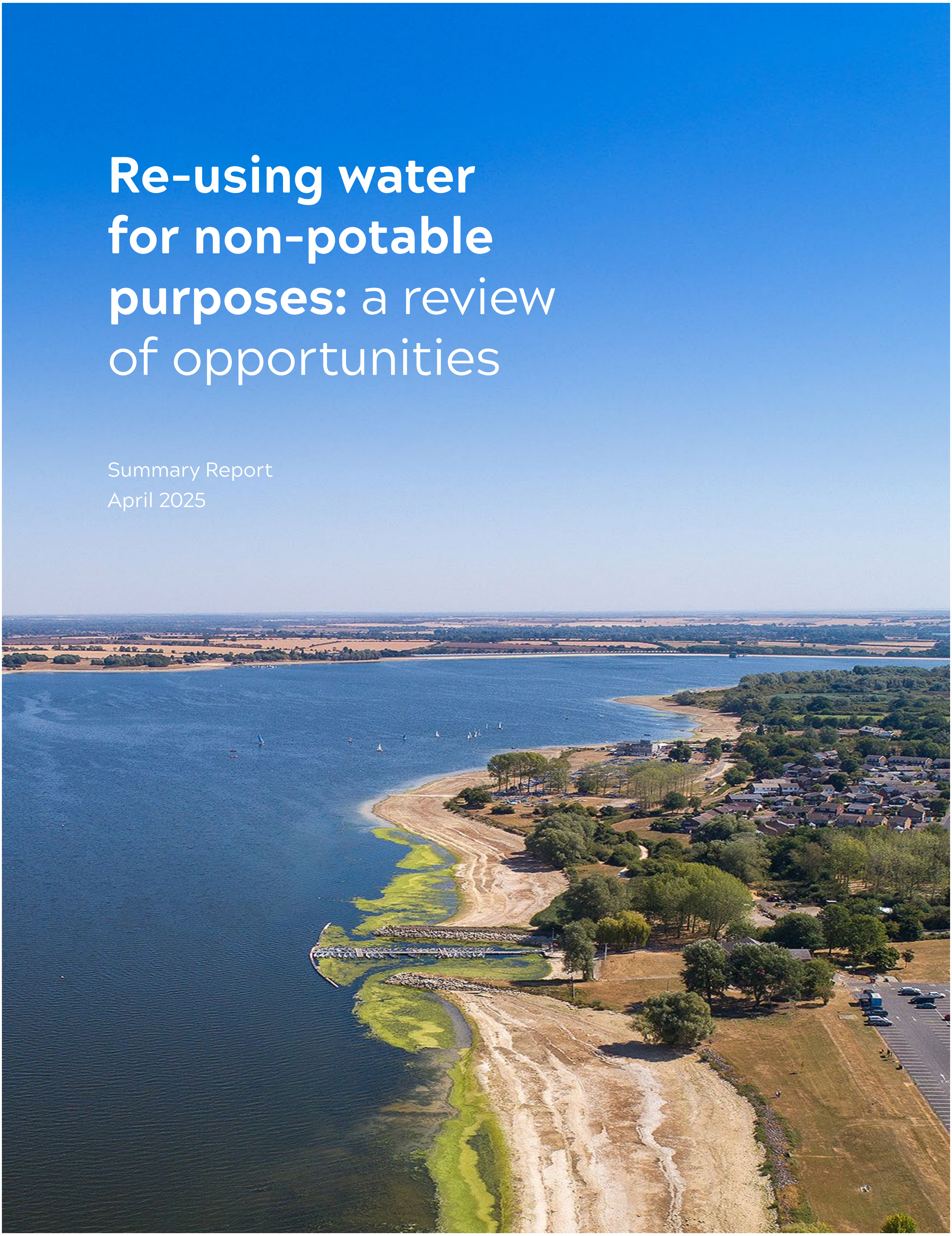
Re-using water for non-potable purposes: a review of opportunities

Summary Report
April 2025



Environment Agency
WRE Water Resources East
Wessex Water YTL Group
South Staffs Water
love every drop anglianwater

Contents

3 Foreword

4 Introduction to this report

5 Opportunities for non-potable water re-use

10 Re-use hierarchy: sources, treatment and uses

12 Barriers and solutions

15 Standards and guidance

17 Conclusions

18 Recommendations

This Summary Report is published alongside an Evidence Appendix, which provides supporting information, and an International Best Practice Review, which provides a set of re-use case studies.

Why the UK's journey to water re-use must start now

The recently finalised set of regional water resources plans, and water company Water Resources Management Plans, has confirmed the significant pressures that all sectors face in balancing supply and demand.

While not always recognised, the Government's top priority for growth means that water also needs to be high on the agenda. Supplies are already under significant pressure, and there is a need to become more resilient to drought, adapt to climate change and enable restoration of the natural environment.

We are going to need a wide range of solutions, at scale, to achieve long-term water security, including sources of water that have been less well developed in the UK. After demand management, the re-use of water should be the next consideration, but the historical availability and low cost of water has meant insufficient action to date. Although there are some good examples of process re-use in industry, uptake remains limited.

The National Framework for Water Resources was published in 2020, and is currently being updated, in order to set the foundation for the next set of regional and company plans. As part of this update, it is important to fully explore the opportunities for re-use. A working group led by Anglian Water was formed to take this initiative forward as a workstream of the National Framework for Water Resources.

In November 2024, the working group brought together more than 50 stakeholders at a workshop in London, representing organisations that could provide, treat or use water that has been recycled. The dialogue was enthusiastic and focussed: many attendees reflected that this was a key moment in the journey to establishing water re-use as a widespread solution.

The energy and enthusiasm following this initial workshop has seen the working group come together to examine a wide range of sources, uses and users for recycled water, identifying barriers and the solutions required to overcome them. They have also created a list of recommendations for further exploration, especially on solutions, including potential updates to legislation, standards and guidance.

An independent study commissioned by the group has provided an inspirational set of international case studies. This report aims to catalyse action in the UK. By adopting the recommendations of this report, inspired by our international counterparts who are already making great use of this precious resource, alongside the need for change and impetus for growth, we can make it happen.

Jean Spencer, Independent Chair, National Framework for Water Resources

Introduction to this report

Water resources are under significant pressure in England, due to a combination of growth, climate adaptation, drought resilience and the need to leave more water in the environment.

As set out in recent company and regional water resources plans, solutions include demand management and the development of new supply-side options.

Although new supply-side options include some examples of water re-use, specifically to increase reservoir levels (e.g. Havant Thicket; Colchester re-use), there has been much less consideration of how non-potable water could be used to meet a variety of demands. This could range from the network scale (e.g. South Humber Bank; Port of Rotterdam) to agriculture (supplementing or replacing existing supplies) or leisure facilities (e.g. golf courses and sports pitches).

A working group has been established to identify and evaluate opportunities for greater uptake of recycled, non-potable water. The group is examining a wide range of sources, uses and users for recycled water, drawing on national and international case studies, and identifying barriers and solutions (legal, financial, environmental and technological).

Current initiatives supporting re-use

- Government is reviewing issues associated with providing non-potable water to households, including potential changes to legislation to allow water companies to provide a second, non-potable supply.
- Enabling Water Smart Communities is an Ofwat Innovation fund project led by Anglian Water exploring the relationship between integrated water management, community engagement and practices, and housing development to unlock new opportunities for cross-sector delivery and stewardship.
- The All Company working group, re-use sub-group, is focussed on large-scale, indirect re-use for ultimate potable treatment.

The scope of the working group is high-level, and in its first phase of work, has produced a rapid analysis of opportunities and constraints, and developed recommendations for further work. It has identified a hierarchy for water re-use and has reviewed current and potential standards and guidance. Complementary initiatives are summarised bottom left.

The working group's findings and recommendations are now available for consideration in the updating of the National Framework for Water Resources. The Framework, being led by the Environment Agency, is due for publication in summer 2025. The report is also relevant to water companies seeking to facilitate sustainable water supplies, to organisations using and perhaps wanting to increase or change their sources of water, and to Government, regulators and other stakeholders involved in setting policies and supporting change.

Opportunities for re-use: sources, uses and Use Journeys

This section evaluates sources of water and their potential uses, and identifies a number of 'Use Journeys' that match promising sources (and treatment) with under-developed uses.

Sources of water and uses have been collated based on a literature review and the experience of the working group and attendees of the stakeholder workshop.

The analysis takes a water resources perspective, focussing on opportunities to replace or supplement conventional sources of raw or potable water.

Although the focus is on water quality, the quantity and reliability of resource has also been considered. Geographic constraints will also apply where it may be infeasible or uneconomic to transfer water. Further assessment of quality and quantity would be required before adoption.

The following tables assess the suitability of different sources of water for different uses, based on quality of water and potential treatment levels, firstly based on no or minimal treatment, and then based on a treatment level. Potential issues with the quantity (drop icon) and reliability (cycle icon) of water are noted.

Table 1: Opportunities for non-potable re-use using no/minimal treatment (e.g. screening)

	Agriculture (Irrigation)	Agriculture (Glasshouse)	Brewing	CCUS (Carbon Capture, Usage and Storage)	Data centre (Cooling)	Domestic (Toilet flushing)	Domestic (Outdoor use)	Energy (Cooling)	Food processing	Hydrogen production	Recreation (Irrigation)
Rainwater (from roofs)	High; quantity, reliability	High; quantity, reliability	Low; quantity, reliability	High; quantity, reliability	High; quantity, reliability	High; reliability	High; reliability	High; quantity, reliability	Low; quantity, reliability	Medium; quantity, reliability	High; reliability
Urban drainage systems	Medium; quantity, reliability	Medium; quantity, reliability	Low; quantity, reliability	High; quantity, reliability	High; quantity, reliability	Medium; reliability	Medium; reliability	High; quantity, reliability	Low; reliability	Medium; quantity, reliability	Medium; reliability
Highway runoff	Low; quantity, reliability	Low; quantity, reliability	Low; quantity, reliability	High; quantity, reliability	Medium; quantity, reliability	Medium; reliability	Medium; reliability	High; quantity, reliability	Low; reliability	Low; quantity, reliability	Low; quantity
Domestic grey water	Medium; quantity	Medium	Low	High; quantity	High; quantity	High	Medium	High; quantity	Medium	Medium; quantity	High
Internal drainage board water	High; reliability	High; reliability	Medium; reliability	High; reliability	High; reliability	Medium; reliability	Medium; reliability	High; reliability	Medium; reliability	Medium; reliability	Medium; reliability
Sea water	Low	Low	Low	Medium	Medium	Low	Low	Medium	Low	Low	Low
Sewage effluent	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Industrials effluent	Low	Low	Low	Medium	Medium	Low	Low	Medium	Low	Low	Low
Mine water	Low	Low	Low	Medium	Medium	Low	Low	Medium	Low	Low	Low
Polluted groundwater	Low	Low	Low	High; quantity	Medium; quantity	Low	Low	Medium; quantity	Low	Low	Low

Key

Quality of water (no/min. treatment): Low suitability (red) · Medium suitability (orange) · High suitability (green)

Potential issue with water quantity: Reliability across the year (cycle icon) · In total across the year (drop icon)

Rainwater (from roofs)

The quality is likely to be suitable for most purposes (except from direct inclusion in food) but there are significant questions regarding quantity and reliability, which would make it unsuitable for large-scale uses such as industrial cooling or widespread irrigation. Even where there may be sufficient quantity, storage may be prohibitively large or/and expensive. Nonetheless, rainwater (from roofs) will continue to be a useful supplementary source of water and/or requiring minimal treatment, and should be considered further for local scale irrigation (e.g. glasshouses) and new buildings, including houses.

Rainwater (from roofs) is considered in two Use Journeys:

1. Rainwater via limited treatment for non-potable domestic use
2. Rainwater via limited treatment for local scale irrigation (e.g. glasshouses, greens)

Urban drainage systems (untreated)

The quality can be variable depending on the drainage catchment area. Where there is significant input from highways it is unlikely to be suitable for many uses, particularly food production and processing, due to the risk of fuel spills and persistent hydrocarbons and heavy metals. There are also concerns regarding quantity and reliability.

Further research should be considered further to fully understand quality variability, reliability of resource and place-based applicability.

Highway runoff (untreated)[1]

This is unlikely to be suitable for most uses due to variability and risk from spills of hydrocarbons. Quality could be suitable for cooling systems, but lack of reliability is likely to make it unviable. This could be considered further, particularly where there are known highway flooding issues, but treatment is likely to be needed.

Domestic grey water (untreated)

There is much potential for reusing domestic grey water, especially close to homes and large non-household domestic uses such as schools, universities, hotels and military barracks (hospitals and prisons may be less suitable if untreated). There may not be sufficient quantities for large uses, such as cooling.

Domestic grey water (untreated) is considered in two Use Journeys:

3. Domestic grey water via limited treatment for non-potable domestic use
4. Domestic grey water via limited treatment for local scale irrigation (e.g. greens)

Internal drainage board water (untreated)

Significant volumes of water are pumped from internal drainage districts especially in winter. The quality of water will limit use, if untreated, to certain uses, including cooling and Carbon Capture, Usage and Storage (CCUS), if these can cope with seasonal availability.

Internal drainage board water (untreated) is considered in two Use Journeys:

5. Internal Drainage Board water via limited treatment for cooling and/or CCUS
6. Internal drainage board water for irrigation (local recreational and/or agricultural)

Sea water (untreated)

Untreated sea water is unlikely to be suitable for many purposes. It may continue to be suitable for cooling (subject to the nature of the cooling system and related requirement for treatment) and could be considered as a media for CCUS. However, it probably has limited potential beyond current uses.

Sewage effluent (untreated)

Untreated sewage effluent has little opportunity for re-use. It is not suitable for any food or recreation applications due to public health risk. Even in closed cooling systems there would be a potential risk from pipe failures.

Industrial effluent (untreated)

Quality needs to be better understood for each potential application but industrial effluent could be of consistent quality and volume and provide a reliable source. Process water from Water Treatment Works could be considered in this category.

Industrial effluent (untreated) is considered in one Use Journey:

7. Industrial effluent via limited treatment for cooling and/or hydrogen and CCUS

Mine water (untreated)

See polluted groundwater.

Polluted groundwater

Polluted groundwater is unlikely to be suitable for many purposes without treatment. It may be suitable for cooling, subject to the nature of the cooling system and related requirement for treatment, and its ultimate destination (disposal). It could also be considered as a media for CCUS, although this may depend on whether sufficient quantity is available in the same location.

Based on a principal of minimum treatment, this section looks at ways to increase viability of use.

1 Highway runoff refers to runoff from major roads, whereas urban drainage refers to runoff from any urban area including local roads. Some urban drainage may contribute to combined sewers, whereas highway runoff may have a discrete system of discharge to the environment.

Opportunities for non-potable re-use with treatment

Further treatment could be applied in order to increase use but for the purposes of this rapid review, the focus is on minimum treatment – with the exception of sewerage effluent where different levels of treatment are already widespread.

Table 2 summarises the assumed treatment. A more detailed description of the minimum treatment required for each use is set out in the Evidence Appendix.

Table 2: Assumed minimum treatment

Water sources	Minimum treatment
Rainwater	No further treatment assumed
Urban drainage systems and highway runoff	Removal of heavy metals and hydrocarbons, potentially via Sustainable Drainage Systems (SuDS)
Domestic grey water	Membrane bioreactor
Internal drainage board water	Conventional surface water treatment (potentially including nitrate removal)
Sea water	Desalination
Sewage effluent	This has been split into the three levels in common use today: – Secondary treatment only – Tertiary treatment i.e. disinfection included – Advanced treatment i.e. disinfection and membrane
Industrial effluent	Removal of potentially hazardous chemicals
Mine water	Conventional treatment (flocculation, clarification, filtration)
Polluted groundwater	Removal of principal sources of pollution e.g. nitrates, PFAS/PFOS

Table 3: Re-use opportunities with minimum treatment

	Agriculture (Irrigation)	Agriculture (Glasshouse)	Brewing	CCUS (Carbon Capture, Usage and Storage)	Data centre (Cooling)	Domestic (Toilet flushing)	Domestic (Outdoor use)	Energy (Cooling)	Food processing	Hydrogen production	Recreation (Irrigation)
Rainwater (from roofs, untreated)	High; In total; Reliability	High; In total; Reliability	High; In total; Reliability	High; In total; Reliability	High; In total; Reliability	High; Reliability	High; Reliability	High; In total; Reliability	High; In total; Reliability	Medium; In total; Reliability	High; Reliability
Urban drainage systems (treated)	Medium; In total; Reliability	Medium; In total; Reliability	Low; In total; Reliability	High; In total; Reliability	High; In total; Reliability	High; Reliability	High; Reliability	High; In total; Reliability	Medium; In total; Reliability	Medium; In total; Reliability	High; Reliability
Highway runoff (treated)	High; In total; Reliability	High; In total; Reliability	Low; In total; Reliability	High; In total; Reliability	High; In total; Reliability	High; Reliability	High; Reliability	High; In total; Reliability	Medium; In total; Reliability	Medium; In total; Reliability	High; Reliability
Domestic grey water (treated)	Medium; In total	Medium	Medium	High; In total	High; In total	High	High	High; In total	Medium	Medium; In total	High
Internal drainage board water (treated)	High; Reliability	High; Reliability	High; Reliability	High; Reliability	High; Reliability	High; Reliability	High; Reliability	High; Reliability	High; Reliability	Medium; Reliability	High; Reliability
Sea water desalination	High	High	High	High	High	High	High	High	High	High	High
Sewage effluent (secondary)	Medium	Low	Low	Medium	Medium	Low	Low	Medium	Low	Medium	Medium
Sewage effluent (tertiary)	Medium	Medium	Low	High	High	High	Medium	High	Low	Medium	High
Sewage effluent (membrane / advanced treatment)	Medium	Medium	Medium	High	High	High	High	High	Medium	High	High
Industrials effluent (treated)	Medium	Medium	Medium	High	High	High	High	High	Medium	Medium	High
Mine water (treated)	Medium	Medium	Medium	High	High	High	High	High	Medium	Medium	High
Polluted groundwater (treated)	Medium; In total	Medium; In total	Medium	High; In total	High; In total	High	High	High; In total	Medium	Medium; In total	High; In total

Key Quality of water (with stated treatment): Low suitability · Medium suitability · High suitability

Potential issue with water quantity: Reliability across the year · In total across the year

Opportunities associated with each source

Rainwater (from roofs, untreated)

As the quality is likely to be suitable for most purposes (except direct inclusion in food) no further treatment is assumed.

Urban drainage systems (treated)

Potentially useful in non-food related applications but reliability of resource may require a back-up supply.

Urban drainage system water (treated) is considered in two Use Journeys:

8. Urban drainage system water via Sustainable Drainage Systems (SuDS) for non-potable domestic use
9. Urban drainage system water via Sustainable Drainage Systems (SuDS) for recreational irrigation

Highway runoff (treated)

Highway runoff may be complex to treat but could be a useful source, for example on major roads with persistent flooding issues. Deployment may be limited to specific locations.

Highway runoff (treated) is considered in one Use Journey:

10. Highway runoff via Sustainable Drainage Systems (SuDS) for irrigation (agricultural or recreational)

Sea water (treated)

Following desalination, sea water can be considered as diversely useful as potable water and is abundant. There are considerations around distribution due to corrosivity in networks and the complexity that multi-use off-takes could give rise to, for example, water re-mineralised for distribution only for further treatment being needed to remove those minerals by end users.

Given the expense of desalination, it might be limited to potable water and industrial scale processes that require a pure feedstock, including hydrogen production.

Sea water (treated) is considered in one Use Journey:

11. Sea water via desalination for hydrogen production

Sewage effluent (treated)

Depending on the level of treatment, this source has a number of uses and provides a reasonably drought resilient, reliable resource.

Treated to a high standard it has similar potential to desalination, however, there is a residual public/consumer perception issue in regard to food processing, production, and possibly even recreation. There could be some be some limitations for contaminants that are particularly resistant to currently available treatment technologies.

Sewage effluent (treated) is considered in four Use Journeys:

12. Sewage effluent via tertiary or advanced treatment for CCUS or cooling
13. Sewage effluent via tertiary or advanced treatment for recreational irrigation
14. Sewage effluent via advanced treatment for domestic non-potable use
15. Sewage effluent via advanced treatment for hydrogen production

Deployment needs to be understood on a case-by-case basis. The identified Use Journeys focus on water company sewage treatment works, which may limit geographical availability to adjacent or in close proximity. However, it is possible to treat sewage effluent at the building or campus, scale (based on tertiary or advanced treatment for non-potable use), with examples in Australia and the USA. This method was used for the London 2012 Olympic Park.

Industrial effluent (treated)

Treatment technologies may differ but applications may be similar to sewage effluent; however, industrial effluent is often viewed as being less reliable than sewage works effluent.

Mine water (treated)

Complex to manage but could provide a medium/long-term reliable resource. See also ‘polluted groundwater’. Settlement and filtration are a likely minimum treatment requirement. However, treatment wetlands and constructed reed beds could be considered too.

The exact nature and extent of the pollution needs to be well understood in order to best match treatment to use. For example, depending on the nature of a cooling process, further treatment may be needed.

Mine water (treated) is considered in one Use Journey:

16. Mine water via conventional treatment for CCUS or cooling.

Polluted groundwater

Probably suitable for all uses with appropriate treatment. The exact nature and extent of the pollution needs to be well understood in order to best match treatment to use. As a result, this may be more appropriately approached on a case-by-case basis. Where treatment is feasible, potable use may be the best application.

Use Journeys

16 Use Journeys (UJ) have been identified for exploration, based on both minimal and additional treatment.

1. Rainwater via limited treatment for non-potable domestic use
2. Rainwater via limited treatment for local scale irrigation (e.g. glasshouses, Greens*)
3. Domestic grey water via limited treatment for non-potable domestic use
4. Domestic grey water via limited treatment for local scale irrigation (e.g. Greens*)
5. Internal drainage board water via limited treatment for cooling and/or CCUS
6. Internal drainage board water for irrigation (local recreational and/or agricultural)
7. Industrial effluent via limited treatment for cooling and/or CCUS
8. Urban drainage system water via Sustainable Drainage Systems (SuDS) for non-potable domestic use
9. Urban drainage system water via Sustainable Drainage Systems (SuDS) for recreational irrigation
10. Highway runoff via Sustainable Drainage Systems (SuDS) for irrigation (agricultural or recreational)
11. Sea water via desalination for hydrogen production
12. Sewage effluent via tertiary or advanced treatment for CCUS or cooling
13. Sewage effluent via tertiary or advanced treatment for recreational irrigation
14. Sewage effluent via advanced treatment for domestic non-potable use
15. Sewage effluent via advanced treatment for hydrogen production
16. Mine water via conventional treatment for CCUS or cooling.

*Greens: Water for use such as recreational grass watering e.g. sports pitches, golf greens, parks

Table 4: Opportunities for use based on treatment

<table>
<tr><th></th><th>Agriculture (Irrigation)</th><th>Agriculture (Glasshouse)</th><th>Brewing</th><th>CCUS (Carbon Capture, Usage and Storage)</th><th>Data centre (Cooling)</th><th>Domestic (Toilet flushing)</th><th>Domestic (Outdoor use)</th><th>Energy (Cooling)</th><th>Food processing</th><th>Hydrogen production</th><th>Recreation (Irrigation)</th></tr>
<tr><td>Rainwater (from roofs, untreated)</td><td colspan="2">UJ 2</td><td></td><td></td><td></td><td colspan="2">UJ 1</td><td></td><td></td><td></td><td>UJ 2</td></tr>
<tr><td>Urban drainage systems (treated)</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">UJ 8</td><td></td><td></td><td></td><td>UJ 9</td></tr>
<tr><td>Highway runoff (treated)</td><td colspan="2">UJ 10</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>UJ 10</td></tr>
<tr><td>Domestic grey water (treated)</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">UJ 3</td><td></td><td></td><td></td><td>UJ 4</td></tr>
<tr><td>Internal drainage board water (untreated)</td><td colspan="2">UJ 6</td><td></td><td colspan="2">UJ 5</td><td></td><td></td><td>UJ 5</td><td></td><td></td><td>UJ 6</td></tr>
<tr><td>Sea water desalination</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>UJ 11</td><td></td></tr>
<tr><td>Sewage effluent (secondary)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Sewage effluent (tertiary)</td><td></td><td></td><td></td><td colspan="2" rowspan="2">UJ 12</td><td></td><td></td><td rowspan="2">UJ 12</td><td></td><td></td><td rowspan="2">UJ 13</td></tr>
<tr><td>Sewage effluent (membrane / advanced treatment)</td><td></td><td></td><td></td><td colspan="2">UJ 14</td><td></td><td>UJ 15</td></tr>
<tr><td>Industrials effluent (limited treated)</td><td></td><td></td><td></td><td colspan="2">UJ 7</td><td></td><td></td><td>UJ 7</td><td></td><td></td><td></td></tr>
<tr><td>Mine water (treated)</td><td></td><td></td><td></td><td colspan="2">UJ 16</td><td></td><td></td><td>UJ 16</td><td></td><td></td><td></td></tr>
<tr><td>Polluted groundwater (treated)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Key | Use Journeys 1-7, which rely on minimal treatment | Use Journeys 8-16, which require treatment

Implications for sources and uses

The analysis suggests that all sources have some potential for greater deployment, especially once subject to treatment. The most polluted sources are the hardest to treat but are often more reliable from a quantity perspective. Overall, in theory, any source is treatable. However, the risks associated with treatment failure mean that some sources are less likely to be acceptable for uses such as food production.

All uses of water could be met via alternative sources, especially once treatment is deployed. Brewing, food processing and to a slightly lesser extent, agriculture, are the hardest uses to meet as water becomes part of or is closely involved with the final product, therefore requiring high quality inputs for example, green hydrogen production requires a pure feedstock.

At this stage, we are not proposing Use Journeys involving brewing and food processing, which are probably best served using good quality raw water or potable water. However, even brewing – which was a historical mitigation for poor quality drinking water – can use treated effluent, with several examples worldwide.

Re-use hierarchy: sources, treatment and uses

This section sets out a hierarchy for re-use. Water re-use itself sits within a hierarchy that starts with demand management, following which re-use should be maximised, before turning to potable water and abstraction from the environment.

Within water re-use, a sub-hierarchy is proposed, starting with rainwater capture, then localised building-scale re-use and finally, point sources (e.g. effluent treatment works).

For some uses, particular sources and treatment techniques are more appropriate. However, it is important not to rule out sources that do not perfectly match requirements, or which cannot fulfil all needs. For example, rainwater harvesting could be a part of many re-use systems, supplemented by sources further down the hierarchy. As such, the Use Journeys should be considered a starting point from which to build specific solutions.

With there being a number of potential sources of non-potable water, it is important to ensure that the most sustainable water re-use solution is fully explored for each application. In order to do this, the following needs to considered:

- the level of treatment required to meet the necessary standard for the use
- the amount of infrastructure required in order to deliver water from the source to the user
- the potential additional benefits that can be unlocked.

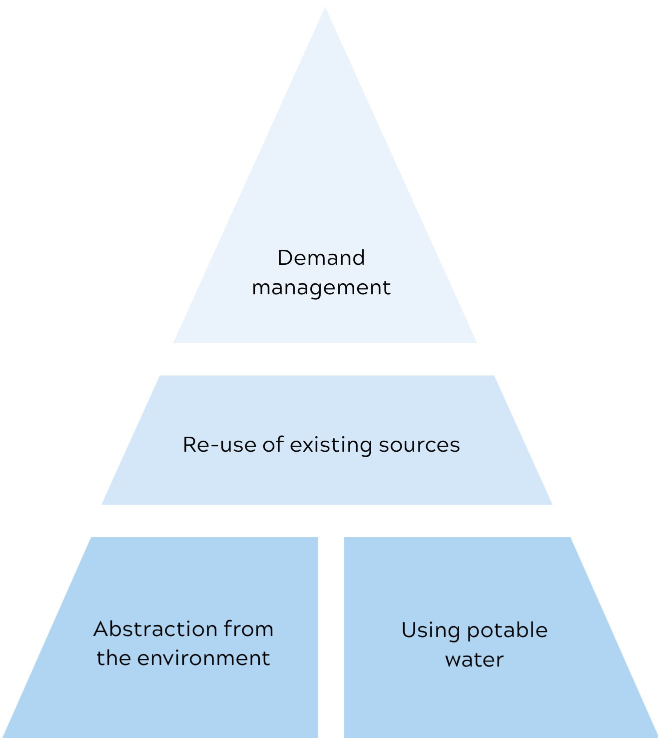
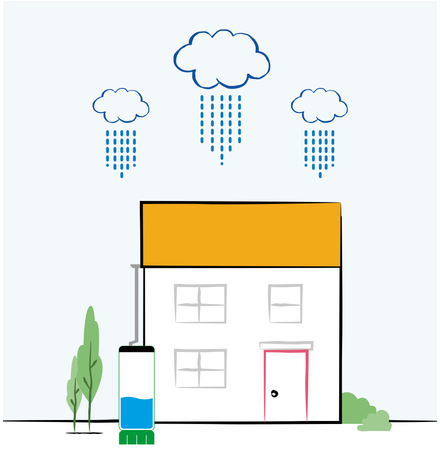


Figure 2: Overarching water use hierarchy

To aid this, a proposed re-use hierarchy has been developed by the working group, which provides an order by which sources should be considered for re-use. It must be noted that often a combination of sources may be required in order to meet the full non-potable water demand of an end user.

Figure 3: Water re-use hierarchy

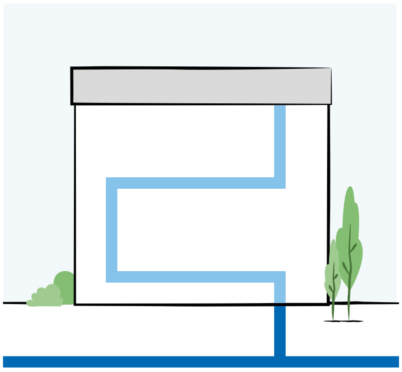


First option: Rainwater capture (water run-off from roofs and roads)

Rainwater

The capturing and reusing of rainwater, before it mixes with more polluted sources, can be done everywhere and should be the first option to fully explore when seeking an alternative water supply. It has several environmental, economic and practical benefits, including its separation from sewers. The following sources should be explored and are ordered based on water quality and the level of treatment required:

- Rainwater from roofs
- Urban drainage systems
- Highway runoff

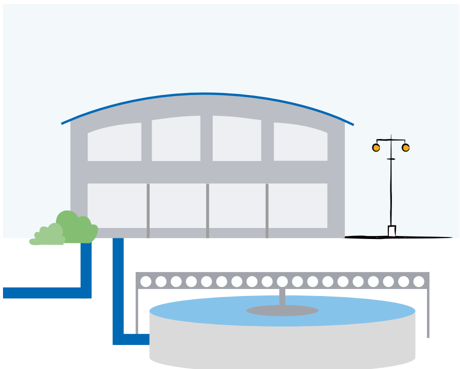


Second option: Localised building-scale re-use (re-using water that has already been "used" within a particular building)

Localised building scale re-use

The reusing of water that has already been "used" within a particular building can be a sustainable solution as it reduces the distance that the water needs to be transported from source to the user. There are also several instances where the water is still of reasonable quality and would only require minimal treatment to achieve the quality needed for a non-potable use. The following options should be explored, ordered by water quality and the level of treatment required:

- Domestic grey water
- Cooling condensate
- Industrial effluent



Third option: Low level: Location specific point sources (e.g. Wastewater Treatment Works)

Location specific point sources

Taking advantage of local sources of water can often provide additional benefits. The following should be explored as potential sources of non-potable water, subject to treatment. The applicability of these options will be heavily influenced by geographic location.

- Sewage effluent
- Internal Drainage Board water
- Polluted groundwater
- Mine water
- Sea water desalination

Barriers, solutions and ongoing requirements

This section describes current barriers to the uptake of sources, potential solutions to improve uptake and the standards that might be required to facilitate safe use.

It focuses on the 'Use Journeys' identified from page 5-9, which take a water resources perspective, focussing on opportunities to replace or supplement conventional sources of raw or potable water with alternative non-potable sources.

Barriers: what prevents greater uptake of non-potable re-use?

The International Best Practice Review shows that water is safely recycled and re-used in many countries, for a variety of purposes. Why is this not the case in the UK? Arguably, the apparent abundance of water resources has meant that there has been little imperative to use anything other than potable water for many purposes, as well as abstracting water directly out of the environment. High quality water has been available and cheap.

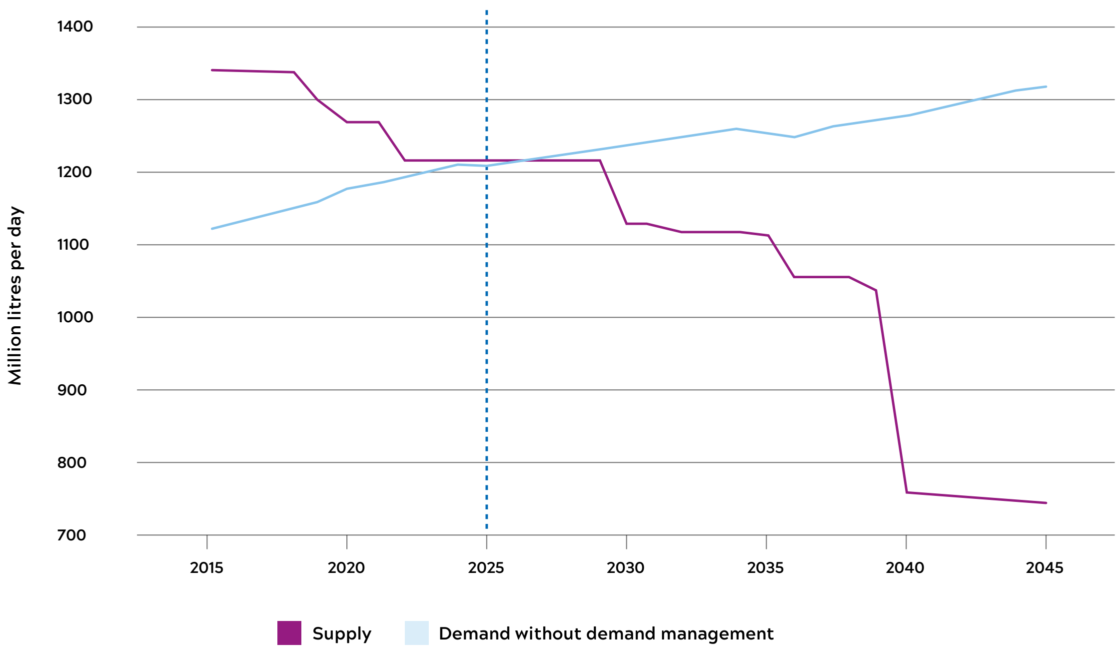
In many parts of the UK, this is no longer the case: potable supply-demand balances are facing into the 'jaws of death'[2], with many areas subject to limits on new non-domestic demands, while abstractions from the environment are being curtailed to avoid the risk of environmental deterioration, and to enable restoration and enhancement of ecosystems. New sources of water, such as desalination, are significantly more expensive than traditional sources.

The UK's experience with water re-use is relatively nascent. Early attempts to introduce such schemes are facing a variety of barriers, including concerns regarding safety, as well as adverse public perception.

Table 5 highlights potential barriers for each of the Use Journeys identified. The boxes are coded as follows:

- **Green** – unlikely to be significant barriers
- **Amber** – potential for significant barriers or where potential impacts may need to be worked through (e.g. via legal review, Environmental Impact Assessment)
- **Red** – known, significant barriers at present
- **?** – where there is insufficient knowledge at present and where further research may be beneficial

Figure 4: Anglian Water's water needs since 2010 and projected to 2050



2 The 'jaws of death' phrase was coined by the former CEO of the Environment Agency, Sir James Bevan, to describe the impending situation where demand for water exceeds available supplies taking into account factors including growth, climate change and changes to abstraction licences. In the Anglian Water supply area, this point is 2025 (see Figure 4).

Most Use Journeys are likely to encounter some sort of financial barrier. The initial investment required for water re-use systems can be significant, and the lack of clear funding mechanisms and financial incentives can hinder adoption. This may mean that uptake is focussed on situations where it makes more sense from an economic perspective. Cost may not be considered a barrier to use Internal Drainage Board water for cooling, although this may be constrained by seasonal availability. Re-use or desalination for hydrogen production is likely to be expensive, but affordable in the context of the overall price of hydrogen[3].

Social barriers may be less significant with some notable exceptions regarding re-use of sewage effluent, although research to date has focussed on potable re-use. More research is required to understand the significance of social barriers, especially in non-domestic settings. Educating the public about the benefits and safety of water re-use is vital to gaining social acceptance and encouraging behaviour change to support water re-use practices.

There are no significant technological barriers, with all Use Journeys feasible and many being used elsewhere in the world. However, there are several opportunities for innovation and technology to overcome technical challenges, alongside improving the efficiency of water re-use systems. Investing in research and development is essential.

Environmentally, there are a number of issues to be addressed including the diversion of resource, need for materials and energy (leading to greenhouse gas considerations[4]), protection of land and groundwater, and the disposal of by-products from re-use and desalination processes.

There are a number of legal and regulatory barriers, with projects often facing hurdles related to building regulations, permitting, licensing, and ensuring that re-used water meets safety and quality standards – including the current inability for water companies to supply houses with anything other than potable water. A lack of qualified installers may also be a barrier to uptake and ongoing avoidance of cross connections. These regulatory requirements can be complex and time-consuming to navigate. There may be further issues to be worked through related to the legal classification of waste, arising contractual matters and regulatory issues involving sewerage effluent.

Additionally, policy and governance are needed to support the development of integrated water management plans. Encouraging collaboration between government agencies, private companies, and non-profits can leverage resources and expertise to support water re-use initiatives, contributing to long-term sustainability.

Table 5: Current barriers to re-use

	Use Journey / Barrier	Economic	Social	Technological	Legal and regulatory	Environmental
1.	Rainwater via limited treatment for non-potable domestic use	[orange]	[green]	[green]	[red] ?	[green]
2.	Rainwater via limited treatment for local scale irrigation (e.g. glasshouses, greens)	[orange]	[green]	[green]	[green]	[green]
3.	Domestic grey water via limited treatment for non-potable domestic use	[orange]	[orange] ?	[green]	[red]	[green]
4.	Domestic grey water via limited treatment for local scale irrigation (e.g. greens)	[orange]	[green]	[green]	[orange] ?	[orange] ?
5.	Internal drainage board water via limited treatment for cooling and/or CCUS	[green]	[green]	[green]	[green]	[orange]
6.	Industrial effluent via limited treatment for cooling and/or CCUS	[orange]	[green]	[green]	[green]	[green]
7.	Internal drainage board water for irrigation (local recreational or agricultural)	[orange]	[green]	[green]	[green]	[green]
8.	Urban drainage system water via wetland treatment for non-potable domestic use	[orange]	[orange] ?	[green]	[red]	[green]
9.	Urban drainage system water via wetland treatment for recreational irrigation	[orange]	[green]	[green]	[orange] ?	[orange] ?
10.	Highway runoff via wetland treatment for irrigation (agricultural or recreational)	[orange]	[green]	[green]	[orange] ?	[orange] ?
11.	Sea water via desalination for hydrogen production	[green]	[green]	[green]	[green]	[orange]
12.	Sewage effluent via tertiary or advanced treatment for CCUS or cooling	[orange]	[green]	[green]	[orange]	[orange]
13.	Sewage effluent via tertiary or advanced treatment for recreational irrigation	[orange]	[orange] ?	[green]	[orange]	[orange]
14.	Sewage effluent via advanced treatment for domestic non-potable use	[orange]	[red] ?	[green]	[red]	[orange]
15.	Sewage effluent via advanced treatment for hydrogen production	[green]	[green]	[green]	[green]	[orange]
16.	Mine water via conventional treatment for CCUS or cooling	[orange] ?	[green]	[green]	[green]	[orange]

3 Unpublished research for Anglian Water suggests that desalinated sea water wouldn't add more than 1% to the final price of the hydrogen.

4 Water companies have committed to being net neutral with regards to operational greenhouse gas emissions by 2030. However, the dependency on energy intensive technologies needs to be considered in light of the availability of green power.

Solutions: what actions would facilitate greater uptake of non-potable re-use?

The multifaceted opportunities associated with water re-use demonstrates the need for a comprehensive approach that addresses economic, technological, social, environmental and legal considerations.

Economic

Traditionally, re-use has been seen as an expensive option compared to direct abstraction from the environment, or to potable water. However, as these traditional sources of water become fully utilised, economic appraisals need to be adjusted to take into account scarcity. In future, there may be economic incentives that alter cost benefit assessments e.g. through credit markets. Additional benefits such as biodiversity net gain, nutrient neutrality, or carbon credits also need to be considered. The case for non-potable re-use could be strengthened by developing a series of case studies.

Technological

Although there are no significant technological barriers, there is a need to scale the provision of solutions so that they are affordable and available. This is likely to require investment in manufacturing and, in particular, in the installation and maintenance of water re-use systems.

Social

Most consumers prioritise convenience and often do not give water much consideration, unless there are supply interruptions. Solutions such as non-potable domestic re-use of rain or grey water are more likely to be accepted where the system(s) that deliver this are low maintenance, do not require large upfront capital expenditure and ideally are cheaper from an operational perspective; in this example, retrofitting would require grants, as has been successful in Australia. Case studies could provide confidence that solutions are safe and reliable.

Legal

A change in legislation is required to allow water companies to supply houses with non-potable water for defined purposes; this will require an impact assessment that will need to address concerns around mis/cross-connections, for example, through training, education and inspections. Further consideration may also be required regarding the legal classification of waste, for example at what point in the re-use process does effluent become a new source? A set of 'model arrangements' should be established in consultation with the Environment Agency.

Environmental

There are existing statutes and regulations that exist to protect the environment. However, there are some novel aspects associated with re-use that require attention e.g. impact of reducing the volume of effluent discharged to the environment, and increases in waste concentration, given the by-products from additional treatment processes. These considerations should form part of the 'model arrangements' suggested above.

See the separate Evidence Appendix for where we have mapped solutions to barriers.

Ongoing requirements

Despite the implementation of targeted solutions to address the complexities of water re-use projects, several residual issues remain that require ongoing attention. These residual complexities include the need for regular maintenance and operation of water re-use systems to ensure their long-term functionality and safety. Ensuring consistent water quality is another critical challenge, as re-used water must meet stringent safety standards to protect public health.

Additionally, public perception and social acceptance continue to play a role, with ongoing efforts needed to educate and reassure the public about the benefits and safety of re-used water. These residual issues highlight the importance of continuous monitoring, innovation, and stakeholder engagement to sustain success.

Standards and guidance

What standards may be required to facilitate safe use of non-potable re-use water?

There is general confusion over the relevant regulations and guidance for water re-use. A document titled "Enabling Water Re-use in the UK: Single Source of Truth" was recently produced as part of the Enabling Water Smart Communities project. The document lays out the current relevant legislation and guidance, and highlights any gaps and inconsistencies, as a first step in adding clarity.

The table below, an extract from the document, summarises the documentation relevant to each stage of the water re-use process and importantly, its current status.

Table 6: Current relevant legislation and guidance in relation to re-use

Section	Document title	Date published	Legislation/ Guidance	Status	Relevant Use Journeys
Concept	Section G, Sanitation, Hot Water safety, and Water Efficiency	2010; 2024 update	Guidance	Current	1, 3, 8, 14
	Section H, Drainage and Waste Disposal	2010; 2024 update	Guidance	Current	1-16
Type of system	BS 8595:2013 Code of practice for the selection of water re-use systems	2013	Guidance	Under Review	1-16
Implementation	The Water Supply (Water Quality) Regulations 2016 Section 4	2016	Legislation	Current	1, 3, 8, 14
	The Water Industry Act 1991	1991	Legislation	Current	1-16
	Private Water Supplies (England) Regulations 2016	2016	Legislation	Current	1-16
	Water Supply Water Fittings Regulation 1999	1999	Legislation	Current	1, 3, 8, 14
Design	BS EN 16941-1:2018 On-site non-potable water systems. Systems for the use of rainwater	2018	Guidance	Withdrawn	1, 2, 8, 9, 10
	BS EN 16941-1:2024 On-site non-potable water systems. Systems for the use of rainwater	2024	Guidance	Current	1, 2, 8, 9, 10
	BS EN 16941-2:2021 On-site non-potable water systems. Systems for the use of treated greywater	2021	Guidance	Current	3, 4
	BS 1710:2014 Specification for identification of pipelines and services	2014	Guidance	Current	1-16
	BS 8525-1:2010 Greywater Systems – Code of Practice	2010	Guidance	Withdrawn	3, 4
	BS 8525-2:2011 Greywater Systems – Requirements and Test methods	2011	Guidance	Current	3, 4
	BS 8515:2009 +A1: 2013 Rainwater harvesting – Code of Practice	2009	Guidance	Withdrawn	1, 2
	BS 8595:2013 Code of practice for the selection of water re-use systems	2013	Guidance	Under Review	1-16

Section	Document title	Date published	Legislation/ Guidance	Status	Relevant Use Journeys
Design	WRAS Information and Guidance Note 09-02-04 Issue 1 August 1999, Reclaimed Water Systems, Information About Installing, Modifying or Maintaining	1999	Guidance and Risk Assessment	Withdrawn	1-16
	ISO 20426:2018 Guidelines for health risk assessment and management for non-potable water re-use	2018	Risk Assessment	-	1-16
	The Water Supply (Water Quality) Regulations 2016 Section 27	2016	Legislation	Current	1-16
	World Health Organization (2023) Water safety plan manual: step-by-step risk management for drinking-water suppliers, 2nd edition	2023	Guidance	Current	1-16
Catchment/ collection network	Volume 1 Streetworks UK guidance on the positioning and colour-coding of underground utilities' apparatus issue 10: 2023	2023	Guidance	Current	1-16
	The Water Supply Water Fittings Regulation 1999	1999	Legislation	Current	1-16
	BS 1710:2014 Specification for Identification of pipelines and Services	2014	Guidance	Current	1-16
Treatment	BS EN 16941-2 2021 On-site non-potable water systems. Systems for the use of treated greywater	2021	Guidance	Current	3, 4
Distribution network	Volume 1 Streetworks UK guidance on the positioning and colour coding of underground utilities' apparatus issue 10: 2023	2023	Guidance	Current	1-16
	The WRAS Guidance Note No. 09-02-05 1999	1999	Guidance	Withdrawn	1-16
	BS 1710:2014 Specification for Identification of Pipelines and Services	2014	Guidance	Withdrawn	1-16
	WaterRegs UK: Pipe Identification Information Note (V 1.1)	2021	Guidance	Current	1-16
End uses	BS EN 16941-1:2024 On-site non-potable water systems. Systems for the use of rainwater	2024	Guidance	Current	1, 2
	BS EN 16941-2:2021 On-site non-potable water systems. Systems for the use of treated greywater	2021	Guidance	Current	3, 4
	ISO 7010:2019 Graphical symbols – Safety colours and safety signs – Registered safety signs	2019	Guidance	Current	1-16
Operation and maintenance	WRAS Information and Guidance Note 09-02-04 Issue 1 August 1999, Reclaimed Water Systems, Information About Installing, Modifying or Maintaining	1999	Guidance and Risk Assessment	Withdrawn	1-16

Conclusions

Historical assumptions about the availability and price of water, and the use of potable water for many non-potable uses, are no longer valid.

There is a need to leave more water in the environment to restore nature, to hold more water to manage extreme droughts, and to use water to facilitate population and economic growth. A step change in how we approach water resources is needed, to ensure the most sustainable match between source and use.

This report – the first of the working group on non-potable re-use – highlights that all sources have at least some potential for greater use. Use of technologies such as nano-filtration and UV mean that virtually all sources of water can be improved and used again. The cost of such treatment, influenced significantly by the cost of energy (as well as carbon emissions if unabated) will be a key factor in uptake, but will need to be balanced against (lack of) availability of traditional sources, and the rising costs of alternatives (both alternative sources of water, and alternatives to water such as air cooling).

This report concludes that all uses of water could be met using alternative sources. Brewing, food processing and to some extent agriculture are harder uses to find permanently available alternative sources for, especially in some locations e.g. rural, inland areas. However, other uses of water could relatively easily make use of alternative sources, often with minimum additional treatment. Domestic uses of non-potable water – notably for toilet flushing – could be replaced with recycled water; for further information on this, refer to the Enabling Water Smart Communities project.

Adoption of a water re-use hierarchy would improve uptake of recycled water, encouraging – and perhaps in some circumstances mandating – its use ahead of traditionally deployed sources of water. It is also important that water re-use is considered as a partial solution, whether permanently or seasonally, and not dismissed because it cannot provide the full amount or quality of required water. The water re-use hierarchy – starting with rainwater, before moving to localised building scale re-use and finally point source use – should guide policy and practice and help to manage costs and other pressures.

The lack of uptake is not just about the availability and price of existing sources: there are a number of barriers that need to be addressed, ranging from costs to legal issues and the need for ongoing maintenance. A set of solutions has been identified which will address these barriers, including immediate actions to facilitate improved uptake, as well as ongoing requirements to maintain residual needs.

A range of standards and guidance already exists to support the safe use of recycled water, including British and ISO standards.

The International Best Practice Review accompanying this report highlights how a wide range of sources have been adopted for different uses across the world. The review describes the barriers for each source and how they have been overcome, illustrated by case studies. Universal barriers and solutions are also identified. The review provides inspiration for the adoption of recycled water: the UK's moment is now.

Recommendations

The working group have developed 12 recommendations to take forward key aspects from this first phase of work.

The recommendations support and build on each other and should be considered as a package of measures, which, if implemented, would facilitate a step change in the uptake of recycled water.

Recommendation 1: Inclusion of non-potable re-use in the next National Framework for Water Resources

Recycled water should be highlighted as a significant source within the National Framework for Water Resources, by the Environment Agency and Defra. National Framework workstreams could support uptake, for example, by making resources available and advocating for the recommendations of this report. The National Framework could also undertake research to look at the scale of opportunity and how this could be integrated into water resources planning and plans, alongside Strategic Resource Options, Local Resource Options and other water company options.

Recommendation 2: Adopt the water re-use hierarchy

The water re-use hierarchy should be adopted by Government, the Environment Agency, Ofwat, water companies and other stakeholders such as developers to:

- recognise the importance of recycled water, once demand management has been exhausted
- identify the most appropriate source of recycled water, starting with simpler and more sustainable sources, such as rainwater, before moving to more complex sources.

Recommendation 3: Develop series of economic assessments

Developing a series of economic assessments would improve understanding and help overcome perceptions that recycled water is prohibitively expensive. Assessments could be undertaken and funded as part of the National Framework and include:

- Evaluation of treatment technologies and how cost may fall over time with greater uptake
- The potential need and benefit for any grants or subsidies
- The potential role and design of a credit system
- Case studies to demonstrate financial costs and benefits at the local level

Recommendation 4: Further research on acceptability of re-use

Conducting research on the acceptability of water re-use, especially beyond domestic settings, is important to gauge perception and to identify how barriers might be overcome. The research should build on that conducted for domestic settings and examine attitudes and issues towards using recycled water in settings such as industry, recreation and agriculture. The research could be taken forward as part of the working group but would require funding e.g. from Defra or UK Research and Innovation.

Recommendation 5: Legal clarification regarding the definition of waste

Legal clarification regarding the definition of waste in the context of water re-use is necessary to define which regulations apply at each point in the process, and whether this remains appropriate or requires modification alongside maintaining protections for human health and the environment. Coordination between water company, Environment Agency and Defra lawyers would be a useful first step, ahead of potential consultation on changes in legislation (if required).

Recommendation 6: Model arrangements for permitting, agreed with the Environment Agency

Re-use may require permits from the Environmental Agency, relating to changes in effluent volume and concentrations, and potentially location, as well as new 'discharges' e.g. to land. Given the legal complexities and the time taken for permit application and determination, it is recommended that a set of model arrangements are developed and agreed with the Environment Agency for different Use Journeys. The model arrangements would help simplify the approval process, making it easier for stakeholders to implement. The arrangements could be coordinated by the working group, with input from Environment Agency teams.

Recommendation 7: Develop case studies

As we have seen from the International Best Practice Review, case studies act as powerful catalysts. It is important to develop case studies in a UK context. This may be as simple as writing up and publicising good examples that already exist and could be coordinated by the working group.

However, it may extend to new projects, perhaps in a particular catchment or locality where water issues are particularly challenging and where re-use offers good potential. A pilot project may require funding (perhaps some 'seed' funding from a central resource, supplemented by partnership funding) and a willingness from various stakeholders to 'make it happen'. Initial investment will enable a pilot project to provide valuable insights into the feasibility and benefits of water re-use, helping to refine approaches and build the case for wider implementation.

Recommendation 8: Evaluate the scope of re-use standards, training and quality assurance

Widespread use of recycled water will require well-trained workers, such as plumbers, to ensure the proper installation and maintenance of water re-use systems. This will require working with professional bodies to develop or adjust training schemes. Quality assurance schemes should be established to maintain high safety and performance standards. These actions will likely fall outside of the remit of the National Framework, and require action from Ministry of Housing, Communities and Local Government (MHCLG), Health and Safety Executive (HSE), Local Authorities, education and training providers, and standards bodies.

Recommendation 9: Identify ongoing management and maintenance needs

As with conventional, centralised water supply systems, water recycling systems require regular maintenance that must be delivered locally. This is likely to require comprehensive maintenance protocols that ensure long-term functionality and safety. There is a close connection between this recommendation, and Recommendation 8, as ongoing management will require training and quality assurance. As above, this recommendation will require action from a wide range of stakeholders including Ministry of Housing, Communities and Local Government, Local Authorities and education and training providers.

Recommendation 10: Identify supply chain needs

Water recycling systems will require new and expanded supply chains in order to scale up and ensure long-term viability. This may include manufacturing of components, with consideration required relating to maintenance and ultimately responsible disposal. Supply chain resilience will be important, including having contingency plans for potential disruptions, to help maintain a reliable and affordable supply of materials and services. This will require working with manufacturing associations and trade bodies.

Recommendation 11: Assess and include non-water resources drivers and benefits

This work has explicitly focused on water resources opportunities and benefits. However, there are other drivers and benefits for water re-use such as remediation of poor water quality, biodiversity gains via deployment of nature-based solutions, and opportunities for cost efficiencies through smarter use of resources. The working group is keen to identify these wider opportunities, which can be built into the case studies and economic assessments recommended above.

Recommendation 12: Continue a collaborative approach

The work summarised in this report has benefited from engagement with a wide range of stakeholders including those who may provide effluent or water, those who are interested in using recycled water (including water and energy companies) and policy makers and regulators. In order to maximise the potential for uptake of recycled water, this collaboration needs to continue and be broadened to the full set of stakeholders needed to deliver the recommendations set out above.

The working group is able and willing to continue to facilitate this process, but will require resources (some financial, lots in-kind via time and expertise) to achieve this. The willingness and positivity of stakeholders who attended the workshop in this initial phase of work suggests significant appetite for success.

This report was created by Anglian Water, on behalf of the National Framework for Water Resources non-potable re-use working group.

Anglian Water Services Limited
Lancaster House, Lancaster Way, Ermine Business Park
Huntingdon, Cambridgeshire, PE29 6XU
anglianwater.co.uk