, p. 18.

effect of climate change[98] in the region is also being studied in collaboration with the North West and the River Severn area. A study report is put together and has been agreed with UU and ST to ensure the required volume of water. EA pressures for "a hands-off load," an amount of water in the River Severn that is not allowed to be touched.

The economic, commercial, and resilience risks are also being studied. EA guidelines ask water companies to look at their costs and benefits every 25 years. In the case of a reservoir, which takes 15–17 years to build, less than 10 years remain for its benefits to be accrued. By contrast, a desalination plant needs only 7 years to construct. TW asked the regulators for a 25-year minimum period so that the reservoir's benefits can be considered through the reservoir's 80-year operating period.

Complexities also characterize the sharing model for water among the different water companies involved. In fact, water companies in the South East of England may consider cooperation for the development of such a strategic asset.

4.2 Water transfer and trading supply options

Transfers move water from areas with surplus to those where it is needed. According to NIC, transfers enhance resilience because "they increase optionality around further supply options," but they could also spread invasive species and pathogens. As a result, transfer options need to be considered on a case-by-case basis. In terms of costs, NIC presents the option of water transfer as a "positive cost-benefit case for greater transfers and water trading." Ofwat has introduced financial incentives to encourage companies to trade.[99] Currently, transfers make up about 4% of the UK's total water supply.

A more dynamic and transparent market should be encouraged, allowing a wider range of options to be identified and lower costs for customers. NIC points out that "the decision needs to be made at a different level. [...] It is likely to need strengthened regional approaches and perhaps an independent national framework. Ofwat has already developed the 'direct procurement' mechanism for large infrastructure projects which could form the basis of more open and transparent competition ensuring all options for significant additional supply capacity can be considered."[100] The regulators ask for new supply opportunities beyond UK borders to be considered, pushing water companies to bilateral water trade through interregional transfer options.

The Severn-Thames Transfer (STT) option

Regionally, transfer options from the River Severn are part of TW's long-term plan. The company looked at a number of options including transferring water from the Midlands,

[98] Going forward, the risk of drought is likely to greatly increase. The way the UK is split up, the impact of drought further north is less and the South East region is at most risk.

[99] If a company wants to apply for the trading incentive, it needs to have and comply with a Trading and Procurement Code that has been approved by Ofwat.

[100] Ofwat is expected to launch a competitive process by the end of 2019, complementing the PR19, with the aim of providing at least 1,300 Ml/day through (i) a national water network and (ii) additional supply infrastructure by the 2030s. (National Infrastructure Commission, "Preparing for a Drier Future," pp. 10–11.)

Wales and the North West and transferring it via the River Seven and across to the River Thames. TW worked together with other water companies across England and Wales and a number of variants of the Severn Thames transfer have been considered. United Utilities, Severn Trent, Welsh Water and the Canal and River Trust have provided options to free-up water in the River Severn catchment. Thames Water has considered these options for transferring water from the River Severn and River Wye to the River Thames. In appraising options Thames Water has selected a Severn Thames transfer as part of its long term preferred plan (the STT was found not to be required for the water needs of the Thames Valley area before 2039).

TW's long-term STT option would add a further step, taking water to the Severn from Lake Vyrnwy (which was built in the 1880s to supply water to Liverpool) before transferring it on to the Thames. TW proposed putting the lake's water into the upper reaches of the River Severn, but that was rejected by EA because the water of that lake is too cold and would affect fish in the Severn. As a result, TW proposed to build a pipe to a point further downstream. Before distributing the water in the Deerhurst region, TW would put in place treatment works to remove the silt, as that region is in the lower part of River Severn and River Avon.

In TW's original concept for the transfer from Severn to Thames, there was a canal option (making use of an existing canal) and a pipe option.[101] The canal option proved to have two main issues: (1) higher costs for the renovation of the canal and the construction of new segments, and (2) water quality issues, as it would have been an open conduit supplying the pristine upper stream part of River Thames. The pipe option was less costly and with fewer water quality issues. Nevertheless, the water would still come into the upper stream of River Thames. EA asked TW to bring the Deerhurst Pipeline into the Thames further downstream. According to the plan, from 2083 onwards the scheme will include:

- 300 Ml/d pipeline transfer between Deerhurst on the River Severn and Culham on the River Thames, including treatment for invasive non-native species,
- 90 Ml/d of support from Vyrnwy reservoir provided by UU,
- 60 Ml/d of which would be released into tributaries of the Upper Severn and 30 Ml/d of which would be provided to Severn Trent Water to offset their abstractions further downstream,
- 15 Ml/d of support from ST at Mythe in Gloucestershire,
- 35 Ml/d of support from ST's Netheridge sewerage treatment works in Gloucestershire.

[101] The silt would have been removed.

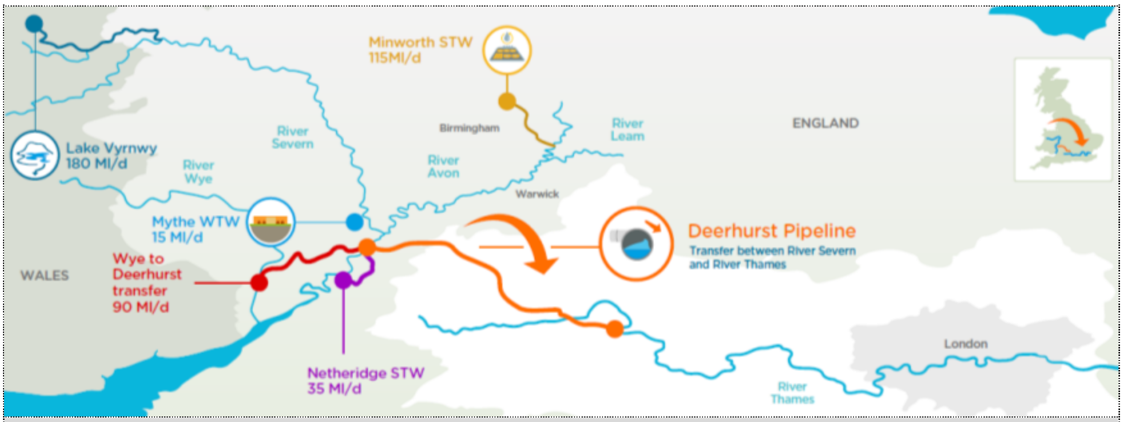

Fig.7: *Water transfer from the River Severn*

SESRO in relation to STT

In terms of operation: "Were the SESRO not to be feasible, STT is the alternative water supply option. Both have the potential to supply similar volumes of water and could be delivered in combination, but the reservoir is preferred to be delivered first on the basis of less cost and higher reliability. Ongoing opex associated with the reservoir is also significantly lower than the STT, which supports usage in non-drought conditions to enable (with new connectivity) reduced abstraction from existing sources perceived to be putting hydrological pressure on vulnerable chalk streams and water courses. The opex cost ratio of the transfer in comparison to the reservoir (at P50 cost confidence) is approximately 3.3 to 1, which illustrates the significantly higher running costs of the transfer option."[102] The dWRMP19 customer research revealed that customers' top three criteria for devising TW's dWRMP are: (a) cost, (b) type of option, and (c) reducing the risk of severe water use restrictions. The reservoir scores higher than STT, together with other factors such as cost, resilience, environmental impacts, intergenerational equity, customer preference, deliverability, and adaptability.[103]

In terms of resilience: "STT supports interbasin transfers between water companies, albeit UU would need to develop new water resources in its own supply area to facilitate a large transfer and, therefore, resource development would still be required. The long conveyance route of the option would in its own right constitute a substantial capital investment project for the pipeline section. The long route is also at risk of pollution events in the rivers Severn and Vyrnwy and, as such, it can be considered less resilient than the SESRO, which is located within the Thames catchment area. On the other hand, inter-basin transfer increases the size of the catchment, which could have a positive effect on resilience due to lower probability of coincidental drought across several companies' regions, although coincidental droughts are likely to become more frequent."[104] The STT scheme also falls under the jurisdiction of Natural Resources Wales and will require support from the Welsh Government.

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[102] dWRMP19, Section 11, p. 15.

[103] For the advantages and the weaknesses of both alternatives, refer to Appendix G.

[104] dWRMP19, Section 11, p. 17.

"SESRO is more flexible with regard to water supply and cheaper than the STT option. It would provide additional untreated water storage, which improves resilience in the SE and enables other TW untreated water storage reservoirs to be taken out of service for routine and unplanned maintenance."[105] The issues associated with the higher cost and lower reliability of the STT option can be mitigated to a certain extent through the construction of the SESRO. The reservoir will increase the existing storage capacity in the Thames catchment before implementing a transfer, reducing financial and environmental costs and improving the reliability of the STT scheme.

4.3 The DPC approach

The direct procurement for customer (DPC) option[106] is a framework set by Ofwat to competitively tender for a third party to design, build, finance, operate, and maintain large infrastructure assets exceeding a Totex of £100 million. The competitively appointed provider (CAP) becomes the owner of the new asset.[107] Potential DPC schemes include resilience schemes, reservoirs, reuse works, desalination and water treatment works, as well as water transfer schemes.

Ofwat has set out a range of potential tender models[108] based on the stage of the project's lifecycle[109] when the CAP undertakes the process. To conclude the best DPC option for each proposed scheme, each water company (the appointee) must deliver to Ofwat an assessment of suitability for delivery via DPC. This assessment includes a value for money assessment (VfM), economic appraisals, assessment of each DPC model and its associated risks, a commercially feasibility study of the proposed approach to DPC, and financial forecasts of the Capex, Opex, and revenue of each DPC option.

The allocation of the technical risks/issues for the potential DPC projects within their project lifecycle are summarized in the following table. According to KPMG's report for Ofwat, "the core principle of allocating risk among the appointee, the CAP and the end customer should be to allocate risk to the party best placed to manage the risk."[110]

[105] dWRMP19, Section 11, p. 17.

[106] A guidance introduced as part of the next asset management period (PR19) with the potential to provide significant benefits for customers by promoting innovation and enabling capital and operational cost savings as well as a reduction in financing costs (https://www.ofwat.gov.uk/publication/1810-direct-procurement-customers-dpc-setting-expectations-high-quality-well-evidenced-case/).

[107] Ofwat has given the guidance under a contract period of about 25 years (interview with Anthony Purcell, TW Commercial Manager).

[108] In the "early" model, the CAP undertakes the project at the option appraisal/initial design stage. In the "late" model, the CAP undertakes it at the planning stage, in the "very late" option the CAP provides only the financing and operation of the new asset, and finally in the "split" option the project is tendered in two stages, an initial design/planning stage and a later construction, financing, and operation stage.

[109] See Appendix G for the project's lifecycle.

[110] See Appendix H in order to compare this with current allocation of risks under status quo models.

Key Risks in Project Life Cycle	Stakeholder			Comments
	Appointee	CAP	Consumer	
1. Solution Development				
Data	✓		✓	— Allocation of early design and solution development risks likely to be similar under DPC to existing models. Especially for later tender models. — Early tender model may allow some greater sharing of risk with CAP.
Uncertainty	✓		✓	
Constraints	✓	✓	✓	
2. Planning				
Land purchase and site risk	✓		✓	
Environmental and social risk			✓	
Planning / Consent permission	✓		✓	
Third Party Consideration	✓	✓	✓	
3. Design				
Design process		✓	✓	— Allocation of design risks likely to be similar under DPC to existing models. Especially for later tender models. — Early tender model may allow some greater sharing of risk with CAP.
Design for construction	✓		✓	
Design for maintenance	✓		✓	
Resource availability and expertise	✓	✓		
Change in design required due to external influences	✓	✓	✓	
Materials and plant		✓		
4. Delivery				
Time and cost overrun risk		✓	✓	— Allocation of construction or delivery risks to the CAP from the appointed company is anticipated under the DPC model but assumed to generally be a direct transfer.
Resource availability of contractors		✓	✓	
Unforeseen ground or existing building conditions		✓	✓	
Third party claims		✓	✓	— Some opportunity for risk transfer from customers may be possible in the competitive tender process albeit that this is likely to be priced in the bid. — We assume that some re-openers to CAP revenue continue for material changes that are outside of management control (see section 4).
Subcontractor default / bankruptcy		✓		
Poor project management		✓		
Commissioning overruns		✓		
Availability of facilities	✓	✓	✓	
Legislative / regulatory change	✓		✓	
5. Operation				
Service performance risk	✓	✓	✓	— Allocation of operational risks to the CAP from the appointed company is anticipated under the DPC model but some service related risks may be difficult to transfer where they relate to statutory obligations. — Some opportunity for risk transfer from customers may be possible in the competitive tender process albeit that this is likely to be priced in the bid. — We assume that some re-openers to CAP revenue continue for material changes that are outside of management control (see section 4).
Resource or input risk		✓	✓	
Demand risk		✓	✓	
Maintenance risk		✓	✓	
External and third party impact		✓		
6. Transfer				
Asset condition and performance at handback	✓	✓		— Introduction of DPC model creates new asset transfer and hand-back risk which we assume is shared across appointed company and CAP. DPC contract would need to include requirements for asset transfer and hand-back.
7. Tender model specific risks				
Procurement failure	✓		✓	— Assume procurement risk is faced by both companies and customers where this results in delays or cost increases.

Fig.8: *Potential risk allocation under the DPC model ("Direct Procurement for Customers: Technical Review," by KPMG LLP for Ofwat, December 2017)*

SESRO as a DPC project

The Thames Tideway Tunnel, which used the DPC framework, was a first for the water industry.[111] TW later developed a series of tests to identify projects that could benefit from the Thames Tideway Tunnel's procurement method.[112] Out of 775 projects tested, those most suitable for a DPC approach are the SESRO, STT, Deephams Re-use Plan, and

[111] For more information on this project visit: https://www.thameswater.co.uk/sitecore/content/Corporate/Corporate/About-us/thames-tideway-tunnel/what-is-it

[112] These tests include: (1) a minimum Totex threshold of £80 million is set over the contract term, (2) the project is sufficiently discrete for the market to offer a procurement solution, (3) there is a strong "customer value" argument for a DPC approach, and (4) the market is able to effectively finance a DPC project (BP20-25, Section 11, p. 88).

Teddington Direct River Abstraction.[113] Both SESRO and the Deephams project are considered priorities and have been put forward in the company's business plan for 2020–2025. The STT option will be worked on in its technical and environmental aspects during the next planning period.

If DPC is approved by the regulator for SESRO, TW will pay for the costs of the preparatory works (site acquisition and planning). Afterwards, TW will be the client of the third party, guaranteeing through the company's RCV allocation that it will buy an amount of water according to a specific timetable and price. TW is working on how the detailed payment method mechanism for such projects would operate.

According to KPMG's report, a reservoir to be selected as a DPC project should be subject to the following criteria:

Stakeholders & Obligations	Interaction points	Capacity & outputs	Failure
A reservoir will require extensive engagement with a range of stakeholders during the initial stages of the project life cycle, each with their unique agenda and concern. E.g. DWI, EA, Consumer Groups, Environmental Pressure and Lobby Groups etc. Types of challenges include desire for companies to demonstrate alternate means of meeting supply demand balances via leakage reduction. Some of the concerns of these stakeholder groups will best be managed by the license holder, for example land rights. Reservoirs have statutory requirements that must be strictly managed throughout its operational life. Failure to comply with any statutory requirements will be the responsibility of the license holder.	In their simplest form reservoirs typically only have one point from which water is drawn but they can be used as storage and water is often pumped into them during dry periods from elsewhere on the network. Have limited interaction points but there are relationships between these and other network assets i.e. reservoirs impact other assets and downstream also impact them.	The volume of water in the reservoir can be easily assessed/ communicated. Usage of these assets are subject to variation depending on a range of factors such as demand and weather. However modelling for various scenarios is mature with long range forecasts complemented with frequently revised forecasting for the short term. The use of such modelling can be utilized for effective management of usage.	Quality failures are generally well understood, but can be complex to manage and in some cases may require mitigation that extend beyond the reservoir itself, adding complexity. A quality incident at the reservoir will have implications for other downstream assets which need to be managed. Catastrophic failure (e.g. the reservoir embankment bursting) is more complex, however, risk models do exist.

The CAP bears risks. As designed, the CAP will only start receiving payment for the delivery of the asset upon completion of certain milestones, and a delay in construction will impact the CAP's cash flow. TW is working closely with the market to understand how palatable that risk is, in terms of Capex. In terms of the quality output, TW looks at contracting service levels and expectations as part of the contract with CAP.[114]

Project finances

In terms of economic modeling (Capex and Opex efficiency, financing efficiency), TW works with Deloitte to support industry benchmarks for the reservoir option. Deloitte

[113] Teddington DRA is no longer in TW's plans due to the inability for known solutions to suitably reduce the impact of this scheme on water temperature.

[114] TW will have the contract and the communication with the CAP. Therefore, Ofwat will continue to regulate TW as an organization and then the utility will manage the CAP as a contracted provider to them.

recommended a percentage range for Capex and Opex, which TW adopted as part of the company's schemes, in line with what Ofwat proposed as standard assumptions for capital net present value (NPV) of DPC.[115] The standards are: duration of contract, cost of equity, cost assumptions, the 10% Capex efficiency and 10% Opex efficiency (mostly energy efficiency). Then there are additional bid costs, procurement costs, etc.

CONCLUSION

TW's WRMP19 provided evidence that the company has considered the full range of water resilience options for the best value for its customers and the environment over the long term. Options include hard infrastructure (reservoir, transfers, network upgrades), soft infrastructure (metering, leaks repairing, efficient appliances), user-oriented measures (change of behavior, trust, engagement), and finally improved contingency planning.

TW planning solutions prove an innovative approach through effectively working with water customers, using new markets in water resources, and implementing demand management and water efficiency measures.

The company's plan sets key priorities of resilient planning by introducing a risk-based planning approach and focusing on the long term, providing best-value solutions including water trading/sharing with other water companies, reduction of leakage and per capita consumption. At the same time TW's planning horizon is more than 25 years and takes into account possible severe drought events.

[115] According to the Initial Assessment of Business Plans (IAP), Ofwat looked all the DPC responses and then tried to align things like operational Efficiency, capital efficiency and the Present Value (PV) calculation.

APPENDICES

A. Thames Valley Water Supply

Thames Valley is a sub-region of SE England (west of London). It includes: Berkshire, Oxfordshire, Buckinghamshire and counts approx. 11,000km2 of catchment area including River Thames, River Lee and its attributes. Its six Water Resource Zones (WRZs)[1] are forecast to be in surplus at the end of 2019/20.[2] The region is characterized by the Environment Agency as "seriously water stressed". Thames Valley WRZs were assessed and "Three out of five were found to have supply-demand deficits within the 80-year planning period (Swindon & Oxfordshire (SWOX), Slough, Wycombe & Aylesbury (SWA) and Guildford). The remaining zones (Kennet Valley and Henley) were found to have surplus throughout the planning period."[3]

Fig.1: *Thames Valley*

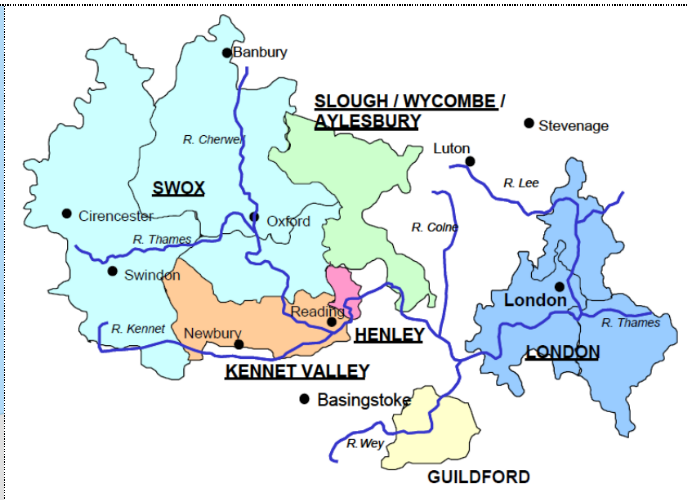
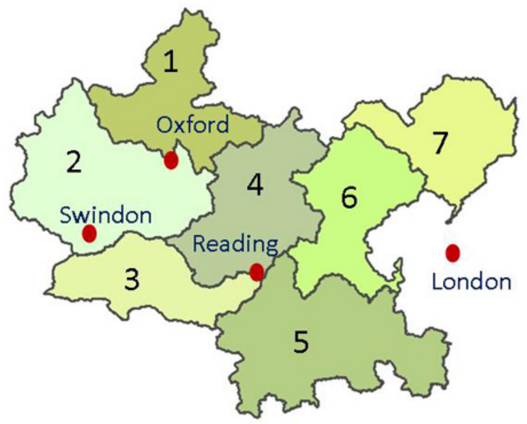


Fig.2: *Water Resource Zones*



River catchments

1. Cherwell

2. Upper Thames

3. Kennet

4. Middle Thames & Thame

5. Loddon, Wey & Mole

6. Lower Thames & Colne

7. Lee

Fig.3: *Sub catchments of Thames Valley*

The Thames basin is one of the most intensively used water resource systems in the world. Of the rain that falls, two-thirds is either lost in evaporation or used by

[1] According to TW a WRZ is the largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall. Thames Valley WRZs are: London, Swindon and Oxfordshire (SWOX), Henley, Kennet Valley, Guildford, and Slough/Wycombe/Aylesbury (SWA).

[2] dWRMP19. Section 00. p.12

[3] dWRMP19. Section 11. p.1

plants. Of the remaining one third, termed 'effective' rainfall, approximately 55% is licensed for abstraction and for use. Of all the water abstracted, 82% is for public supply, with the remainder being used predominantly by industry and agriculture. The water supplies are derived from a combination of surface (river) water and groundwater. In London approximately 80% of the water comes from surface waters (the River Thames and the River Lee) and is stored in reservoirs before being treated and put into supply, with the remainder taken from groundwater. A desalination plant is also located in east London and can be used to provide water in periods leading up to and during drought. In the Thames Valley 70% of the water comes from groundwater with more than 2,600 billion litres of water supplied daily to around 10 million people and 215,000 businesses.[4]

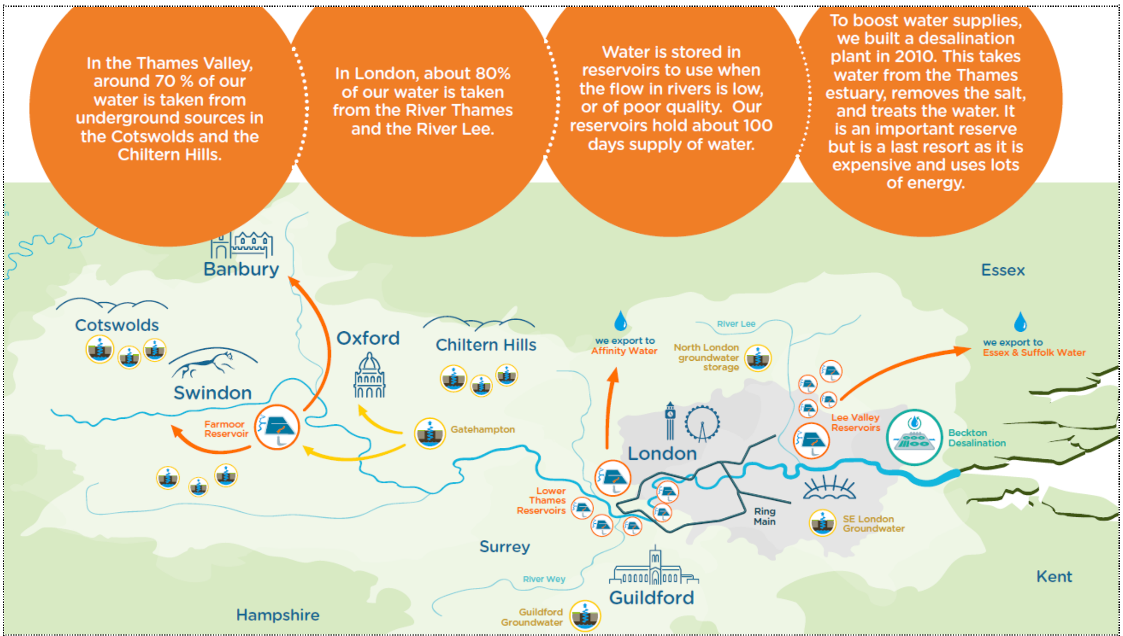


Fig.4: *Current water supply facts (dWRMP19, Overview)*

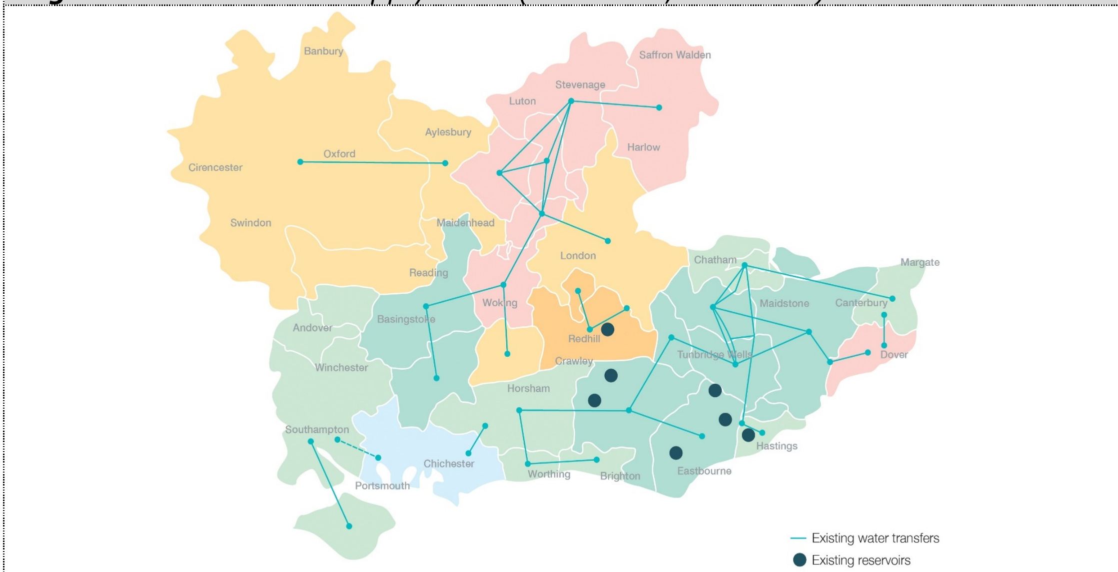


Fig.5: *Water Resources in the South-East, 2017*

[4] dWRMP19, Section 0, p. 4

Water Demand

Water demand is composed of Household water use (to nearly 3.7 million households), Non-household water use (from 215,000 businesses), Operational water use (for network maintenance), Water taken unbilled (legally or illegally without charge), and Leakage (from pipes of the network or those of the customers).

Demand forecasts are being developed in 2 scenarios. The forecast for a dry year (a period of low rainfall) where there are no constraints on demand (Dry Year Annual Average scenario (DYAA), and the average daily demand during the peak week for water demand (Average Day Peak Week scenario (ADPW). Both scenarios are based on information that are drawn mainly from population and property projections and water use data trends. TW forecasts that an increase in total household demand of more than 220Ml/d by 2045 and a total increase of410Ml/d by 2100.

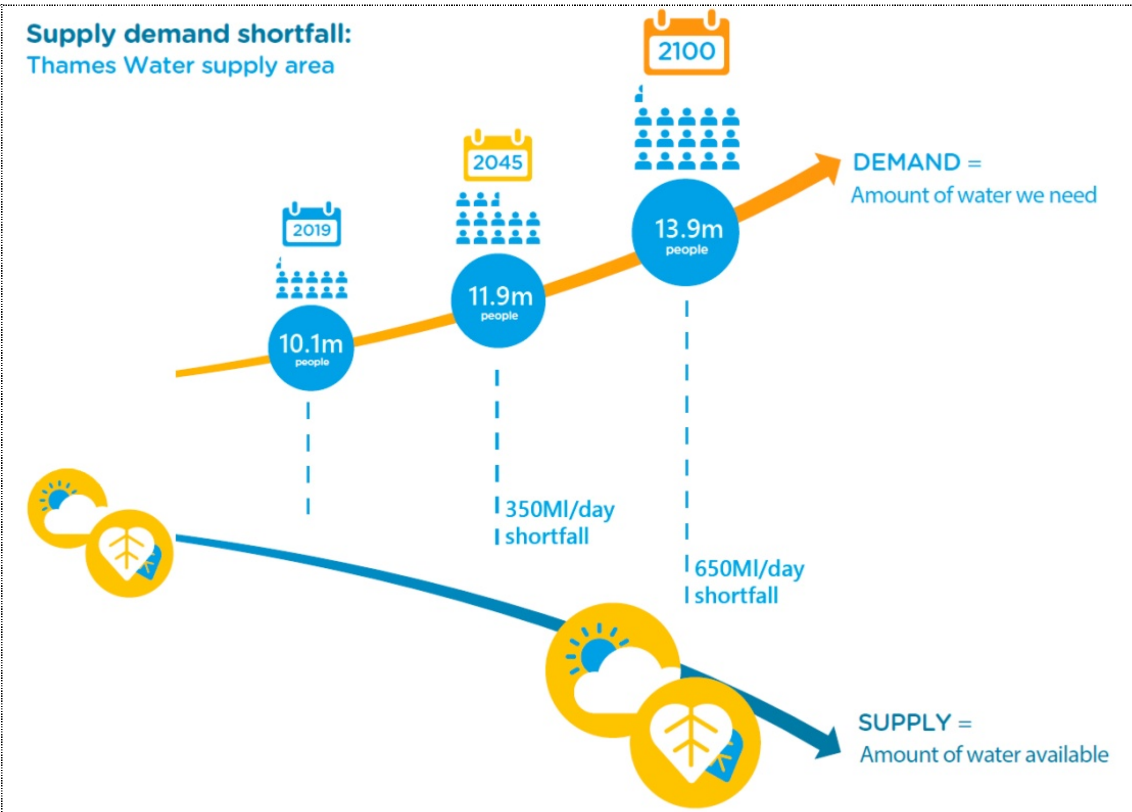


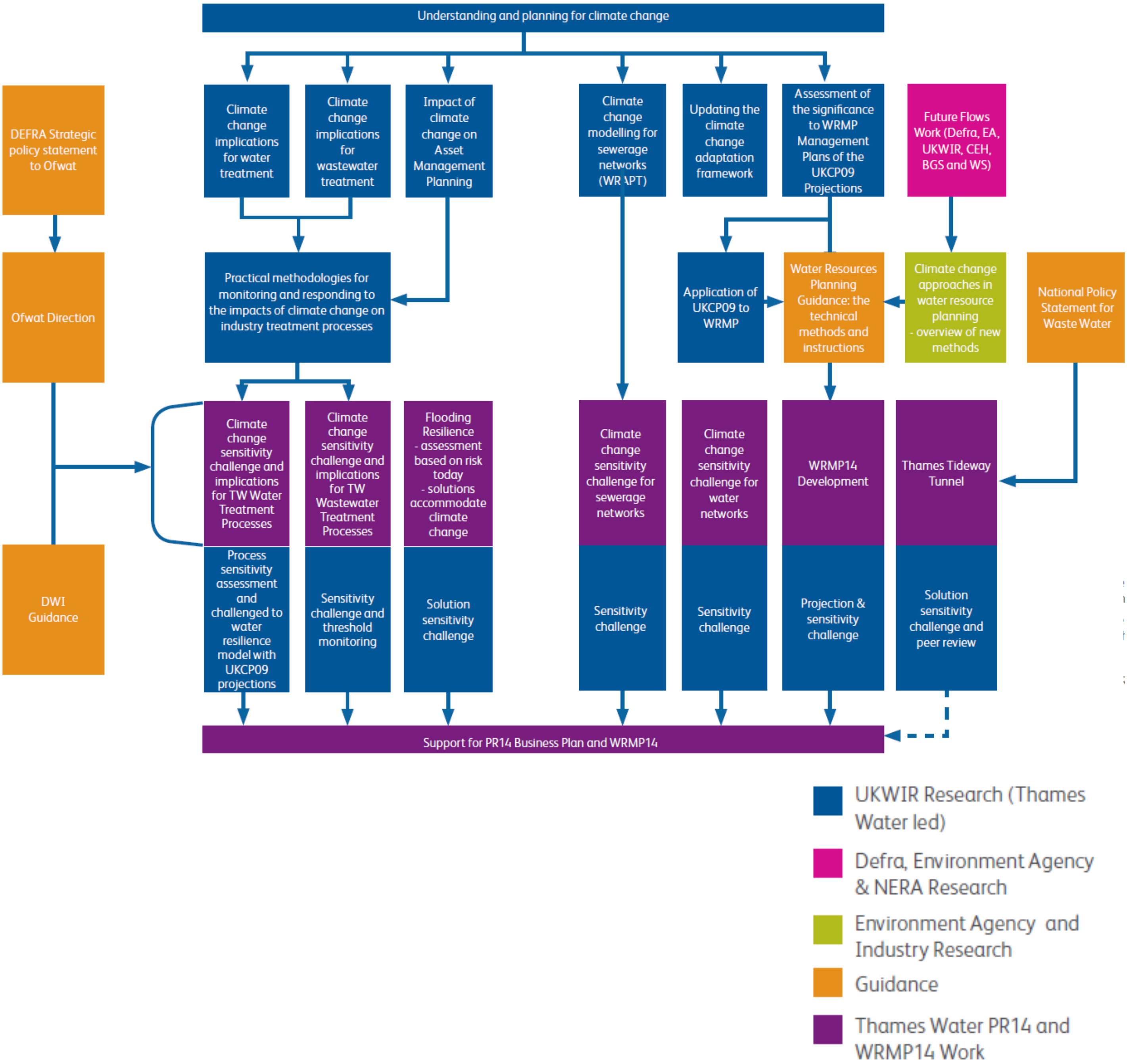
Fig.6: *Thames Valley population growth & water demand forecasts (dWRMP19,Overview)*

WRZ	Total population	Change in population from base year				
	2016/17	2019/20	2024/25	2029/30	2044/45	2099/00
London	7,595,624	246,205	562,497	733,487	1,584,089	3,241,288
SWOX	1,021,824	62,121	134,637	182,091	279,508	460,410
SWA	548,844	21,152	42,819	58,582	114,509	220,443
Kennet Valley	401,735	16,666	37,731	49,905	76,506	132,995
Guildford	160,186	4,909	14,426	24,605	44,019	72,616
Henley	50,901	2,237	3,698	4,132	5,895	12,791
Total	**9,779,115**	**353,289**	**795,807**	**1,052,801**	**2,104,527**	**4,140,543**

WRZ	Total properties	Change in properties from base year				
	2016/17	2019/20	2024/25	2029/30	2044/45	2099/00
London	2,729,586	131,218	332,222	482,909	989,749	2,066,895
SWOX	425,681	25,148	59,520	84,705	145,951	256,414
SWA	205,640	9,339	20,717	30,318	61,080	123,453
Kennet Valley	159,064	4,855	13,083	19,096	37,080	70,795
Guildford	62,720	2,081	6,045	10,455	20,709	37,537
Henley	21,292	508	875	1,290	3,011	7,427
Total	**3,603,983**	**173,148**	**432,463**	**628,774**	**1,257,580**	**2,562,521**

Fig.7: *80 year (2016-2100) population and properties growth projections for each WRZ (dWRMP19, Section 0. p.17)*

B. TW progress in planning for climate change[5]



[5] Case study – Thresholds and Monitoring, January 2016 (https://corporate.thameswater.co.uk/About-us/Protecting-our-environment/Climate-change)

C. Demand Management appraisal process[6]

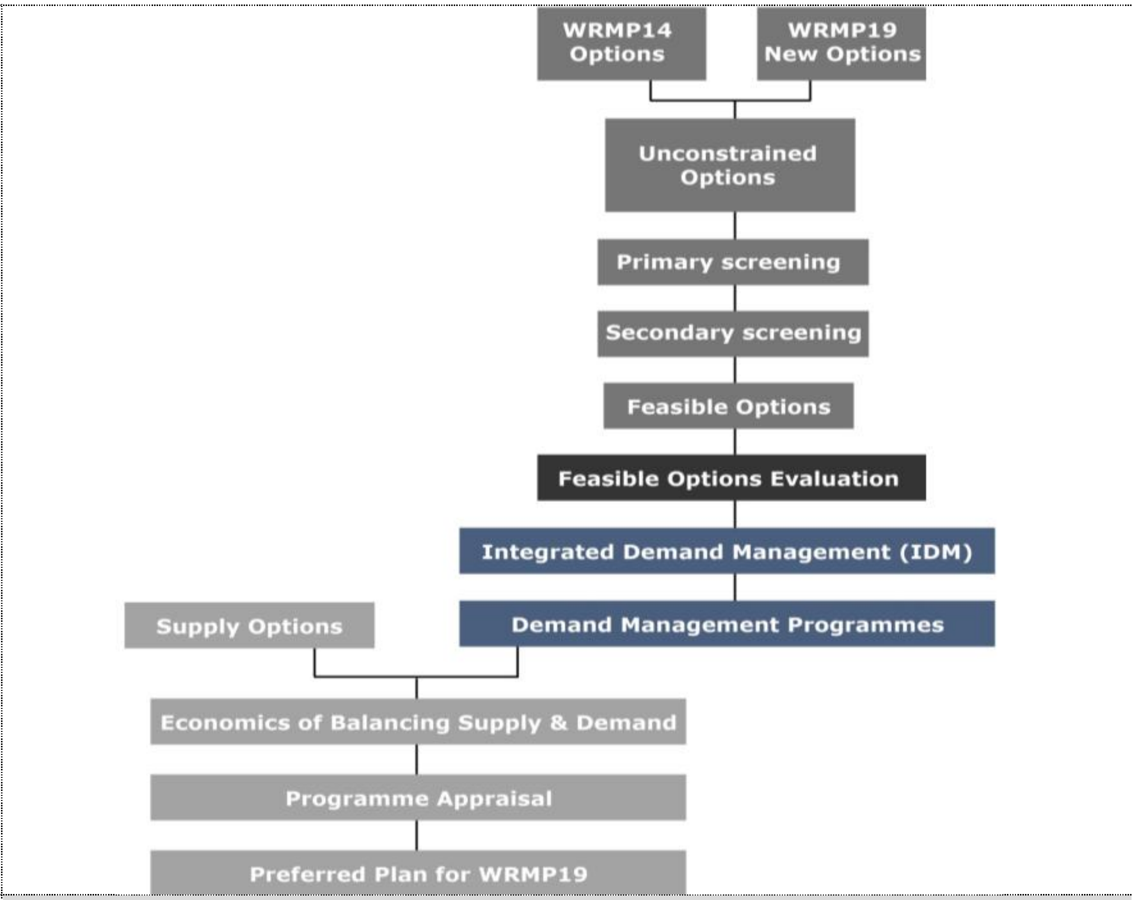


Fig.8: *Demand management options appraisal process overview*

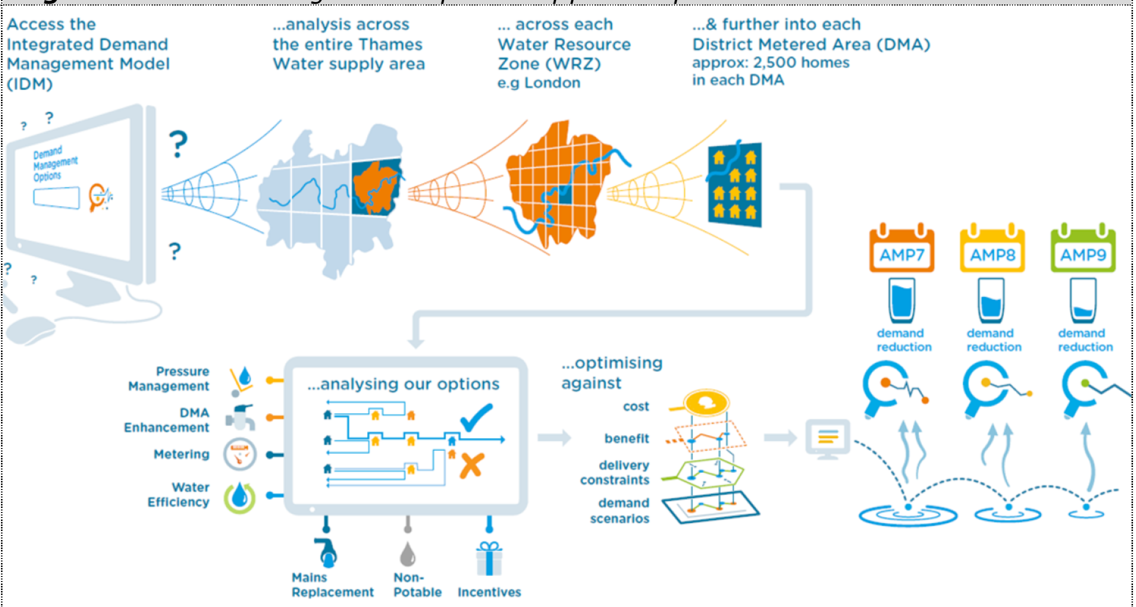


Fig.9: *Integrated Demand management process*

[6] dWRMP19. Section 8

D. New water resource options appraisal process overview

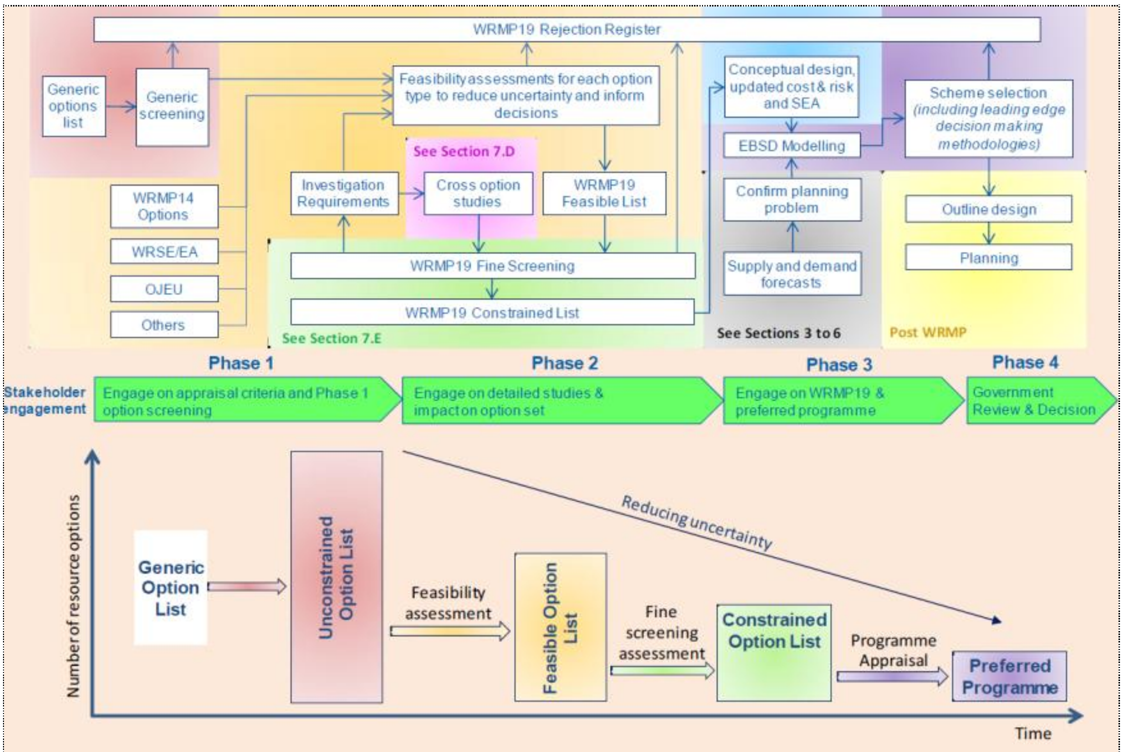


Fig.10: *New water resource options appraisal process overview (dWRMP19, Section 7)*

E. Constrained list of new water resource options

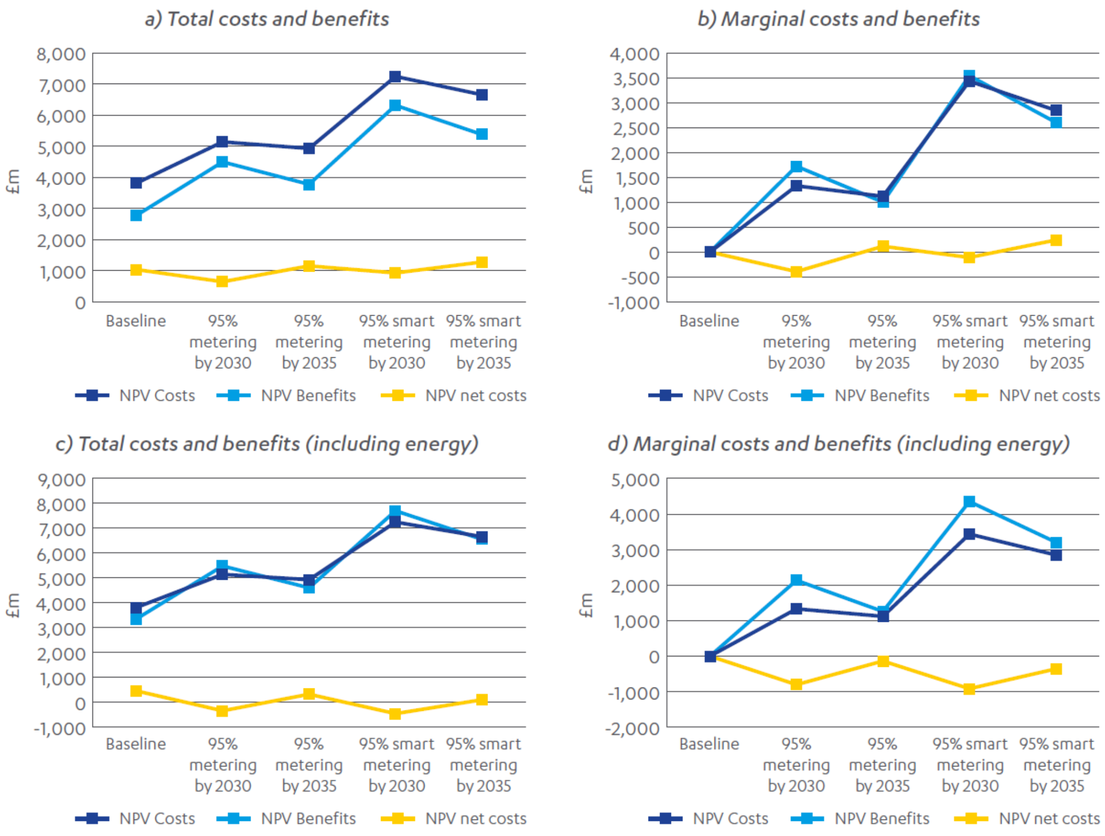
Option type	Resource Element	
	Location	Deployable Output* (ADPW, Ml/d)
Swindon & Oxfordshire (SWOX)		
Raw water Transfer	Severn Thames Transfer (See London WRZ for support elements)	See Table 7.3
	Oxford Canal	12
New reservoir	Abingdon (See London WRZ Table for sizes)	See Table 7.3
Groundwater	GW - Moulsford 1	3.5
Removal of constraints to DO	Ashton Keynes borehole pumps	1.5
	Britwell	1.3
Inter-zonal transfers	Henley to SWOX	2.4/5
	Kennet Valley to SWOX (incl. GW Mortimer)	4.5
	Kennet Valley to SWOX	2.3
Inter-company transfer	Wessex Water to SWOX (Flaxlands)	2.9
Slough, Wycombe & Aylesbury (SWA)		
Raw water Transfer	Severn Thames Transfer (See London WRZ for support elements)	See Table 7.3
	Oxford Canal	12
New Reservoir	Abingdon (See London WRZ Table for sizes)	See Table 7.3
Raw Water Purchase	Didcot	18
Groundwater	GW - Datchet	5.4
Inter-zonal transfers	Henley to SWA	2.4/5
Guildford		
Groundwater	Dapdune licence disaggregation	7.8
Removal of constraints to DO	Dapdune removal of constraints	
	Ladymead WTW removal of constraints	
Inter-co. transfers	South East Water to Guildford	10
Kennet Valley		
Groundwater	GW - Mortimer disused source (recommission)	4.5
Removal of constraints to DO	East Woodhay borehole pumps	2.1

Fig.11: *Thames Valley constrained water resource options*

Option type	Resource Element: Location	Resource Element: Deployable Output* (DYAA, Ml/d)
Water reuse	Deephams 45 Ml/d	45
	Beckton 100 Ml/d	95
	Beckton 150 Ml/d	138
	Beckton 200 Ml/d	183
	Beckton 300 Ml/d	268
Raw water Transfer	STT – Vyrnwy	60/148/180*
	STT - Mythe	15*
	STT - River Wye to Deerhurst	60*
	STT - Netheridge to River Severn	35*
	STT - Minworth to River Avon	115*
	STT - Redeployment of Shrewsbury abstractions	12/30*
	Oxford Canal	11
Desalination	Beckton 150 Ml/d (blended)	142
	Crossness 100 Ml/d	95
	Crossness 200 Ml/d	189
	Crossness 300 Ml/d	284
New Reservoir	Abingdon 75 Mm^3	142
	Abingdon 100 Mm^3	190
	Abingdon 125 Mm^3	253
	Abingdon 150 Mm^3	294
	Abingdon 30+ 100 Mm^3	49+199
	Abingdon 80+ 42 Mm^3	151+83
Aquifer Recharge	AR/SLARS - Kidbrooke (SLARS1)	7
	AR Merton (SLARS3)	5
	AR Streatham (SLARS2)	4
Aquifer storage and recovery	ASR South East London (Addington)	3
	ASR Thames Valley/Thames Central	3
	ASR Horton Kirby	5
Groundwater	GW - Addington	1
	GW - London Confined Chalk (north)	2
	GW - Southfleet/Greenhithe (new WTW)	8
	GW - Honor Oak	1
	GW - Merton recommissioning	2
	Epsom removal of constraints	2
	New River Head	3
Inter-company Transfer	Chingford raw water purchase	20
	Didcot raw water purchase	18

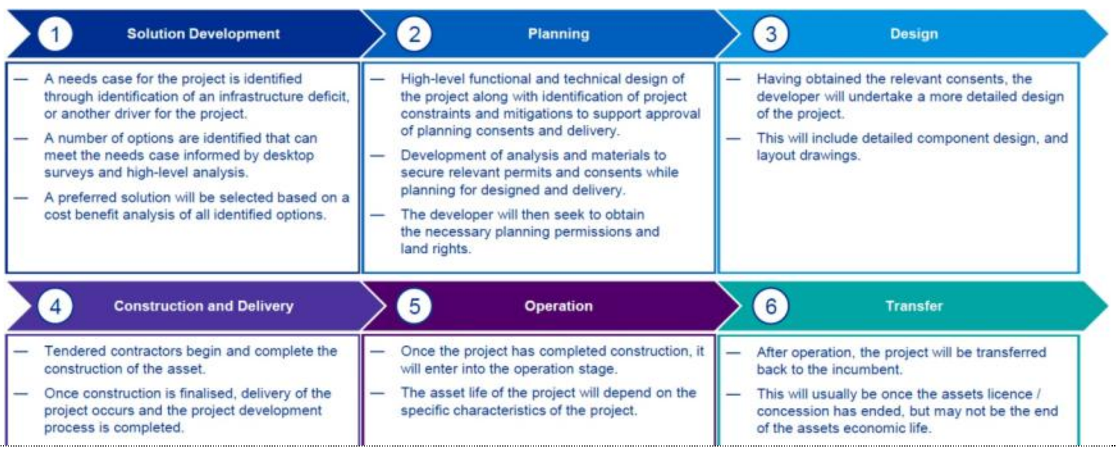
Fig.12: *London WRZ constrained water resource options*

F. Costs and benefits of metering policies.[7]



Source: Commission calculations using input from Regulatory Economics Ltd.

G. Project's lifecycle according to Ofwat[8]



[7] National Infrastructure Commission, Preparing for a drier future: England's water infrastructure needs, April 2018, p. 25

[8] Source: Direct Procurement for Customers: Technical Review, KPMG LLP for Ofwat, December 2017

H. DPC: Current allocation of technical risks[9]

Key Risks in Project Life Cycle	Stakeholder			Comments
	Appointee	Contractor	Consumer	
1. Solution Development				
Data	✓		✓	— Solution development and planning elements generally undertaken by incumbents under current model in line with WRMP and other statutory requirements. — Risks shared between appointee and customers under cost sharing and re-opener arrangements in regulatory framework. — Some contracting models allow for some sharing of risk associated with latter elements of solution development with contractors/supply chain.
Uncertainty	✓		✓	
Constraints	✓	✓	✓	
2. Planning				
Land purchase and site risk	✓		✓	
Environmental and social risk			✓	
Planning / Consent permission	✓		✓	
Third Party Consideration	✓	✓	✓	
3. Design				
Design process	✓	✓	✓	— Assumes outline design undertaken by appointed company — Some design risks may be passed to contractors under current tendering arrangements or shared (e.g. plant, resource availability) — Where design fails to reflect most efficient whole-life costs approach or is subject to change cost sharing would share risk with customers.
Design for construction	✓		✓	
Design for maintenance	✓		✓	
Resource availability and expertise	✓	✓		
Change in design required due to external influences	✓	✓	✓	
Materials and plant		✓		
4. Delivery				
Time and cost overrun risk	✓	✓	✓	— Various alliancing and other contracting models typically seek to share risks between appointee and contractors. — Some construction risks can be passed to contractors entirely.
Resource availability of contractors		✓	✓	
Unforeseen ground or existing building conditions	✓	✓	✓	
Third party claims	✓		✓	— Where major schemes are late or there are significant cost overruns ODIs are typically used to ensure customers do not pay and companies may be subject to penalties which are likely to be reflected in contracting arrangements. — Cost sharing arrangements still pass some risk back to customers. — Companies have re-openers for certain material risks outside of management control (e.g. legislative change).
Subcontractor default / bankruptcy	✓	✓		
Poor project management		✓		
Commissioning overruns	✓	✓		
Availability of facilities	✓	✓	✓	
Legislative / regulatory change	✓		✓	
5. Operation				
Service performance risk	✓		✓	— Operational risks generally shared between companies and customers. — Where contractors used for operational services it may be possible to share some of these risks in contracts. — Customers bear all demand or volume risk under current arrangements. — Appointed companies are subject to a range of statutory service obligations from which they can receive significant penalties but other aspects of service share risks with customers.
Resource or input risk	✓		✓	
Demand risk			✓	
Maintenance risk	✓		✓	
External and third party impact	✓			
6. Transfer				
Asset condition and performance at handback				— Not similarly present in current model.
7. Tender model specific risks				
Procurement failure				— Not similarly present in current model.

Fig.13: *Allocation within project lifecycle & under status quo models*

[9] Direct Procurement for Customers: Technical Review, by KPMG LLP for Ofwat, December 2017

I. SESRO & STT Options Strengths and weaknesses[10]

South East strategic reservoir	Supported Severn Thames transfer
Advantages	**Advantages**
Least cost, reliable and proven option selected through EBSD+ programme appraisal analysis with potential for significant recreational benefits. Storage and transfer hub for the South East region.	Supports inter-basin transfers and increases size of catchment from which water resources can be drawn
Low ongoing running costs which facilitates reduced abstraction from perceived environmentally sensitive sources during normal years without incurring extra cost.	No loss of agricultural land
Facilitates unplanned and routine maintenance of existing raw water storage reservoirs, without incurring additional cost.	
Offers opportunities for secondary activities, including recreation and solar power generation.	
Disadvantages	**Disadvantages**
Loss of agricultural land and displacement of 20 households and businesses. Strong opposition from local pressure group.	Environment Agency hands-off flow on lower Severn creates risk of non-availability of water for abstraction at times of low flow. Increasing risk of coincident drought affecting both the South East and West areas, as occurred during the drought of 1976. As part of the MaRIUS project, CEH Wallingford found that droughts in the Thames and Severn regions are going to be more coincident in the future as a result of climate change. A major drought in both the Severn and Thames catchments at the same time is projected to increase by 56% in the near future (2022-2049) and 135% in the far future (2072-2099).
Eight year construction period with disruption to local residents	Long conveyance route increases risk associated with pollution.
	Phosphorous from agricultural lower Severn catchment contributes to high algal loading, which risks changing the characteristics of the upper Thames. Transfer could potentially further increase Thames Water's exposure to this risk, to which we are particularly vulnerable because of our reliance on surface water abstraction (80% in London and 40% in SWOX WRZs).
	Potential opposition from stakeholders against water transfer to England. Disruption to Cotswolds AONB during construction period.
	Customers' least favoured option and no opportunities for recreational benefits linked to the pipeline.
	Requires alternative resource development in donor area to free up water resources for transfer with potential for WFD deterioration.
	Cost used in EBSD+ analysis is for a single pipeline only, which is at higher risk than a dual pipeline.

[10] dWRMP19. Section 11. p.16

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