The Water-Energy-Food Nexus: Freshwater England 2022/23

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Neil Edwards- AquaInform

Interaction of thermal power plant & aquatic environment since 1981

(CEGB, National Power, Innogy, RWE Innogy, RWE Generation UK)

1977-81 Applied Mathematics MA, Mathematical Modelling & Numerical Analysis MSc. Csci., Cmath.

Initially specialised in modelling power station cooling water discharges

Broadened into environmental policy, regulatory and environmental risk management, permitting

New plant siting and configuration

Power projects in UK, Europe, Pakistan, China, India, Indonesia & USA

Technical studies, due diligence and joint venture development

Represented RWE Generation UK, JEP, EnergyUK and Eurelectric in regulatory stakeholder forums

1997-2000 Power sector representative on Industry Group supporting UK negotiating Water Framework Directive

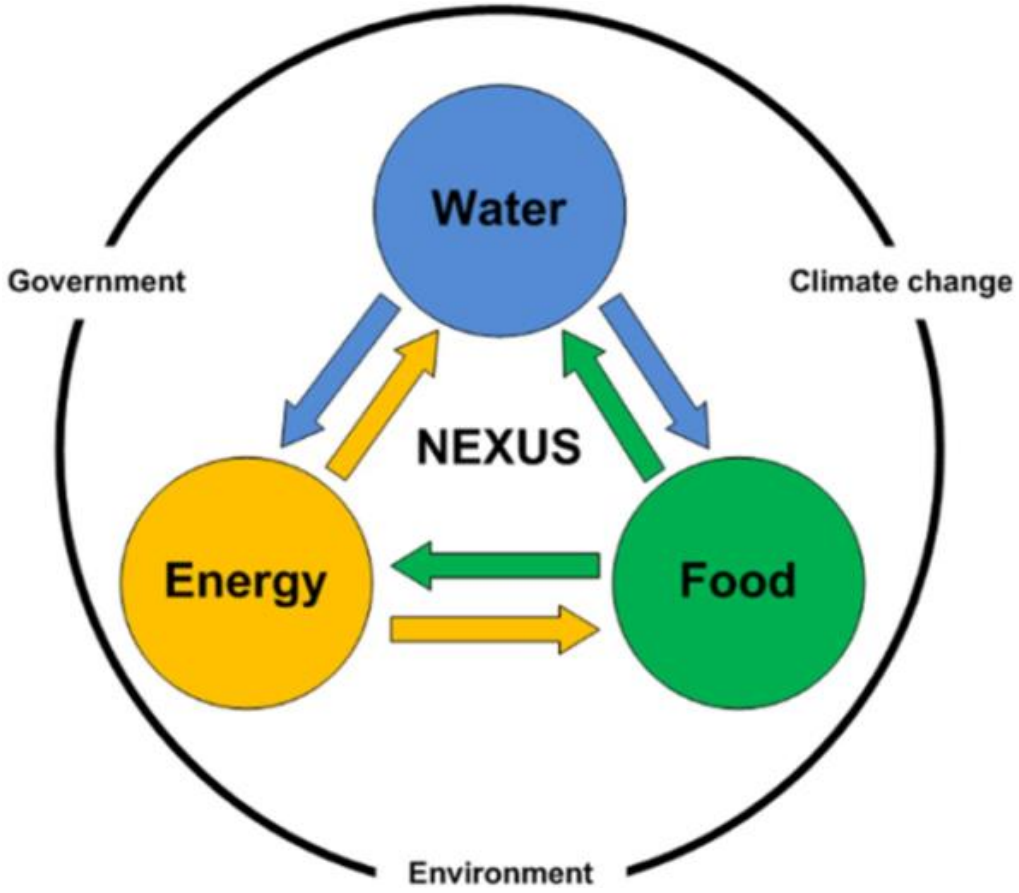
2007-15 General Industry member on Thames River Basin District Liaison Panel

2013- 2021 Energy UK representative in Water Resource East

2013- Visiting Researcher University of Southampton

2021 - Founded AquaInform - an independent consultancy to help organisations identify and deliver responsible use of water and the aquatic environment

Traditional Trilemma Representation of Energy-Food-Water Nexus



Water, energy, and food nexus: review of global implementation and simulation model development

Albert Wicaksono, Gimoon Jeong, Doosun Kang

Published June 2017, 19 (3) 440-462; **DOI: 10.2166/wp.2017.214**

- Energy, Water, Food can be interpreted differently eg as
  - industries
  - ecosystem services
  - resources
- Government, climate change, environment eg as
  - external drivers
  - constraints
- Definition 'Nexus'
  - '… connection between parts of a system or group
  - A centre or focus
- Competition/Collaboration/Choice?

Discussion – Dividing a Birthday Cake

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How should I divide the cake at a birthday party? What could I consider?

Possible approaches
Same entitlement for all
Bigger children should get bigger pieces
Your idea 1
Your idea 2
…
…
…
…
…
…
…

How should I divide the cake at a birthday party? What could I consider?

- Same entitlement for all?
  - If not what are the factors influencing entitlement?
    - Size
    - Appetite/asserted 'need'
    - Closeness of child's friendship to birthday child
    - Politeness
    - Degree of 'demand'
    - Closeness of parent's friendship to child's parents?
    - Behaviour during party
    - Child's parent's expressed views
- How big a cake have I got?
  - Should I have got a bigger or smaller one?
  - What if the cake turns out to be different to what I'd planned when I open the box?
- How many children are present?
  - How many children did I invite
  - How many should I have invited
  - Did some not turn up – what should I do with what I would have given to them
    - Send it to them,
    - Divide it between those who did turn up,
    - Save it for next year
    - Keep it for the birthday child tomorrow
- What if some children want some bits of cake but not others -the cake is not uniform!
  - 'I want that bit'
  - 'I don't like those bits'
  - Promote swapping after initial hand out
  - Hand out in sealed party bag for later consumption
    - Somebody else's problem
  - Use the "Who should have this?" principle

Freshwater Nexus England Context - Rivers

Freshwater Multilemma – multi-activity, multi-party, with variability and deep uncertainty

Preference

Instream Recreation

Events

Commercial Navigation

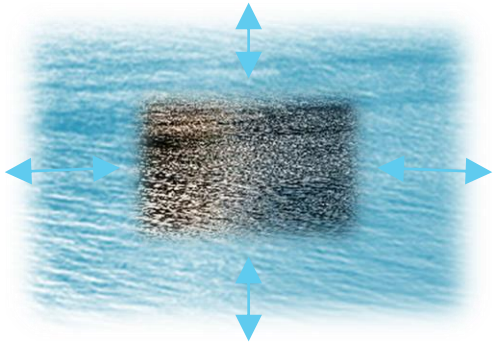
Population Growth

PWS potable

PWS discharge

River Environment

Climate



Power Energy Industry

Agri Food Env Land stewardship

Flood Risk Management

Other Events

Angling

Weather

Economics & wider world

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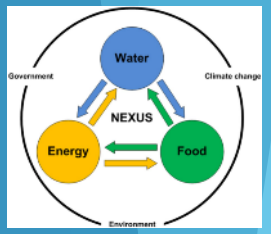
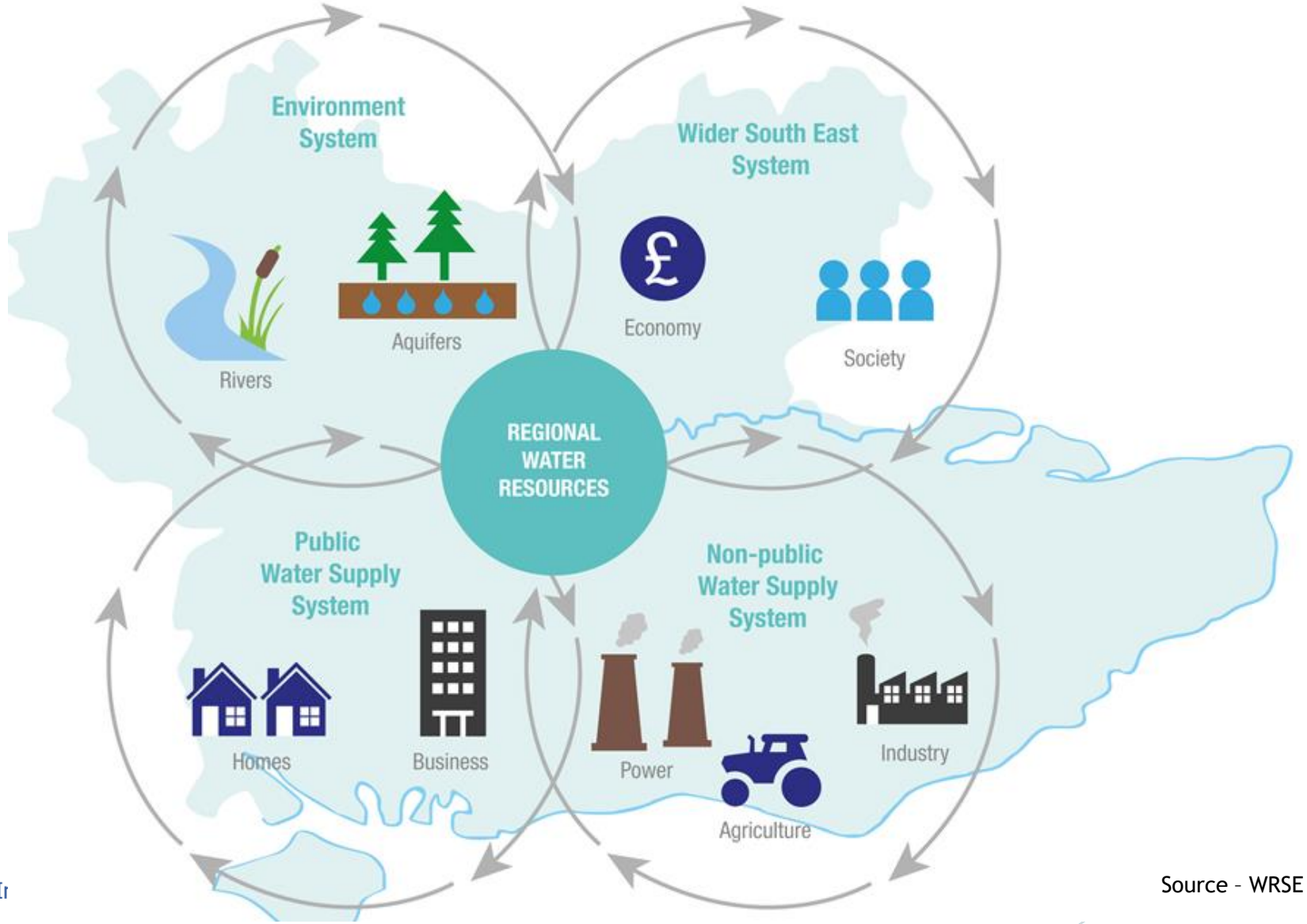
WRSE-Water System of Systems





Source – WRSE Resilience Framework summary

‘Jaws of Death’ Speech 2019

Escaping the jaws of death: ensuring enough water in 2050

Speech by Sir James Bevan, Chief Executive of the Environment Agency Waterwise Conference, 19 March 2019

Published 19 March 2019
From: Environment Agency and Sir James Bevan

- James Bevan (EA Chief Exec, March 2019)
  - Action is needed to avoid demand for water exceeding supply in the next few decades as a result of …
    - Climate change
    - Population growth
    - Environmental ambition
- EA National Framework for Water Resources (March 2020)
  - Defines Regional Planning including ‘alignment’ between regions
  - EA assess there is enough water for each sector within current allocations but not necessarily in the right place or time
- ‘Abstractors should not assume they can always meet future growth using volumes of water held on their licences but historically unused’
  - Context indicates because of EA view of environmental pressures & WFD no deterioration interpretation
  - Not all required reductions are currently quantified/agreed
- Acknowledges uncertainty in projecting non-PWS future water demand
  - Creating challenges and opportunity in regional planning
  - *?What is a ‘valid’ future need, demand, desire, aspiration?*

Current Complex Legal & Regulatory Framework including Implementation of European Law eg

Water Resources Act 1991 (as amended Water Act 2001 and others)

- Abstraction licence regime

Water Framework Directive (2000, as implemented in 2017 Regulations)

- River Basin Management Plans with statutory water body targets and programmes of measures to achieve them
- Disproportionate cost tests possible when setting targets

Environment Act 1995 (as amended)

- Duties of Environment Agency

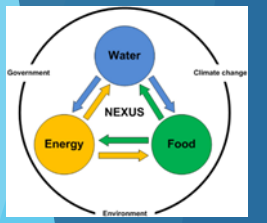
Abstraction Plan 2017

- Direction of travel on reform of abstraction licencing recognising future challenges

Catchment Abstraction Management Strategies (CAMS)/ Abstraction Licensing Strategies

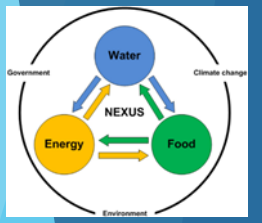
- Sets out how Environment Agency will manage water resources and licences in catchments

Environment Act 2021 & 25 year plan 2018



- Post Brexit England's approach to Environment includes …
- Long term targets (including for water, biodiversity and resource efficiency))
- Environmental Improvement Plans (>15 years period)
- Policy statement on how Ministers should interpret and apply 'environmental principles':
  - environmental protection
  - Preventative action to avert env damage
  - (environmental) Precautionary principle
  - Env damage to be rectified at source
  - Polluter pays
- Biodiversity strategy
  - Local nature recovery strategies
- Water (Resources) Specific Content
  - From 2028 removal of compensation for variation of a non-time-limited abstraction licence
    - to protect environment
      - =prevent damage or avoid compromise of an environmental objective (WFD))
    - to remove 'excess headroom'
      - Applies if in each year in the relevant 12 year period abstractor did not take more than 75% of the quantity authorised and the abstractor does not 'reasonably require' the 'excess'
        - Licence could still be reduced but compensation would then be payable
    - In practice makes Environment Agency more likely to reduce or curtail existing licences by removing need for compensation in many circumstances. EA already can amend or revoke a time-limited licence without compensation at the licence end date. EA can amend licences without compensation in the event of 'serious damage'

Environment Act 2021 & 25 year plan 2018



- Post Brexit England's approach to Environment includes …
- 25 Year Plan 2018 (water resource aspects)
  - Improving 75% of our waters to be as close to their natural state as soon as is practicable by :
    - Reducing damaging abstraction from rivers & groundwater
      - By 2021 90% of water bodies should support environmental standards
    - Reaching or exceeding objectives for specially protected areas (biodiversity or drinking water designations)
    - Supporting ambition on leakage reduction
  - More low flow controls
  - Allow more abstraction at high flows
  - Encourage water trading and storage
  - Catchment focus
  - March 2022 long-term targets consultation proposes
    - Reduction in pollution from abandoned mines
    - Reduction in nutrients from agri and PWS
    - PWS per capita demand reduction of 20% by 2037 from 2019/20

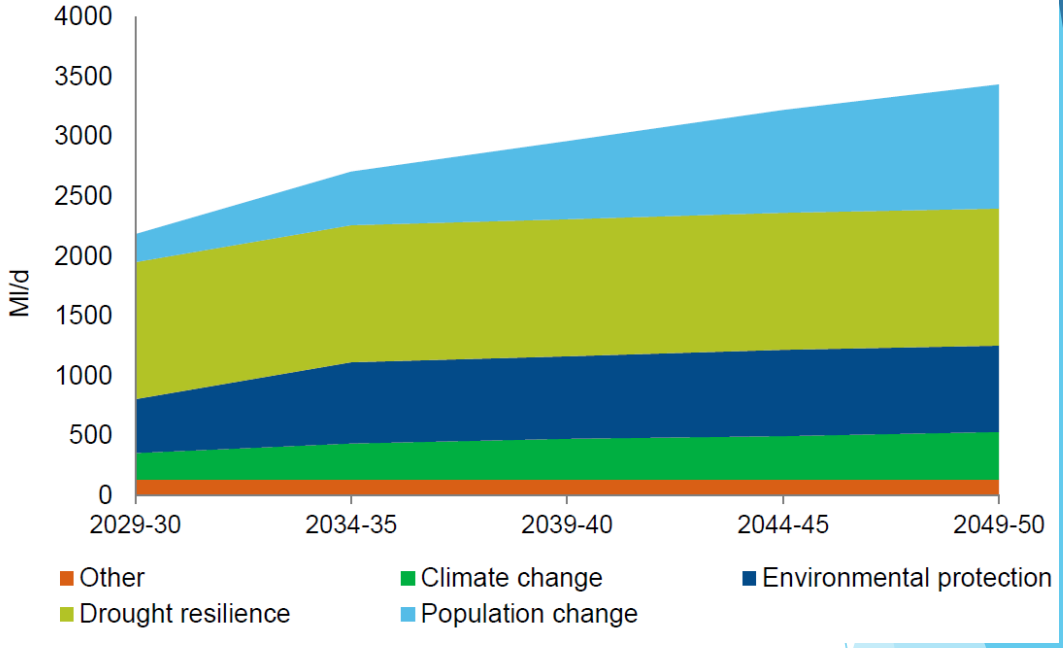
Drought in England- Spatial Coherence

- 2017-18 studies suggested some major droughts could extend over much of UK
- 2019 studies suggests climate change will increase drought severity at a given frequency with little correlation beyond 100-150km
  - little point in local connections for drought resilience though they may give increased flexibility and more general resilience but …
  - Longer range transfers could be useful
- Arrangements for PWS drought resilience could also remove much water resource risk for other users in situations other than PWS drought
  - Mechanisms to enable water sharing?
- Possible change in signals for locating activity if water-available sites are created?
  - Where and what to farm?
  - Where to site future water-using industry?

Regional Water Resource Planning in England 2020-2022

EA National Framework Water Resources March 2020

- PWS to move to 1:500 year resilience
- Outline Definition of Regional Planning
  - Strategic Public Water Supply issues
  - Define regional environmental destination
    - Encouragement to be environmentally ambitious
      - abstraction reductions principally on WatCo
    - No checks/balances
  - Consider needs of non-Public Water Supply interests
    - Traditional silo-sector approach
    - Sectors to establish their own needs
    - No recognition of different sector institutional arrangements
      - Eg there is no body which can make legal agreements on behalf of the power sector or agriculture
  - WatCo to 'lead' regional processes
    - Tight integration with WatCo Water Resource Management Plans (and Drainage & Waste Water Management Plans)
  - Output to be a single adaptive, best value plan in each region which together form a coherent national plan

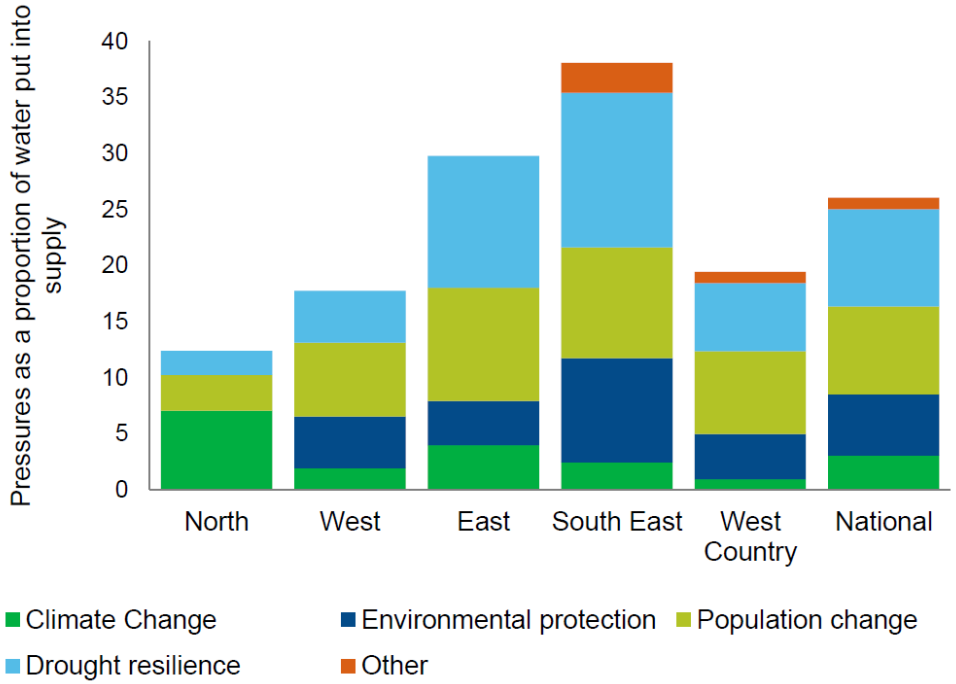


English 'additional water need', Ml/d, 'do nothing' scenario
Source: NFWR, 2020, Fig 3

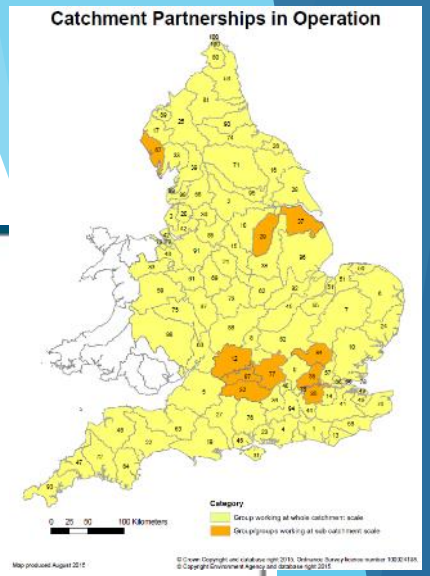
[env protection needs subsequently increased significantly

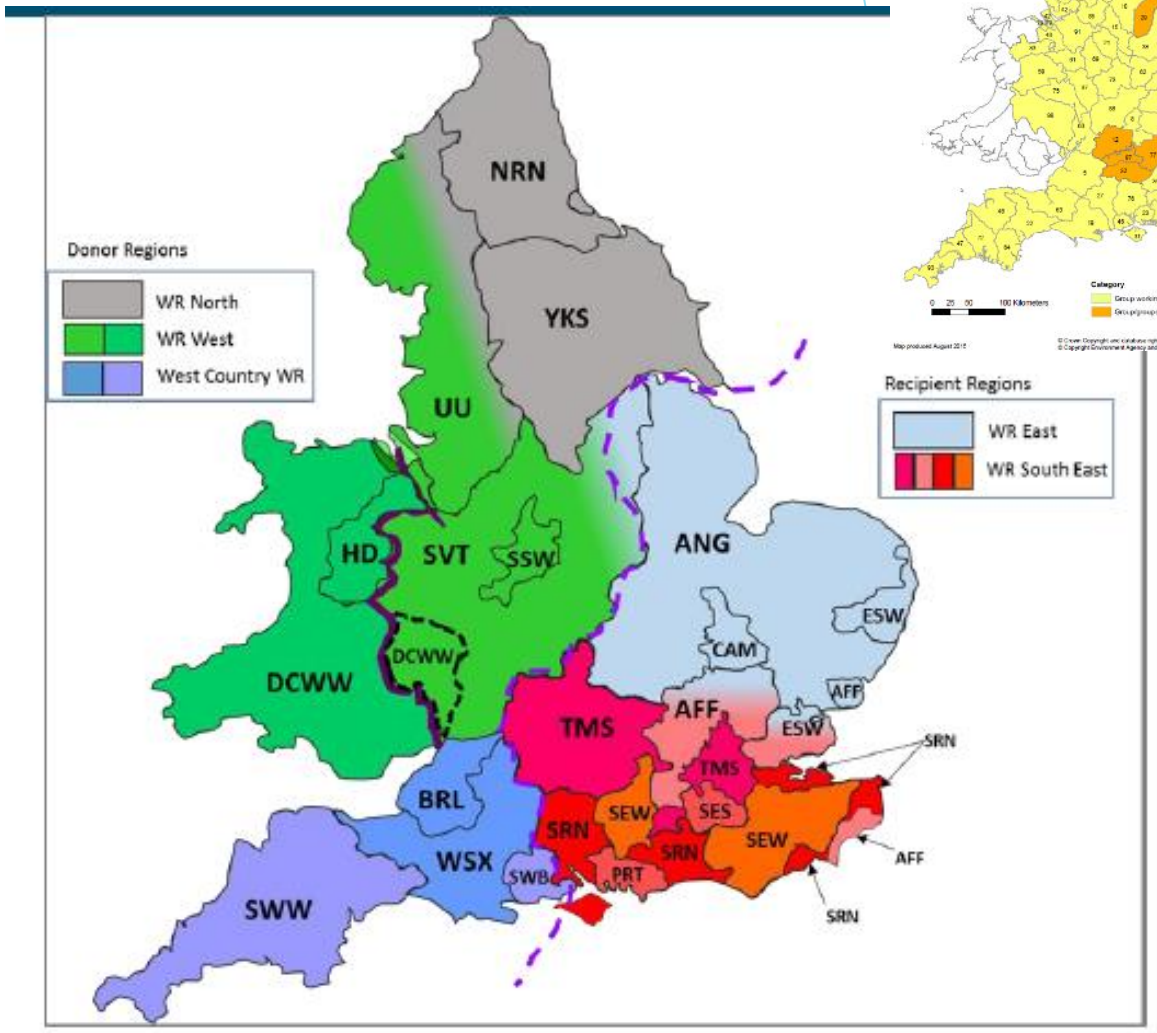
Regional Planning & WatCo Boundaries

Figure 5: The potential pressures on water needs as a percentage of the volume of water put into supply. This is to adjust for the scale of the regional groups.



Source NFWR 2020 Fig 5





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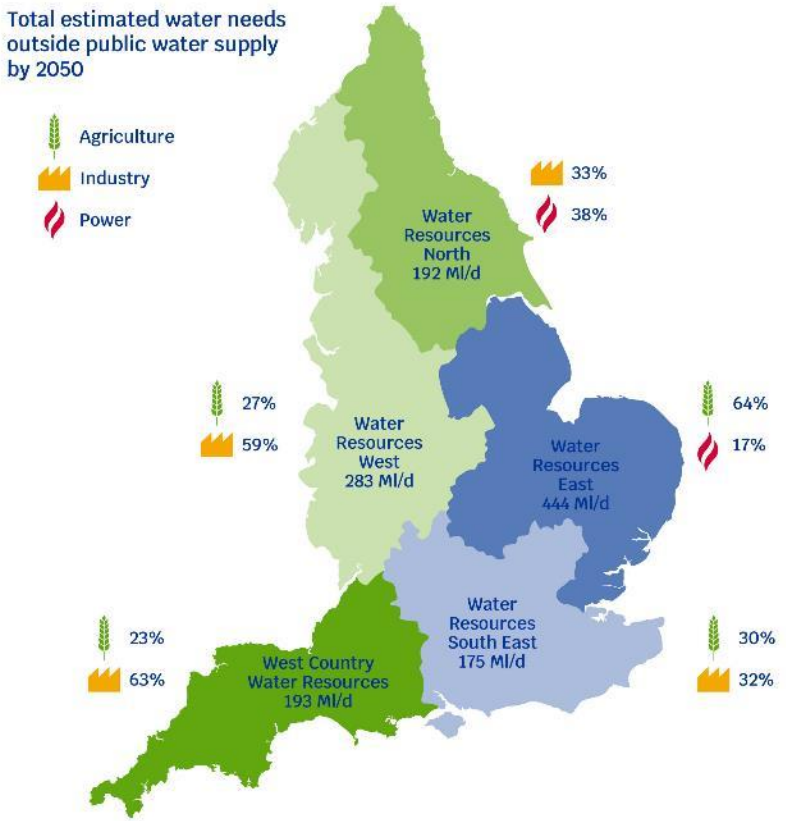
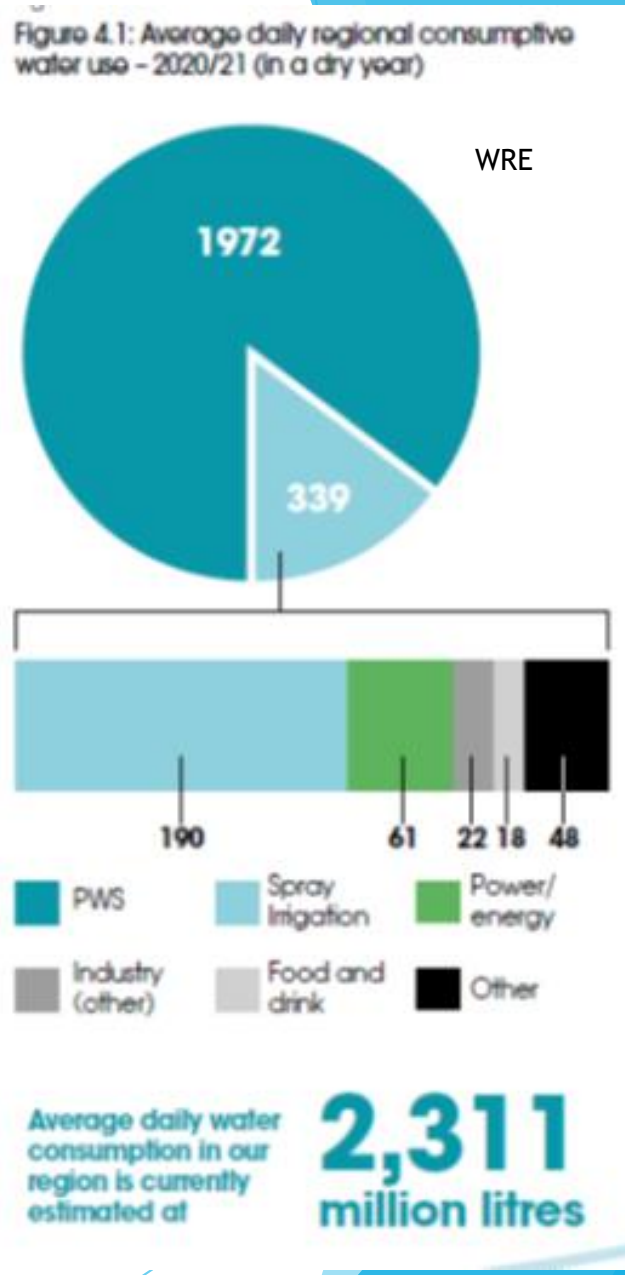
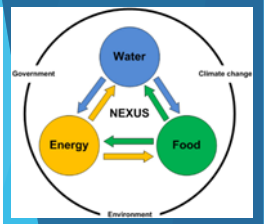
Regional Variety of Water Users

WCWR



WRE

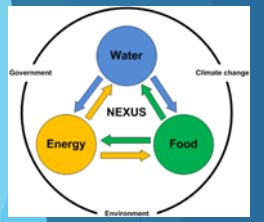




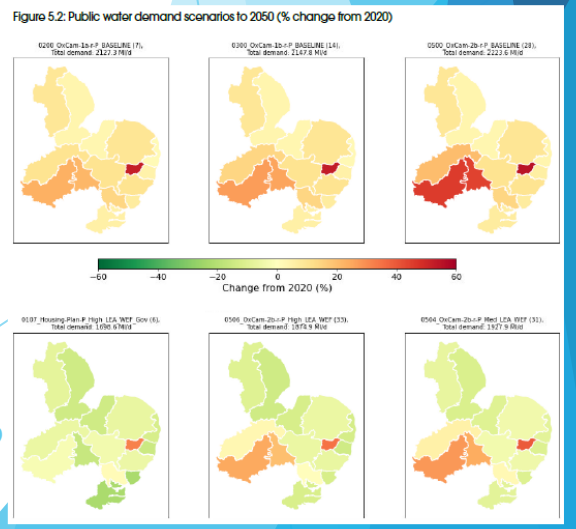
- Some uses of water are small in volume terms (compared with public water supply) but are of regional and national importance by value

Sources WCWR Emerging Plan, WRE Emerging Plan 2022, RAPID – long term resilience: https://www.ofwat.gov.uk/wp-content/uploads/2021/08/Water-2050-scaled.jpg

Future Public Water Supply freshwater need

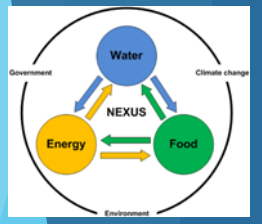


- PWS Drought Resilience
  - Move from 1:200 yr event to 1:500 yr event by 2039
- Multiple scenarios linked to growth forecasts
  - Numbers
  - Locations
  - Socio-economics
- Consumption
  - Post pandemic 'working from home' structural changes
  - Household demand management
    - Metering/smart metering
    - Appliance water efficiency
    - Building regulations
    - Aiming to achieve 110 l/head/d by 2050 (from av 145.1 l/h/d 2020/21)
    - Need government policy interventions to achieve
  - Non-household demand management
    - Water efficiency drive
    - Growth trends
- Leakage management
  - By 2050
    - industry wide target to reduce by 50% by 2050 (from 2017/18 base)
  - 2050+
    - Eg 0-2% per 5-year cycle from 2049/50 base
  - 2020/21 national PWS leakage actuals
    - **3112.7** Ml/d
    - Approx 21% of water entering PWS
- PWS already experiencing abstraction license reduction pressure from EA
  - Environmental protection
    - Damaging
  - Removal of 'headroom' previously in place to cover 'growth'
    - Deterioration risk



Sources : WRE Emerging Plan Jan 2022
OfWat Service Delivery Report 2021 https://www.ofwat.gov.uk/wp-content/uploads/2021/11/Service-Delivery-Report-2020-2021.pdf
WRPG21 Supplementary Guidance - Leakage

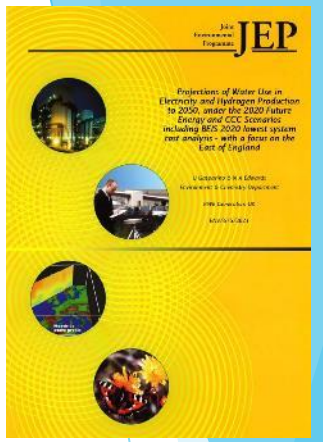
Future agri-food freshwater need

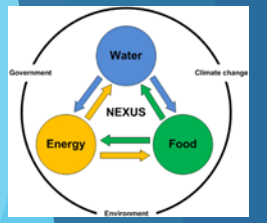


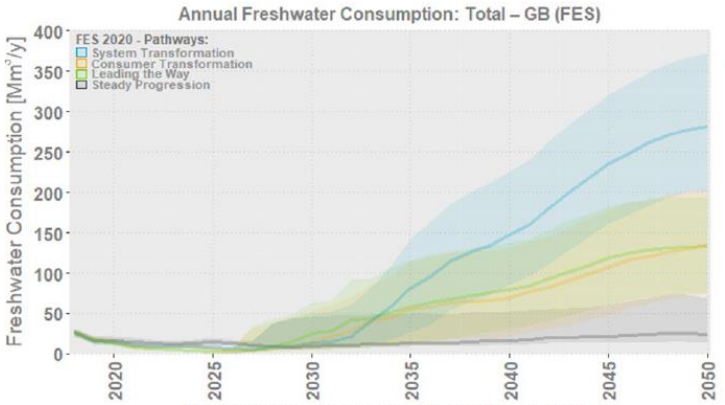
- Intrinsically uncertain
  - Market facing
- Intrinsically variable
  - Irrigation needs vary from year to year with weather, crop choice
- Adaptation to climate change required
- Post Brexit food security, affordability drivers + perceived opportunity perceptions for growth
- Individual agents making their own individual decisions
  - No sector plan
- Potential to diversify
  - from managing land for food …
  - … to managing land for biodiversity
  - … to managing land for ‘nature-based solutions’
    - Eg restoration of drained peatlands + switch to ‘wet’ agriculture
  - …to managing land for water
- Eg WRE agri-food water demand growth projections (Knox et al 2018, to be updated in 2022)
  - Baseline peak demand dry year of 190 Ml/d
  - 2050 peak demand +59Ml/d to + 220Ml/d
- But note pressure on current agri licences
  - some high-profile curtailments in 2020

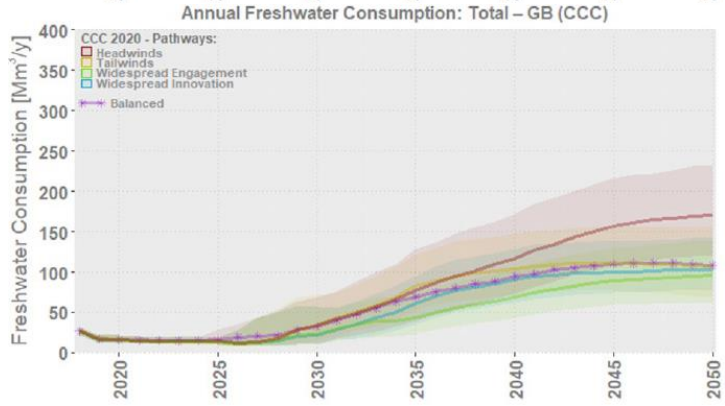
Future power/energy sector freshwater need

- Decarbonisation is principal driver
  - UK GHG net zero statutory target
- New technologies
  - CCUS
  - BECCS
  - Hydrogen
  - Direct air capture
- New locational signals
- Individual market facing agents making their own perceived risk/reward judgements on plant closure and development
  - No sector plan
- Stochastic modelling of water consequences of FES20/CCC20 scenarios
- Considerable uncertainty in volumes, timings and locations!









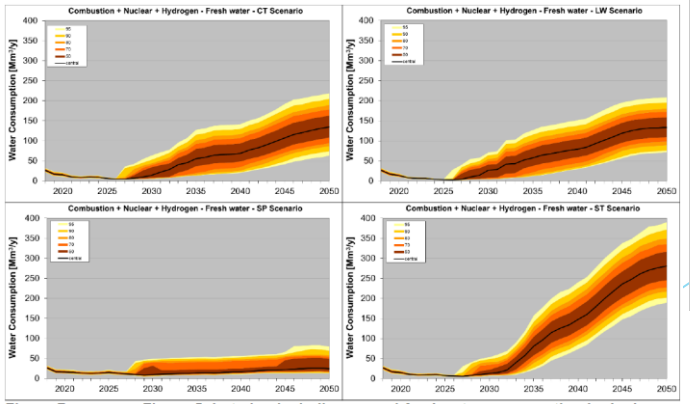
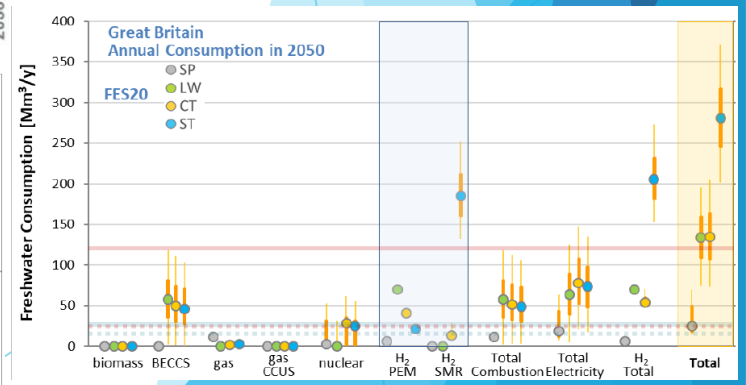


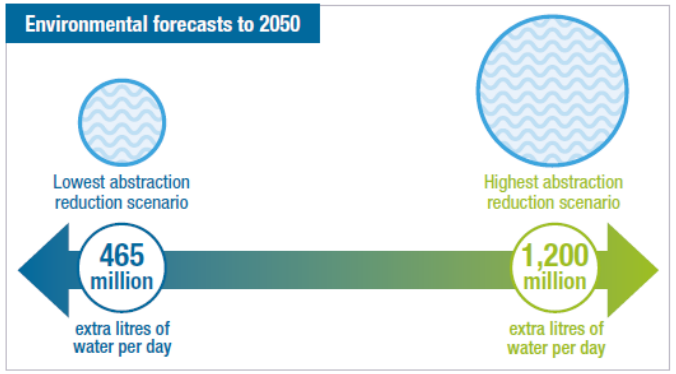
Figure 7: same as Figure 5, but also including annual freshwater consumption by hydrogen production (electrolysis and steam methane reforming).

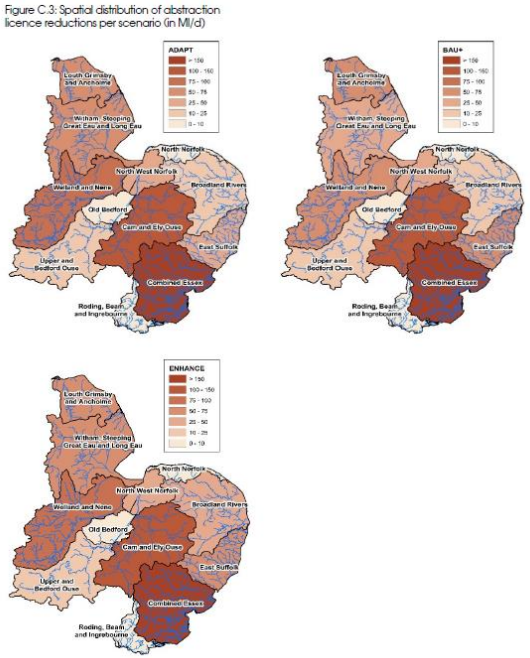
- Continuing decline in water use to mid 2020s then sharp and uncertain dramatic increase
- Water for hydrogen production is a big factor
  - Electrolysis
  - Steam methane reformation with CCS

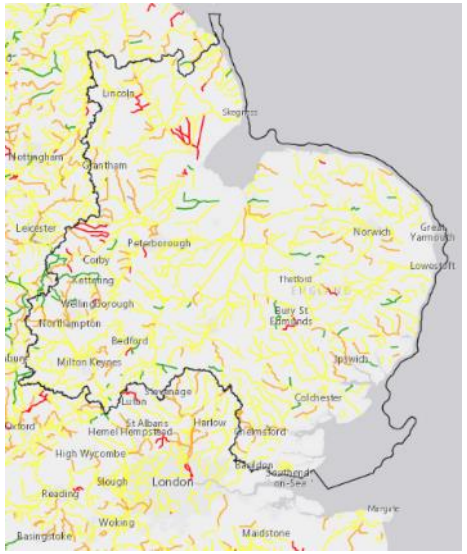


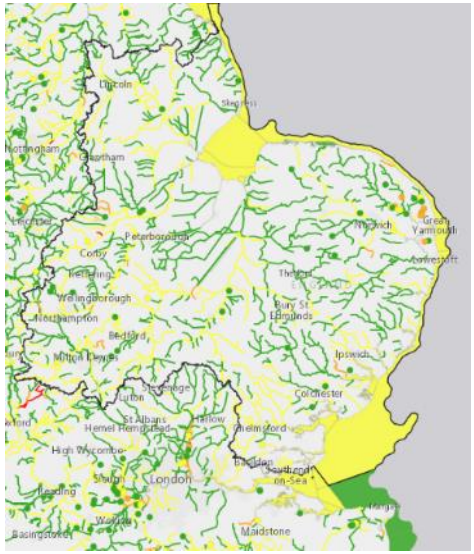
- Source: Gasparino & Edwards 2021, JEP Report ENV/675/2021 https://www.energy-uk.org.uk/publication.html?task=file.download&id=7941

Future Environment freshwater need- 'Environmental Destination'









- NFWR definition
- Long-term environmental objective (eg 2050)
- **Business As Usual(+)**
  - Environment allocation same % of natural flow as now (typically 80-90% of natural)
- **Adapt**
  - Aim for lower standards in heavily modified water bodies
- **Enhance**
  - Greater protection for protected areas, for salmon and chalk rivers
- **Combined**
  - fusion of all allowing some water bodies not to achieve WFD-good
  - Requires local exploration

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Sources – EA Catchment Data Explorer, WRE – example Env Destination Scenarios and reduction range (superseded) – highest estimated abstraction reduction 1325Ml/d, being up to 50% in some areas

Future Water Needs of a Region

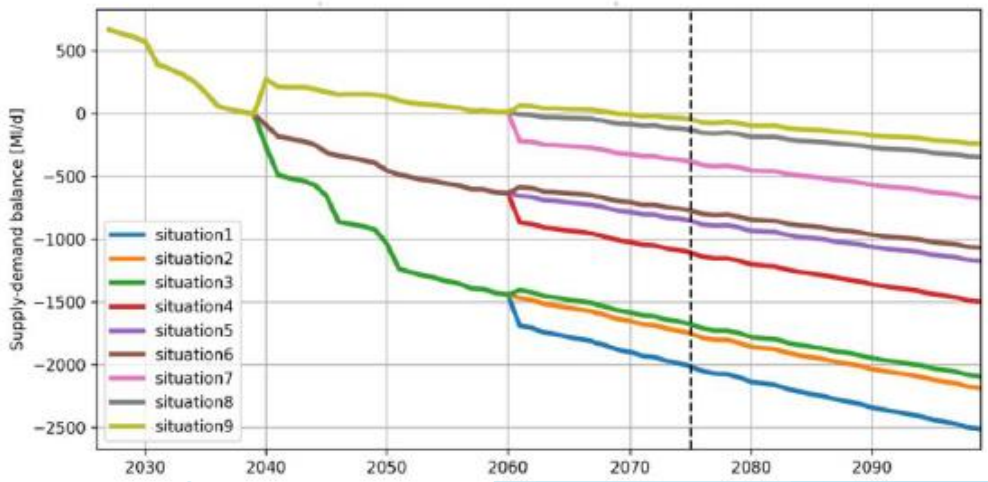
Table 5.1: Regional water resource challenge to 2050

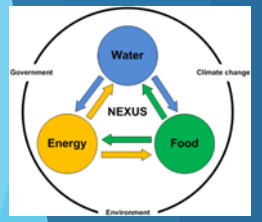
Sector	Pressure	Dry year annual average estimated impact (Ml/d)		Comment
		Lower	Upper	
Public water supply	Climate change	54	180	Includes range of possible high/low climate change impacts mostly on reservoir yields.
	Sustainability reductions	790	1,325	Includes cross-sector abstraction licence reductions resulting from a range of environmental destination scenarios outlined by the EA. The lower limit represents the business as usual (BAU) scenario, with the upper limit accounting for the enhanced scenario. Current values apply to all existing licences except the energy sector. Further refinement will be made through discussion with the EA and Natural England.
	Growth (population)	-250	273	Upper limit accounts for growth targets in local plans and some consideration of strategic growth and limited progress with planned demand management measures. Lower end represents lower population forecasts and high uptake of water efficiency measures.
	Drought resilience	88	88	Methodological uncertainties subject to work in progress.
	Regional exports	0	0	Not considered at this stage, although 100 Ml/d export to WRSE is currently assumed for the South Lincolnshire Reservoir SRO development.
Energy	Decarbonisation	-38	181	Updated forecast based on research commissioned by the Joint Environmental Programme, Energy UK[9] on a baseline of 61Ml/d.
Agriculture	Growth (irrigation)	59	220	Updated forecast based on uplift factors from research commissioned by WRE[10] on a baseline of 190Ml/d.
Total		**703**	**2,267**	

Sources : WRE &WRSE Emerging Plans 2022

- Significant PWS demand reduction
  - Decreasing from 150l/h/d to 110 l/h/d
  - Success uncertain
- Climate change may affect water resource 'useable'
- Increased allocation to 'environment' (restore, protect, enhance)
- Non-PWS changes too
- Great range in uncertainty
- Detail varies between regions though environment need is generally the dominant 'new' need
- New water sources are needed!

Figure 5.7: Supply demand balance plot for South East region under NYAA





Possible Interventions

Demand management

Reduce PWS Leakage

Reduce personal PWS use

Reduce use of non-household connected to PWS

Improve water efficiency of non-PWS water users *(but BAT water use optimisation not necessarily minimisation*

Supply Options

Transfers (shifting in space)

Reservoirs (shifting in time)

Aquifer storage & recovery (shifting in time)

Water Re-use schemes

Desalination plant

Sea Tankers

Change Allocation of Water Rights

Change the water right allocation eg favour ‘desired’ or more ‘valuable’ activity including ‘use by environment’ over ‘non-desired’ or ‘less valuable’ activity

Re-distribution Mechanisms

Change the actual use of water available under issued rights compared with the allocation eg favour those activities whose ‘need’ for water is greater than allocation basis in the current circumstances eg trading to those prepared to pay more than the existing rights holder values current water.

Example strategic supply options

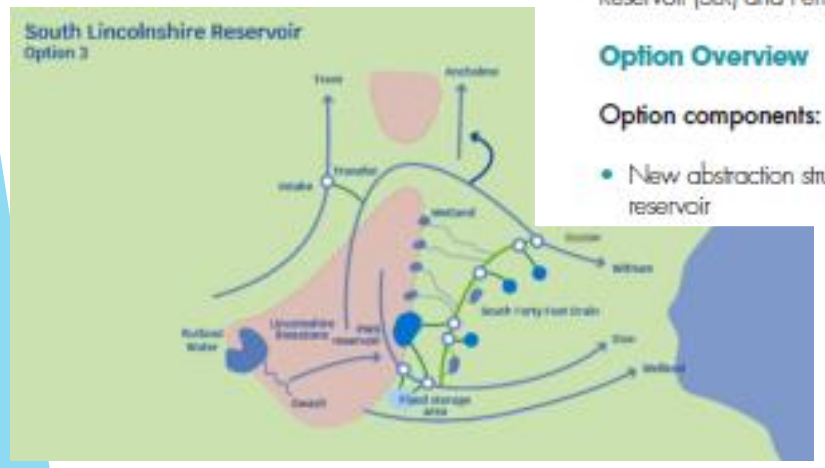
Reservoirs

The WRE Water Companies have investigated a number of reservoir schemes in the region. The studies established that dredging and/or raising the existing reservoirs in the region is not feasible. As such the reservoir supply option is limited to a small number of new options, including South Lincolnshire Reservoir (SLR) and Fens Reservoir.

Option Overview

Option components:

- New abstraction structure from a river and transfer to the reservoir



Environmental Considerations:

Desalination Floating/Seawater

Option Overview

Option components:

- Desalination barge consisting of:
  - Standard barge/hull fitted out with a 2-stage reverse osmosis (RO) plant
  - 8-point mooring system to anchor the barge to a location
  - An intake pipe mounted to the underside of the vessel will draw water in from the desired level in the seawater column
  - A pipe mounted under the barge or attached to the moorings will discharge the brine to the water column
  - The barge will be powered from shore via a submarine cable

Note: This image is illustrating the construction phase of a pipeline to shore.

Sea Tankering

The basis of this option is to import treated water from Norway by sea tanker.

Option Overview

Option components:

- A water supply agreement with a vendor to transport treated water from Norway to a port in the region
- Offloading facilitates at the port
- Short transfer to a service reservoir and conditioning treatment plant
- Treated water pump station and transfer pipeline to a suitable distribution hub.

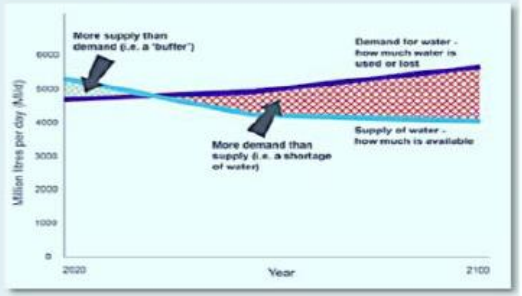
- Sources
  - https://www.ofwat.gov.uk/regulated-companies/rapid/the-rapid-gated-process/gate-one-submiss… accessed 2022_03_03
  - WRE Briefing Pack for Regional Planning Conferences September 2021

PWS Customer/Stakeholder-Preferences

Figure 5.1: Summary of customer preference topics

Long-term water resource and resilience planning - customer research topics

Resilience



- Priorities for long-term plan
- Importance of resilience planning measures
- Drivers of customer support for long-term plan

Environment

- Attitudes towards dependency on rivers and groundwater (short-term and long-term)
- Importance of environmental vs. other outcomes

Options

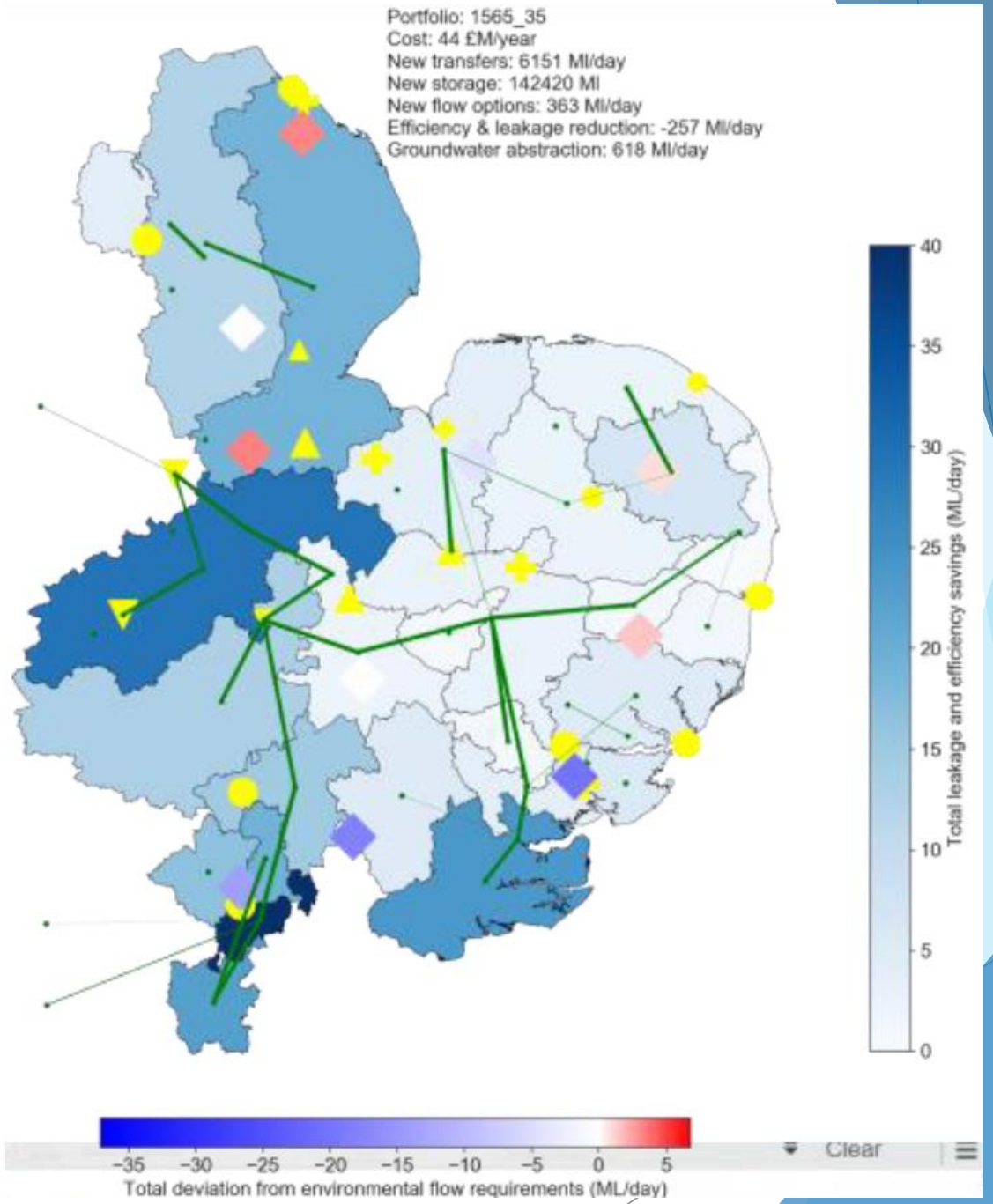
- Preferences for demand and supply options
- Views on water sharing and transfers (intra- and inter-region)
- Views on outline proposals for strategic resource options (SROs)

Service levels

- Preferences for water use restrictions and emergency drought measures

- How to ensure any preferences obtained are representative?
  - Survey respondents are self-selecting
  - Meeting attendees may not be representative
    - Even of their own organisations!

Source:WRSE Emerging Regional Plan Annex 4 2021

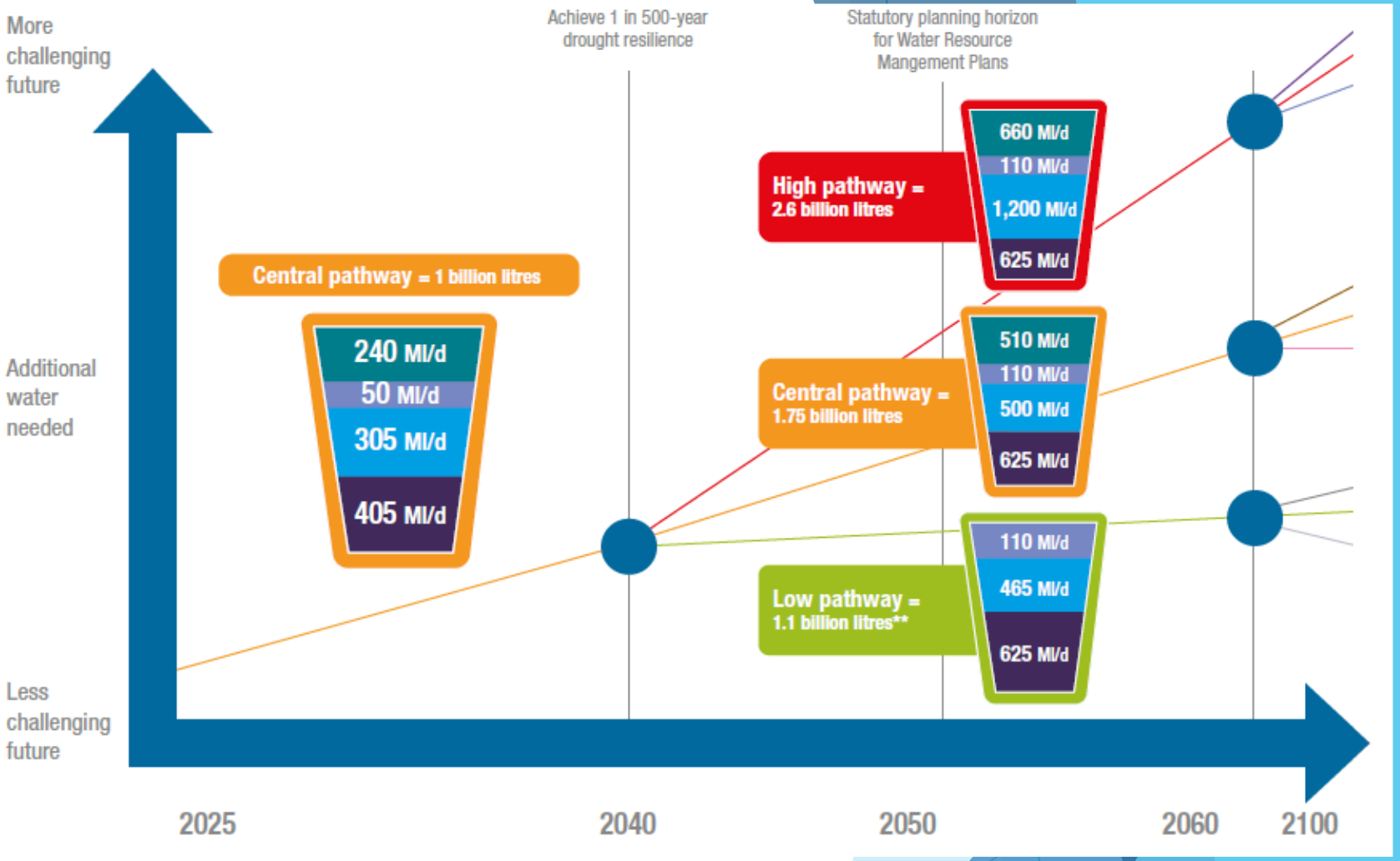


Assessing portfolios of possible interventions: Modelling

- Evaluate performance of a portfolio of supply and demand interventions…
- …in a wide range of scenarios of
  - Climate change
  - Weather
  - Population growth
  - Environmental destination preference
- at 2050
- at 2100
- in the period 2025-2050+

Source : WRE Method Statement August 2020

Adaptive Planning



- Adaptive means the route through the plan depends on ‘events’ or ‘tests’ occurring during course of the plan
- Implies
  - Phasing of interventions
  - Definition of ‘triggers’/’tests’
  - Multiple pathways defined in plan
    - and choose which of them to follow when ‘trigger/test’ is reached

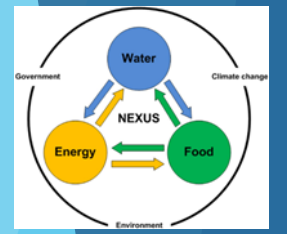
Eg WRSE water ‘need’ pathways in adaptive planning framework with x3 branching at 20 year epochs

Source WRSE Emerging plan 2022

Discussion - Best Value Factors in a Water Resource Plan

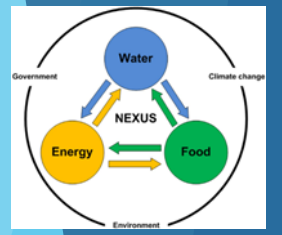
AquaInform

What factors might be relevant in establishing '**Best Value**' in a Regional Water Resource Plan



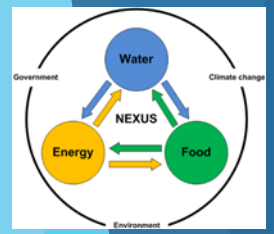
- You are the Regional stakeholders meeting for the first time to consider best value water resource planning in your region
- Your region:
  - English weather, climate and climate change projections
  - English law, governance and institutional frameworks
  - 15M people and growing fast (20% of the current national population)
  - Several small cities, many towns, numerous villages and large rural economy, has a coastline including two industrialised estuaries with ports. There is a developing offshore renewable energy industry. There is aspiration for development of hydrogen production facilities in the near future.
  - Many heavily protected environmental sites, generally aquatic environment is not achieving target flow or quality standards. There is pressure on agricultural use of water. Terrestrial environment outside urban areas has been much modified for agriculture over the last few centuries. Marine environment protection has been neglected and strong pressure to improve all aspects of its protection.
  - Some industrial centres, including around a few ports, with some industries needing potable and/or non-potable water – some abstract directly from rivers and lakes, strong agriculture (national significance) with much dependent on spray irrigation sourced from groundwater or rivers in most summers, well established leisure, recreation and tourism activity
  - Several water companies operate - each in a different area in region. PWS supply is good quality and currently major supply interruptions are extremely rare (1 in 150 years). WatCo1 relies on a major import transfer from an adjacent RegionD. WatCo2 delivers a significant export to Region R which contains the national capital. Climate change projections indicate water resource availability from existing sources will decline over the next 50 years though still high year to year and seasonal weather variability
  - Wide range of policies and national targets are in force
    - Eg GHG net zero 2050, environment improvement particularly natural capital and biodiversity targets
- What factors would you like to include within plan scope in deciding whether a plan outcome represents 'best value'?
  - When suggesting a factor can you quantify it or is it unquantifiable?
    - allocation of water to public water supply, m^3/y
    - Public water resilience to drought, 1 in N years

Your Ideas on Best Value will Shape the Future of Your Region and its People!



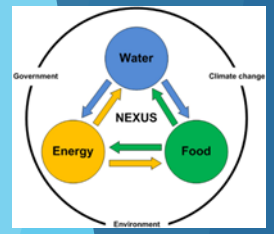
factor	Measure/unit

What does your choice of **Best Value** factors imply about your views on 'resolving' the water-food-energy nexus?



- Have you considered all elements from the outset
  - Or did you try to see it from only one perspective
  - And then another?
- Have you implicitly filtered out any views that occurred to you?
  - If so why?
- Have you ensured that all the potential interests of the region have been considered in the process of generating best value factors?
  - If not who/what is missing?
- Have you considered the region's role nationally?
  - if so how?
  - Is your national interest more important then the interests of your region?
- Have you considered sub-regional aspects?
  - Are you content to let your sub-regions experience the consequences of whatever results from a regional best value plan without further consideration?
- Have you considered value in money terms?
  - What about the difficulty of monetising non-market items
- Have you considered non-quantifiable factors?
  - Maybe ethical, moral …
- Are you prepared to define the approach to 'best value' without knowing what the resulting plan would be?
  - If not what to do about it?
- Have you considered control, collaboration or competition?
  - Or all 3?
- How have you drawn the boundaries in your assessment framework?
  - If you consider also a nexus centred on 'land management' would your views change? eg
    - Food - availability, security, affordability
    - Biodiversity, species, habitats
    - Land management for water resource/flood risk
    - Land management for carbon capture
    - Land management for biomass (for net negative energy production)
- Is the traditional trilemma view of the food-energy-water nexus complete?

Example Best Value Metrics in Current Regional Water Resource Planning



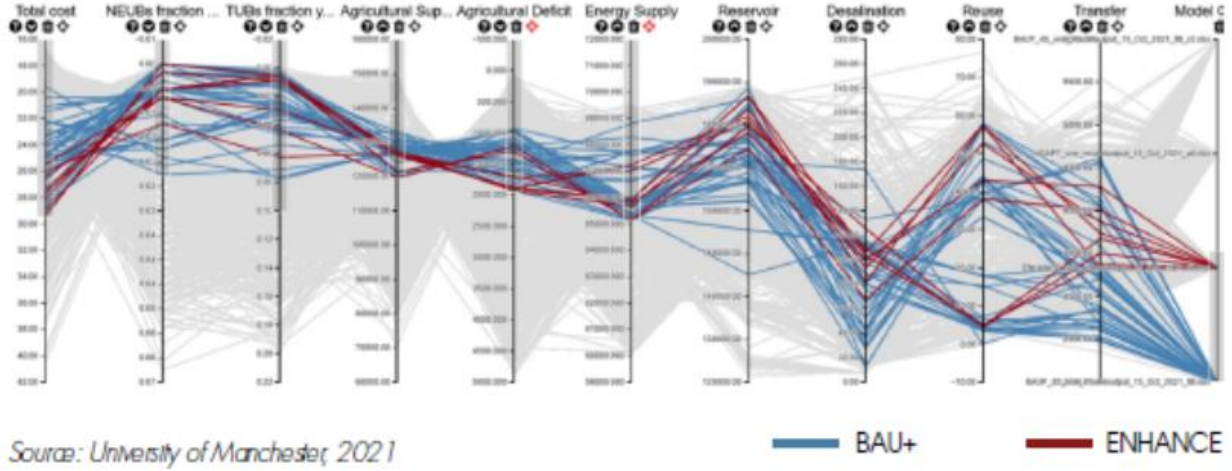
- PWS drought resilience (1 in N years)
- PWS customer drought resilience (£ NPV from willingness to pay surveys)
- PWS system reliability - ability to cope with short-term shocks – bespoke
- PWS system adaptability - ability to adapt to cope with short-term shocks – bespoke
- PWS system evolvability - ability to adapt to long-term trends-bespoke
- PWS Leakage reduction (m3/y)
- PWS Per capita water consumption (l/h/d)
- PWS Non household demand reduction (%, bespoke)
- Flood risk management (qualitative)
- Multi abstractor benefit - bespoke
- non-PWS resilience to drought – bespoke
- Non-PWS demand reduction (%, bespoke)
- Agri-food water allocation - (m3pa)
- Agri-food water deficit – (m3pa)
- Industry water allocation - (m3pa)
- Industry water deficit – (m3pa)
- Regional Export - (m3pa)
- Regional Import - (m3pa)
- Carbon embedded in construction (t CO2eq)
- Carbon in operation (t/y CO2eq)
- Carbon cost total NPV (£)
- Carbon offset cost NPV (£)
- Human & Social Well Being (combining human health, social & economic well being, cultural heritage, air quality, amenity) – bespoke
- Cost total capex and NPV opex (£)
  - With sensitivity to discount rate (£)
- Option Deliverability(Risk) -bespoke
- Ecosystem resilience (biodiversity, habitats, natural capital)- bespoke
- Environmental Flow Targets (statutory) – m3/s max deviation through year for each component water body & aggregated versions
- Environmental Flow Targets (sensitive sources) – m3/y
- Environmental effects of construction and operation of new supply assets – bespoke
- Biodiversity (net gain metric)
- Natural capital (£)
- Intergenerational equity - bespoke
- Stakeholder priorities - bespoke
- Water Company Customer Preference (options) - bespoke

Sources: all Regional Emerging Plans 2022

How to Decide ‘Best Value’?

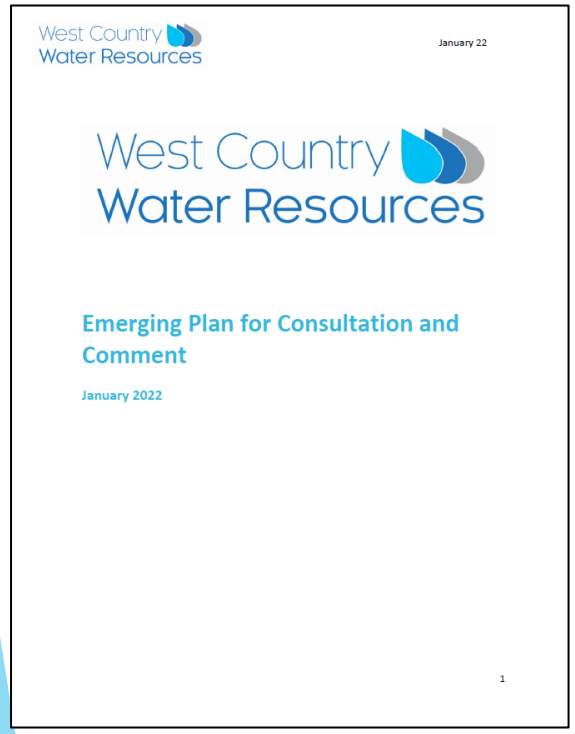
- No unique ‘best’ solution recognised by all involved
  - There will be winners and losers
  - Who decides and how could be important.
- Eg Collapse all the metrics to a common scale or ‘weight’ the metrics
  - Choose the best score?
  - Rank possible solutions and decision-makers debate?
- Eg Select some or all metrics, find candidate best solutions, decision-makers debate the ‘trade-offs’ and uncertainties
  - Eg WRE MO-RDM Multi-objective- Robust Decision Making
  - Use other metrics to ‘filter/promote’ candidate best solutions that might not be visible from first process
- Consider the ‘phasing’ or ’trajectories’
  - Losing an abstraction licence tomorrow is different to progressive reduction over 30 years or a step-change loss in 30 years time
  - Should phasing be built into ‘best’ or is it sufficient to optimally phase the ‘best’ 2050 solution?

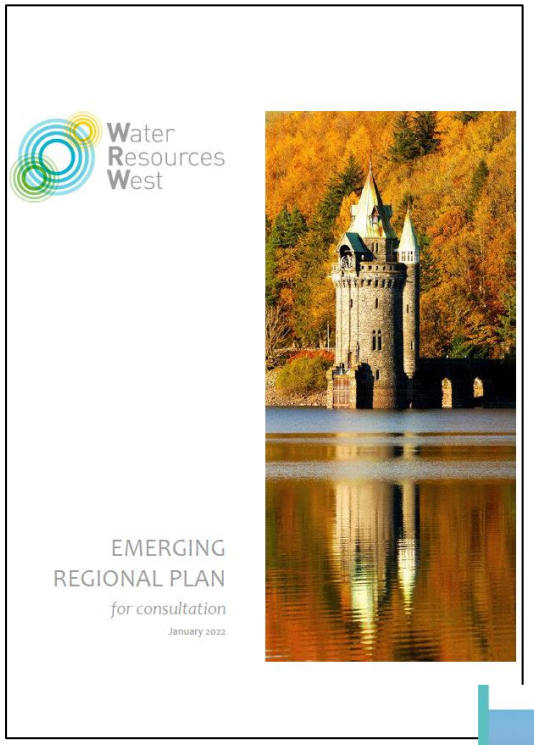
Figure 7.1: Example Polyvis parallel plot



Source: University of Manchester, 2021

The Current Emerging Plans





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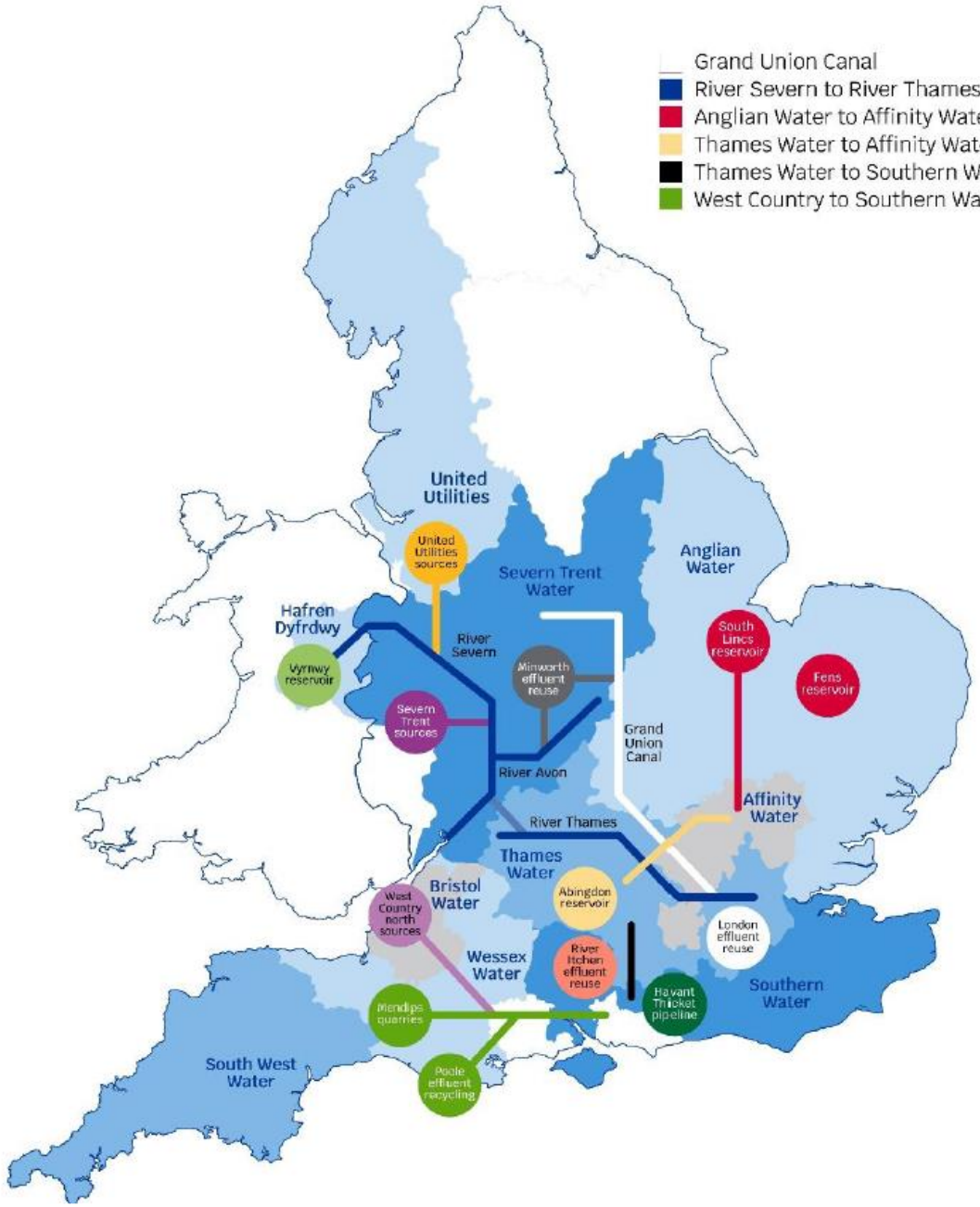
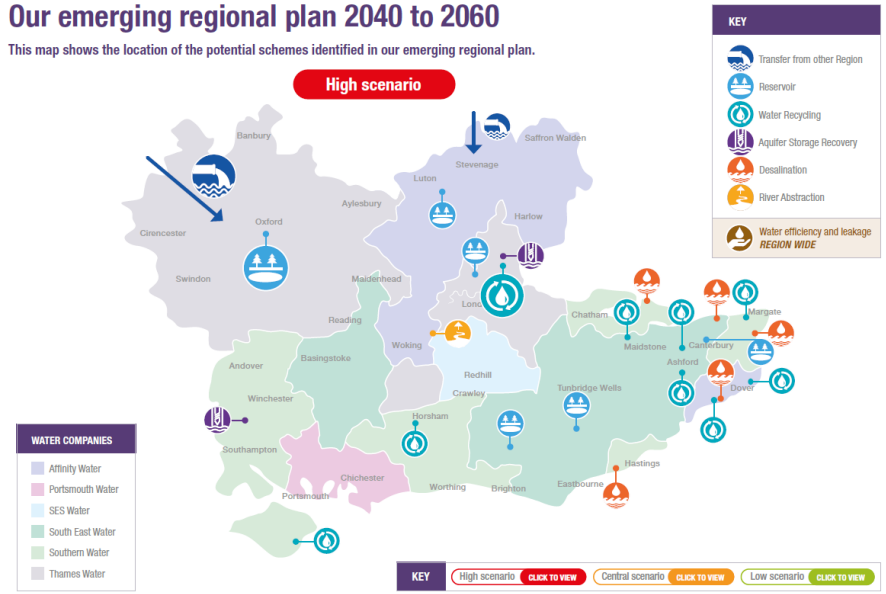
Water Resource Strategic Options - England

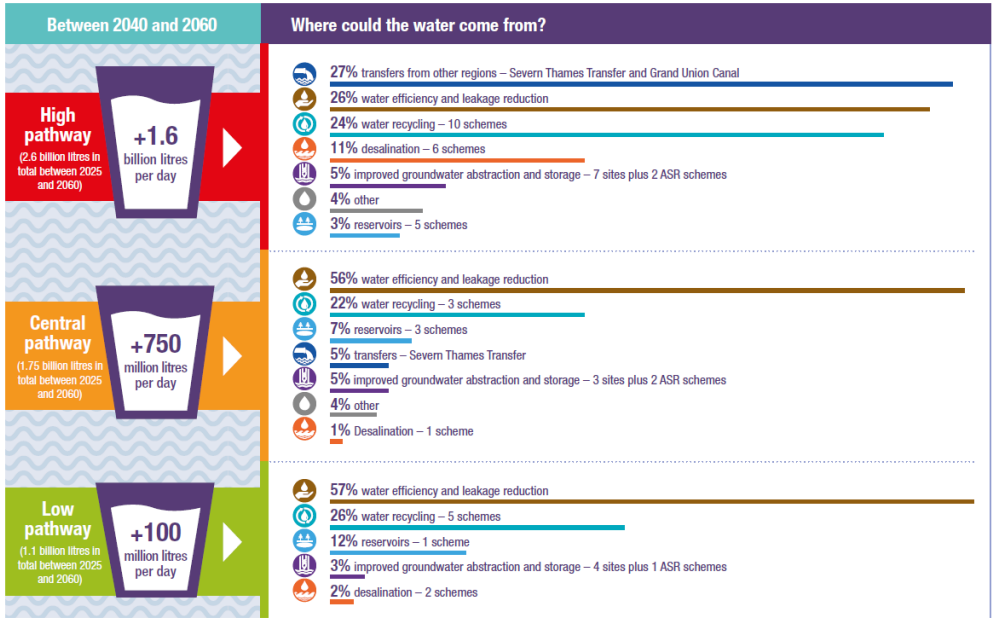


- strategic reservoirs in WRSE &WRE
- strategic transfers into WRSE
- Strategic effluent re-use

Source:RAPID Standard Gate One Key Themes and Final Decisions Overview Jan 2022 https://www.ofwat.gov.uk/wp-content/uploads/2022/01/RAPID-Final-Decision-Themes-Document.pdf

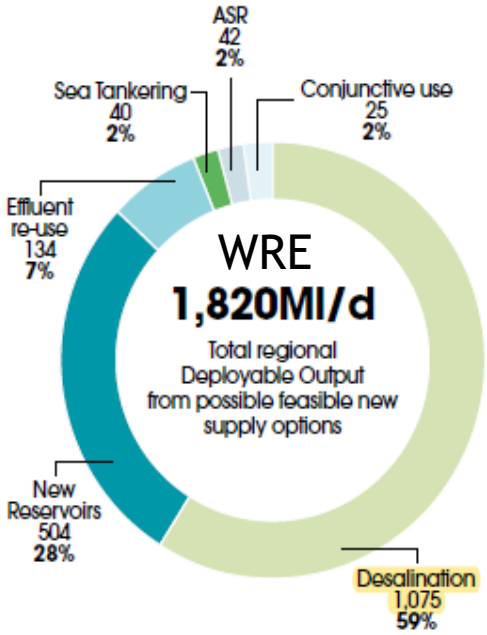
Regional Emerging Plans January 2022





- No group has yet produced a full adaptive best value plan
- Few event based adaptive triggers identified – mainly calendar 'tests' of reality and change projections
- All groups are proposing low regret long lead time supply interventions in early phases including a few major new strategic reservoirs
- Some major strategic transfers from NW to SE being considered
- Early start on major demand and leakage reduction
- Desalination not favoured (except in WRE if 'low carbon')
- Some effluent re-use schemes favoured

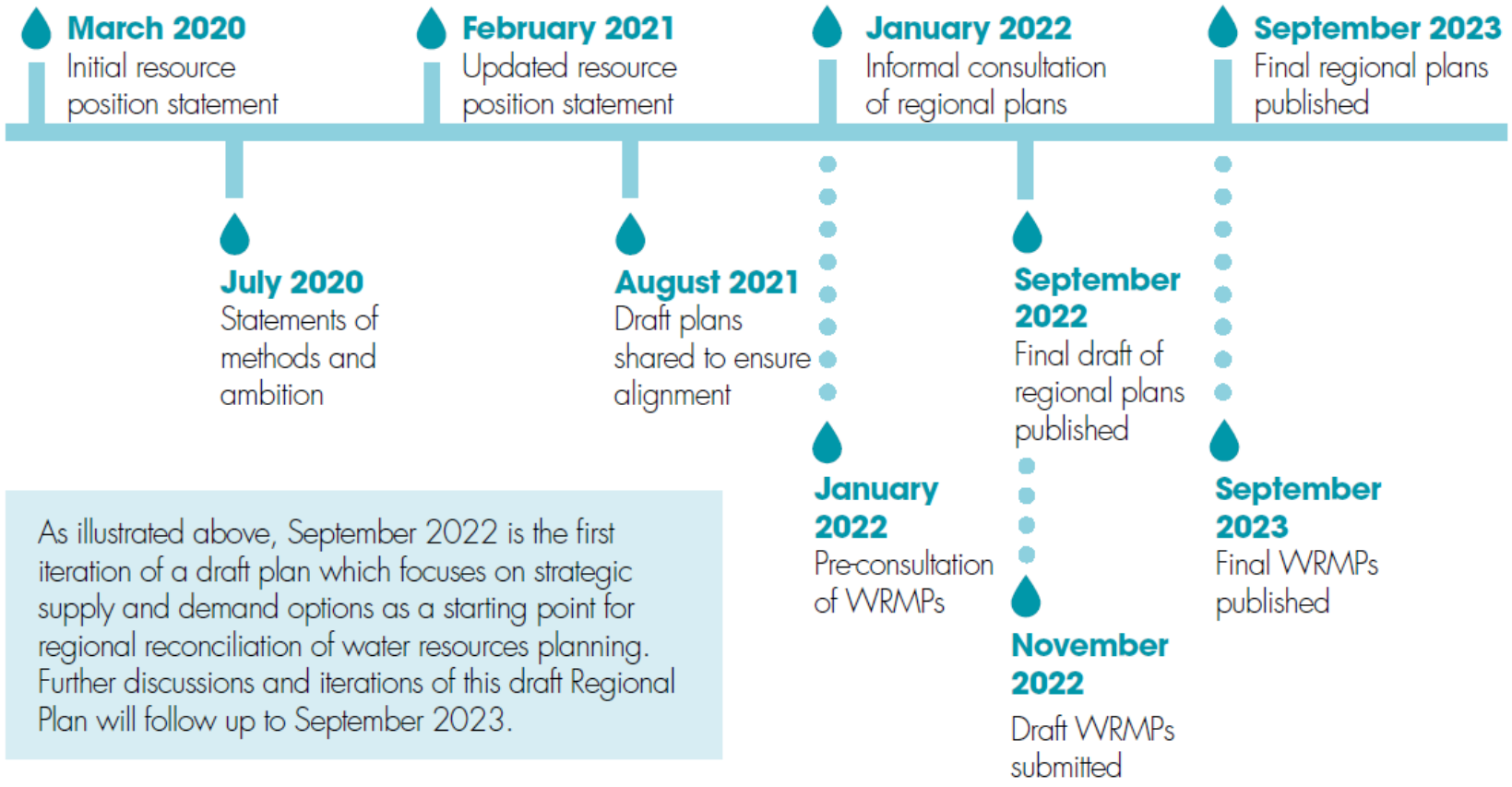
Figure 6.3: Feasible strategic supply options



Sources:WRSE & WRE Emerging Plans 2022

Timeline

Figure 1.2: Timeline of Regional Plan and WRMP24 alignment (dates subject to change)



- Source - WRE Emerging Plan 2022

Want to learn more?
Current Water Resource Planning Processes England

Environment Agency | Natural Resources Wales | Office for Water Services

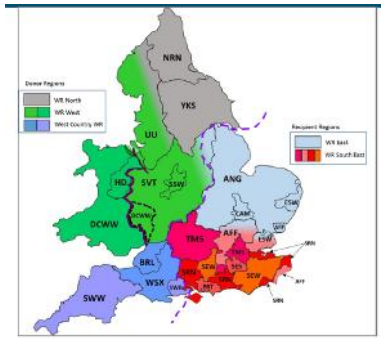
Guidance
Water resources planning guideline
Updated 17 March 2021

Environment Agency

Meeting our future water needs: a national framework for water resources

16 March 2020
Version 1

Water Resources West



WRE
WATER RESOURCES EAST

Department for Environment Food & Rural Affairs

Policy paper
Water abstraction plan
Updated 25 September 2020

West Country Water Resources

wrse
WATER RESOURCES SOUTH EAST

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Click on the icons for links

Thanks for Your Attention

Neil Edwards

AquaInform Ltd

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Sustainable Infrastructure for Cities
Centre of Doctoral Training University of Southampton

28th March 2022

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Supplementary Material

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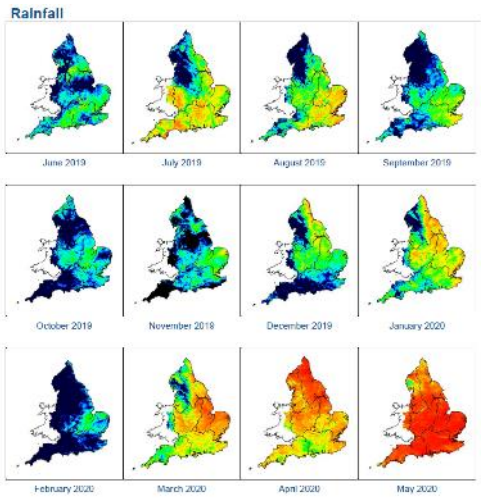
Sustainable Infrastructure for Cities
Centre of Doctoral Training University of Southampton

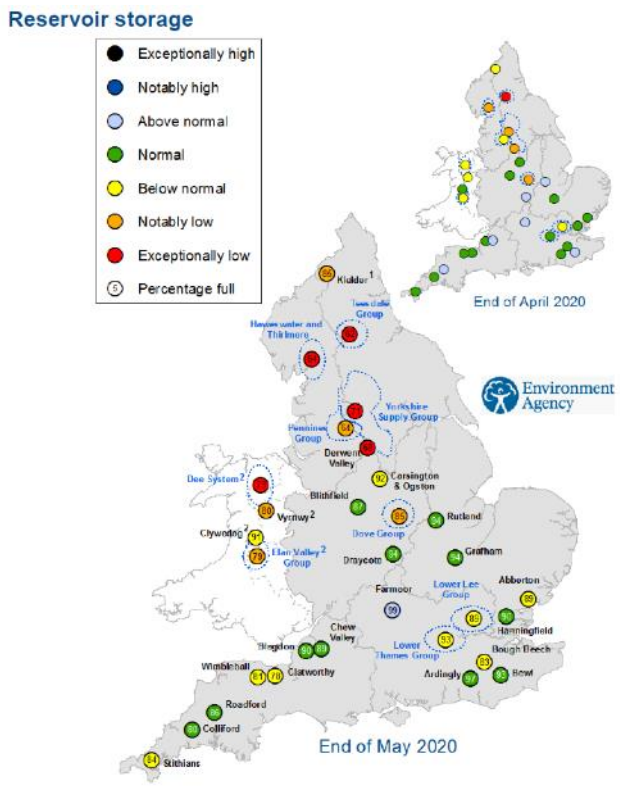
29th April 2021

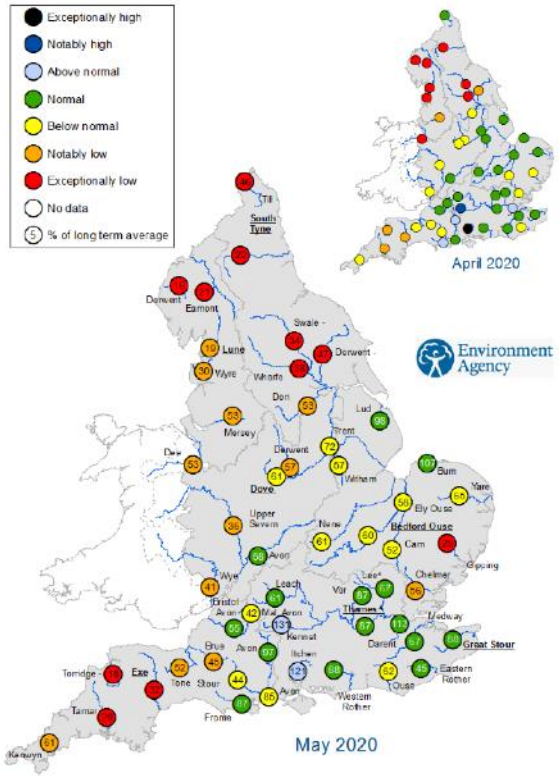
James Bevan Speech – Water Myths & Truths (selected extracts)

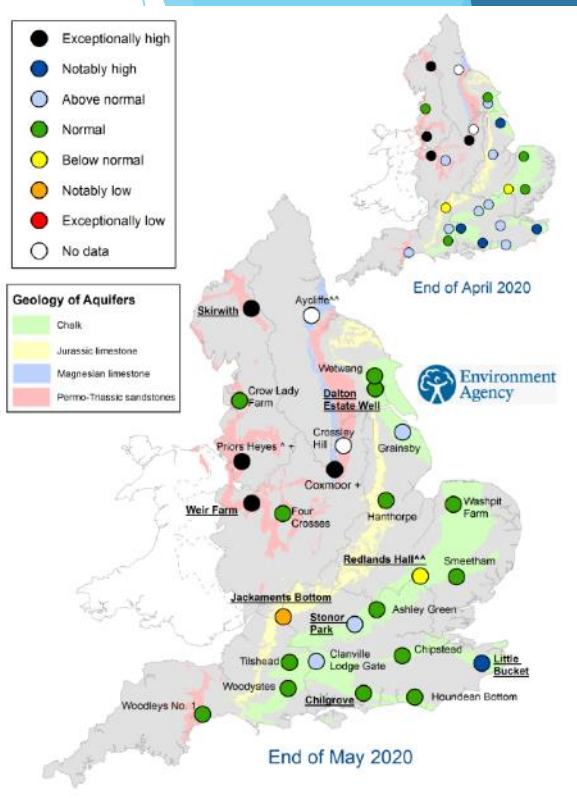
- The water crisis
  - In the age of social media, fake news and clickbait journalism … not everything being said is accurate
  - "Spoiler: the truth is more complicated and less convenient than you might hope. It does not fit into 280 characters on Twitter."
- **Myth number 1: "all our waters are in a terrible state."**
  - Wrong. It's a lot more complicated than that. There is bad news and good news, myth and fact.
- **Myth number 3: "the biggest problem we have is water quality"**
  - "The biggest long term threat to the environment, our economy and our lifestyle, and the one on which I'd like to see the media and NGOs campaigning equally hard, is water quantity – simply having enough for people and wildlife."
  - "We know how to avoid the jaws of death: reduce demand by using less water more efficiently; and improve supply, including by investing in the right infrastructure. And we have a plan to do that: an initiative the Environment Agency launched last year, the National Framework for Water Resources".
- **Fact number 1: water is far more precious than we think**
  - "we tend to assume that water is free and limitless on Earth. It isn't: it is astonishingly rare and easily damaged".
  - "…drinkable fresh water is pretty rare here on Earth itself. It makes up only 2.5% of all the water on our blue planet, and only 1% of that is accessible".
  - "Water is precious not just because it's relatively scarce but because it's also fragile: the water that nurtures us humans, wildlife and plants is very easily damaged and that damage can last for a long time. Example: mines. Almost all the mines in England closed decades, sometimes centuries, ago. But the pollution seeping out of them is still damaging many of our streams and rivers today."
- **Fact number 2: farming is doing as much damage to our waters as sewage**
  - "Farming and rural land management impacts a higher proportion of our water bodies - 45% - than any other source, mostly through what is called diffuse pollution"
- **Inconvenient Truth number 1: You get the environment you pay for**
  - "Nothing in life is free, and that includes better water quality. If we want it, it will have to be paid for."
  - … the polluter isn't always currently paying
  - "We welcome the government's recent agreement to increase the charges we apply for some of the abstraction licences we issue. Those are designed to stop water companies and others taking unsustainable amounts of water from the ground or our rivers".
  - "Clean and plentiful water is a public good. So it is right too that the government – which means ultimately the taxpayer - should pay some of the cost of achieving it,"
- **Inconvenient Truth 2: climate change may make things worse before they get better.**
- **Inconvenient Truth 3: if we want better outcomes, we need to think differently**

Source : https://www.gov.uk/government/speeches/water-myths-facts-and-inconvenient-truths?utm_medium=email&utm_campaign=govuk-notifications-topic&utm_source=772858f9-0719-4cb2-8f4d-45f7fff1353f&utm_content=daily 22nd Feb 2022









England Situation Report – May 2020
3 dry months after a wet period

Can Users 'Sort it Out for Themselves'?

- Water Wars/Range Wars – 'derogation' of 'existing water rights'
- Protection of environment
  - It can't compete for itself
  - Agent(s) acting for environment (eg Environment Agency, Natural England, Rivers Trusts, Wildlife Groups…)
- 'Social' mechanisms including legal frameworks tend to develop to resolve dispute once dependence on rivers evolves eg
  - Risk of unavailability of water resource
    - Intrinsically uncertain subject to natural seasonal and weather related statistical distribution
  - Risk of Flood
  - Risk of adverse water quality
    - Intrinsically uncertain subject to natural seasonal and weather related statistical distribution
- In England legal basis of abstraction licensing was only established in 1963 Water Resources Act
  - Though there had been long history of previous rules/laws often acts of parliament with effect only at local level.
  - Has evolved through 1991 Water Resources Act and subsequent tweaks but has retained essentially the same principles
  - 'Action' results from interplay between various legislation, plans and policies
- Need a future-facing system to deliver sufficient confidence for would be users to commit to invest in new activity/infrastructure & provide a degree of protection (but not fossilise) existing users eg
  - against new (excessive) upstream consumptive use, or diversion or excess
  - against new upstream (excessive) impairment of quality
- ie Planning
  - Anticipating problems and avoiding them
  - Towards 'best' use?
- Institutional Arrangements
  - Failure
  - Mismatch
  - Statutory responsibility
    - Eg regulated business WatCo
  - Sector structure
    - Small number of players with no or regulated competition (PWS)
    - Large number of individual players competing against each other may not be able to organise to compete with out of sector interests
      - Representation of 'sector'
        - Who/what if any makes a sector plan
        - Who/what if any can do a deal on behalf of a sector

Regional Water Resource Planning – Multi-Sector resilience

Going beyond ‘traditional’ least cost Economics of Balance of Supply & Demands (EBSD) planning for Public Water Supply towards ‘Best Value’

Who judges ‘value’

‘Value’ to ‘whom’

How?

Providing new supply options (or revised resource allocation) for non-PWS sectors

Who should pay?

Should non-PWS agents be left with supply options PWS don’t reserve for themselves?

Should non-PWS seek (or be forced) to …

Adopt non-optimal reduced or non-water intensive alternative technology

move to the coast to use salt-water (responsibly), possibly with desalination

England – Water Resource Regulation <1945

- PWS originally seen as a public health issue
  - 18th C provision by local authorities or private companies with powers by local act of Parliament
  - Problems as populations grew
    - Competition for new sources of supply (each of which was 'assigned' through a new local act of Parliament)
    - No 'area' policies though 'Regional Advisory Water Committees' (Min Health led) set up 1924 to co-ordinate water supply schemes with more than one supplier. Govt scope was domestic supply only
- Thames Conservancy (created 1857)
  - Crown reclaimed rights from City of London
  - gave them to a new Thames Conservancy
  - extended from Staines to source at Cricklade in 1866
    - Navigation (trade, tolls, structures)
    - Protected rights of anglers against landowners
    - Later evolved into a Catchment Board in 1930, and Thames Water Authority
- River Conservancy Bill 1878
  - Responding to Select Committee Report
    - Suggested new single body Conservancy Boards for each River
- Thames Preservation Act 1885
  - Protected right of public to use of river for recreation, preventing 'shooting'
- Land Drainage Act 1930
  - Flood risk management oriented but created …
  - Catchment Boards (for 47 of 100 identified catchments)
  - Little gauging of river flow took place!
- Water Act 1945
  - Introduced non-domestic supply
  - Minister of Housing & Local Govt to …'promote the conservation and proper use of Water Resources … and secure effective execution by water undertakers … of a national policy relating to water'
    - Conservation to be delivered through some powers on abstraction controls (but not constituting a full abs licensing system)
    - Ensuring sources of water supply were protected against pollution

England – Water Resource Regulation 1948-63

- River Boards Act 1948
  - Led to 17 larger River Boards replacing the 47 catchment boards – each by individual act of Parliament. Ultimately became 32 River Boards
  - River Boards have responsibility for fisheries (subsuming the work of Fishery Boards which had come into being though salmon fishery act 1861, salmon and freshwater fisheries act 1907 & 1923)
- Rivers (Prevention of Pollution) Act 1951
  - Introduced discharge licensing
- Water Resources Act, 1963
  - 27 River Authorities replacing River Boards
    - For conservation, re-distribution and augmentation of water resources in their area or ensuring that water resources were used properly in their area, or were transferred to the area of another river authority
  - + duties/power on fisheries + prevention of pollution + gauging
- Abstraction licensing system
  - Existing users having 'licences of right'
  - Charges levied
  - PWS abstractors required licences
- Primary focus was protection of interest of abstractors (FCFS principle)
  - Not a basis for allocation
    - perception of surplus in most places
  - Not about protecting aquatic environment

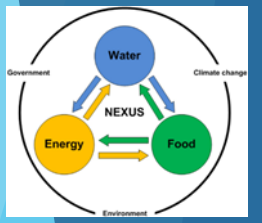
England – Water Resource Regulation 1973-91

- Water Act 1973
  - 10 regional Water Authorities (=Water Board) replacing Rivers Authorities – integrated control over individual river basins
- Water Act 1989
  - Separation of regulatory roles (National River Authority, OfWat) from
  - PWS delivery by 10 privatised WatCo (eg Southern Water plc, Thames Water plc …
- Water Resources Act 1991
  - + Water Industry Act + Land Drainage Act + Statutory Water Act consolidating 20 pieces of water legislation
- Environmental Protection theme
  - Quality (GQA) for controlled waters
  - quantity of water functions - Minimum ecological flow concept
  - Definition of pollution
  - Offences
  - Discharge consents (offence if #cause' harm no need for negligence or intent = strict liability)

England – Water Resource Regulation >1996

- 1996 Environment Agency formed and absorbed National River Authority
- 1999-WatCo produce voluntarily Water Resource Management Plans following EA guidelines (becoming statutory in 2003) with consultation process covering +25 years and subsequent refinement of guidelines (2007)
- 2001 -all new licences or major variations to be time-limited (previously was locally determined time-period or 'without end date')
- Water Act 2003
  - Followed Taking Water Responsibly 1999
  - Drought plans, permits, orders
- [Abstraction Reform initiative 2013-2017]
- Abstraction plan 2017
  - Environmental protection initiative (unsustainable abstraction)
  - Catchment focus (CaBa)
  - WatCo working with others to find 'best solutions'
  - Initial Priority Catchment Trials
- Environment Act 2021
  - Curtailment of damaging or underused abstractions without compensation (from 2028)
  - 25 year Environment Plan targets
- Transition to Environmental Permitting Regulations (2023)

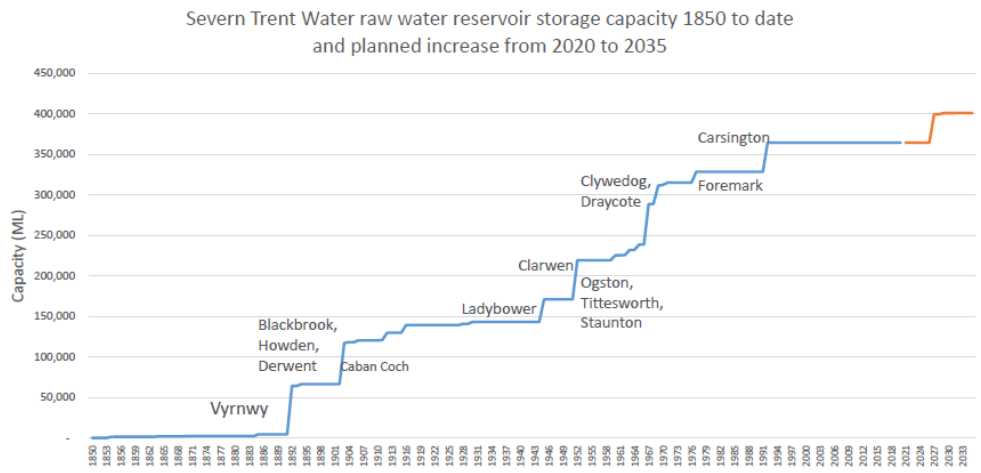
Environment Act 2021 & 25 year plan 2018



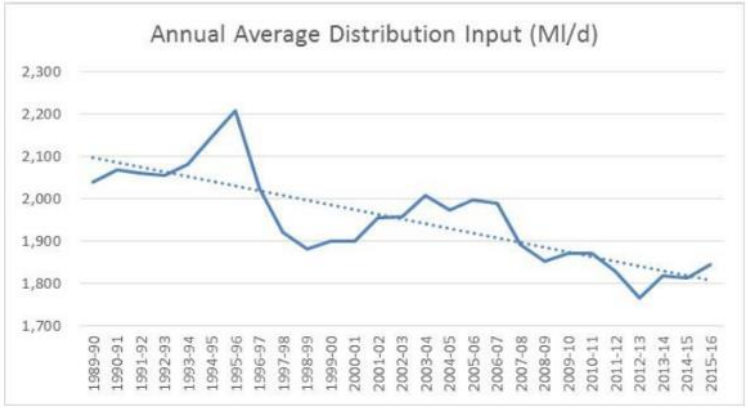
- Post Brexit England's approach to Environment
- Long term targets (including for water, biodiversity and resource efficiency))
- Environmental Improvement Plans (>15 years period)
- Policy statement on environmental principles – how Ministers should interpret and apply 'environmental principles' of:
  - environmental protection
  - Preventative action to avert env damage
  - (environmental) Precautionary principle
  - Env damage to be rectified at source
  - Polluter pays
- Biodiversity strategy
  - Local nature recovery strategies
- Water (Resources) Content
  - Water Undertakers : must prepare Statutory Drainage & Sewerage Management Plans as well as Statutory Water Resource Management Plans & Drought Plans
  - But no linkage with Water Resource planning is forced (at least in the Act).
- Abstraction Licences – from 2028 removal of compensation for variation or revocation of a non-time-limited licence (generally those issued before 2001)
  - to protect environment
    - =prevent damage or avoid compromise of an environmental objective (WFD))
  - to remove 'excess headroom'
    - Applies if in each year in the relevant 12 year period abstractor did not take more than 75% of the quantity authorised and the abstractor does not 'reasonably require' the 'excess'
      - Licence could still be reduced but compensation would then be payable
  - In practice makes Environment Agency more likely to reduce or curtail existing licences by removing need for compensation in many circumstances. EA already can amend or revoke a time-limited licence without compensation at the licence end date. EA can amend licences without compensation in the event of 'serious damage'

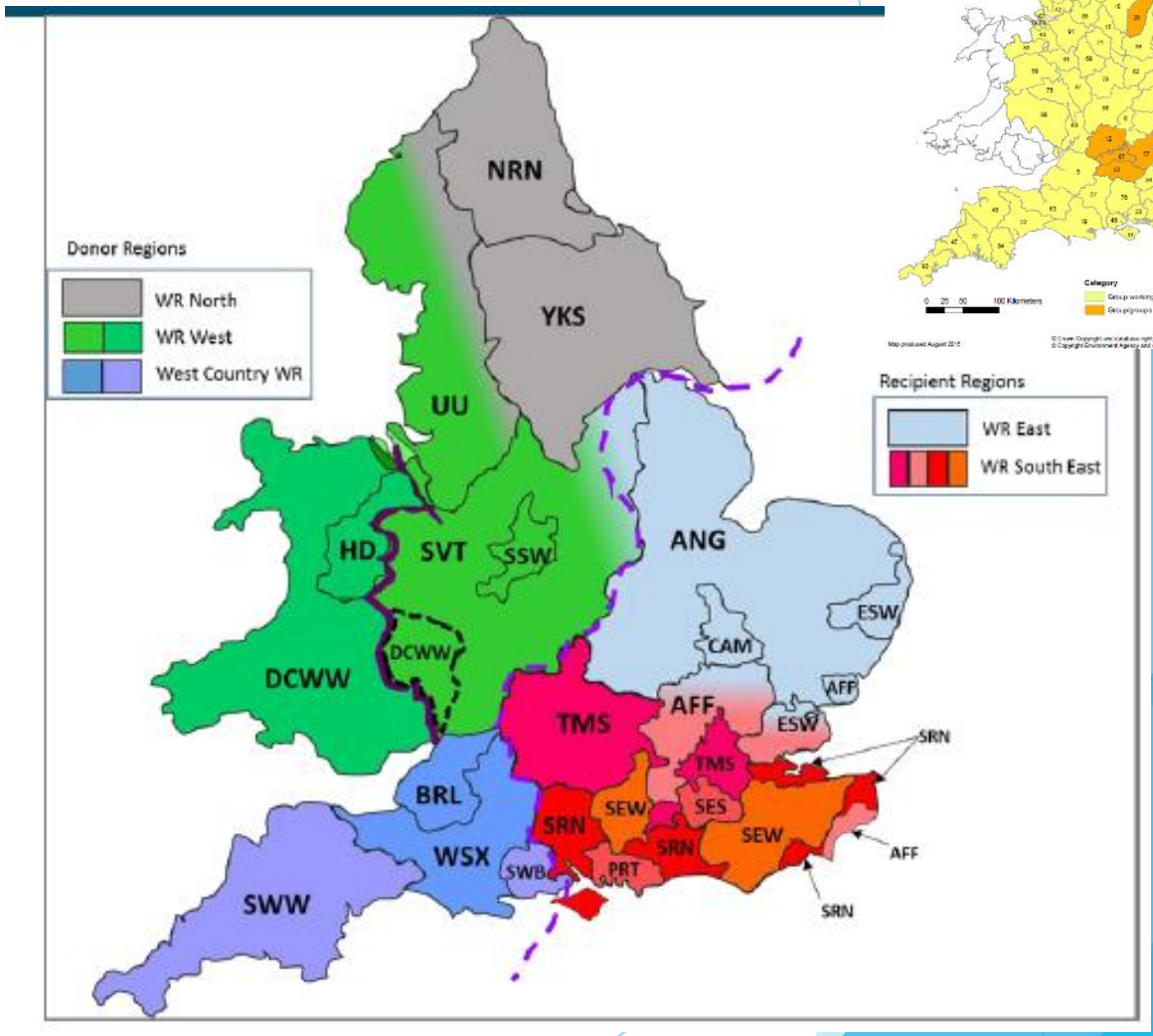
Regional Planning & WatCo Boundaries 2020

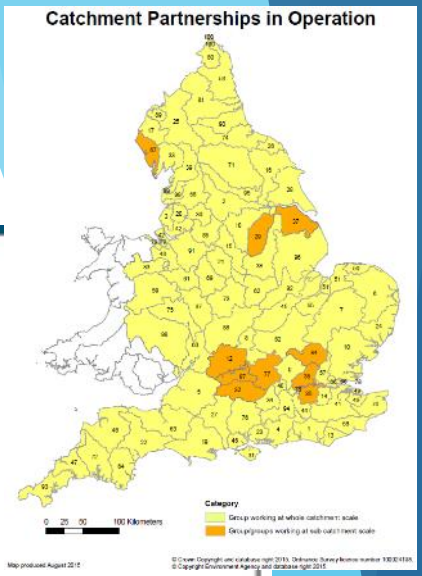
RESERVOIR DEVELOPMENT



Source:John Deval, Head of strategic asset planning STW, 2019







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England – Water Resource Regulation Development

<1878 2000-3000 individual 'local' Acts of Parliament (Local Sanitary Authorities, Statutory Water Undertakers, Conservancies)

1878 River Conservancy Bill – advocated integrated water management at river basin scale

1930 (Land Drainage Act)
- 47 of 100 identified Catchment Boards created

1945 (national policy on proper use of water resources)

1948 River Boards Act
- 17 River Boards
- Expanded to 32
- Subsumed Fisheries Boards

1951 Rivers (Pollution Prevention) Act
- discharge licences

1963 Water Resources Act
- 27 River Authorities
- Abstraction licensing (first come first served)

1973 Water Act
- 10 regional Water Authorities

1989 Water Act
- 10 Water Companies (PWS) + 1 National Rivers Authority (Aq Env Regulation)

1995 Environment Act
- 1 Environment Agency integrates 1 National Rivers Authority with Her Majesty's Inspectorate of Pollution and multiple Waste Authorities

2000-date Water Framework Directive River Basin Management Planning
- 11 River Basin Districts (Eng & Wales)

1999-2013 various changes to water resource management planning and abstraction licensing including all new licences to be time limited to 12-24 years
- 14 Catchment Abstraction Management Strategy 'areas'
  - Each with several (3-10) Catchments

2017 Abstraction Plan replaces 2013-2017 Reform Initiative to fix abstraction licensing regime perceived no longer fit for purpose
- Unsustainable abstraction to be remedied
- Catchment Based Approach (100+)

2019 5 Regional Water Resource Planning Groups (England) introduced

Detail in supplementary slides

Key Regulatory Theme – Much Simplified

- Institutional arrangements
- 1879-1973 - towards functional integration at river basin scale :
  - Increasing geographic scale to whole watersheds controlled by a single institution
  - Across sufficient range of interrelated issues and services including PWS
    - = Integrated river basin management
  - Knowledge
  - Power/Authority
  - Funding
- Culminating in the Water Authorities of 1973 as public bodies
- 1973-date – 'oscillation on scale' and more emphasis on 'economics' principles :
  - Water Authorities dismantled in privatisation of 1989 (economics principles applied in many settings not just 'water')
    - Separation of regulation & 'activity'
- New integration requirement via Water Framework Directive (2000)
  - Integrated Management Planning at River Basin District scale with Environment Agency as Competent Authority
  - Requires public participation
  - Balance of costs and benefits in setting targets
  - 2000-2015 RBDLP Liaison Panels (acting as critical friend to EA)
    - Dismantled in 2016 to focus at catchment scale
- New National and Regional Water Resource Planning initiatives
  - Water Company and Environment Agency dominated
  - Consideration of non-Public Water Supply interest

Primary features of an abstraction licence (England) & factors influencing determination

- Features
  - Abstraction position / (area)
  - Abstraction volume flows permitted for purpose(s)
    - Instantaneous, hourly, daily, [weekly], Annual
    - Possibly linked to river flow/level
      - Hands Off Flows (HOF)
      - Hands Off Levels (HOL)
  - Reporting requirements
    - Compliance
    - Information
  - {Biota Protection Provisions eg behavioural deterrents, fish recovery and return arrangements}
  - [formerly included specification of land on which use takes place]
- Factors
  - Aquatic environmental protection (Water Resources)
    - Environmental Flow Indicators (EFI)
    - Protected Area requirements
  - Biota Protection
    - Entrainment/impingement/ modification of flows …
  - User protection
    - Against derogation (of existing licence right)
  - Reasonable need and efficient use test
    - For the purpose
    - Does not consider the 'worth of the purpose'
  - System does not always result in economic efficiency of use of scarce water resource
  - Is First Come First Served (FCFS)
- But not all non-trivial abstractions require an abstraction licence!
  - Coastal waters out of scope of abstraction licensing

Does compliance with a licence constitute responsible use of water?

- With a reputable licensing system, what can possibly go wrong…?
- … change eg
  - Technology/techniques evolve to be more water efficient
    - What was reasonable need when granted may no longer be reasonable for the purpose
  - Production/demand tails off but leaks/losses/inefficiencies develop
    - May not be cost efficient for user to fix leaks if cost of fixing > cost of water eg long period until leak fix project payback
  - Views on environment needs change
    - Higher allocation to environment now thought desirable or become legally required
    - More licencing might have been issued than is now thought consistent with desired environment protection
    - Could imply occurrence of environmental damage (in fully licenced scenario) if nothing is done on licensing/restricting actual use
  - Growth in demand from existing users
    - PWS- Population growth and change in affluence leads to demand outstripping improvements in household water use efficiency
    - Agri/food – market develops to favour more water intensive products
  - Would be users with higher economic value purposes appear
    - if all available rights have been issued then barrier to their market entry
      - role for markets/trading to supplement or replace existing water resource allocation?
  - Climate
    - Timing, frequency, duration and intensity of rainfall events changing differently in different areas affecting water supply and storage
      - Changing snow occurrence and snow melt timing
- What was once appropriate allocation of water resource (and implied use of rivers) may not continue to be as things change

Possible actions to address multilemma

- Promote changes in water use within current licenced quantities
  - Incentivising or forcing leak-fixing
    - Eg more stringent reasonable need/efficient use testing on licence review
  - Increase price of abstraction licence and/or charging for actual use of water
    - Difference in economic role of water right and physical water
  - Use tactics linked to reputation to nudge abstractor/user behaviour
    - 'Name and shame' on water use/product metric if peer group data are published
    - Could result in direct stakeholder action (eg customer boycott, demonstrations …)
- Set up a stakeholder process to tackle the nexus – may revise licenced quantities ie water resource allocation
  - eg Integrated National/Regional and Catchment Water Resource Planning
  - Siting within an already busy arena
    - River Basin Management Planning
    - 25 year Environment Plan …
- Does an action drive towards 'responsible use of rivers' if it …
  - increases cost of product/service
    - Could lead to closure of activity if cost cannot be 'passed through' impacting on market position
    - Implications for customers if passed on
  - Leads to other environmental impacts eg
    - Increased use of chemicals,
    - More chemical discharge to manage more complex system chemistry
    - Increase emissions to air
  - Leads to worsening of production performance in other measures eg
    - Energy/product
      - air cooling rather than water cooling
    - Fuel or feedstock / product
- Need to consider the wider picture – not just about the river?