Guidance Leaflet

the Rippleffect
Water efficiency for business

Reducing water use through **direct reuse or reclamation and reuse**

Although it seems there is an abundant supply of water in England, there are many parts that have been identified as water stressed areas as a result of human demand.

The natural balance of water is effectively maintained by the water cycle, where water is constantly recirculated and reused – evaporation from water bodies and transpiration from plants condenses in the atmosphere and falls back to the earth as precipitation. However, human demand for water interferes with this natural cycle (e.g. by taking water out of rivers) and places real stress on the environment. By reusing abstracted water where possible, this stress can be reduced.

In the man-made environment, reuse is often limited by the quality and quantity of water available. The quality requirements, such as aesthetic, microbial or physicochemical properties, will differ depending on the intended use of the water.

The quality requirement may be high, for example, for wholesome water where the risk to human health must be minimised, or it may be low, such as water for irrigating gardens. Depending on the quality requirements, water:

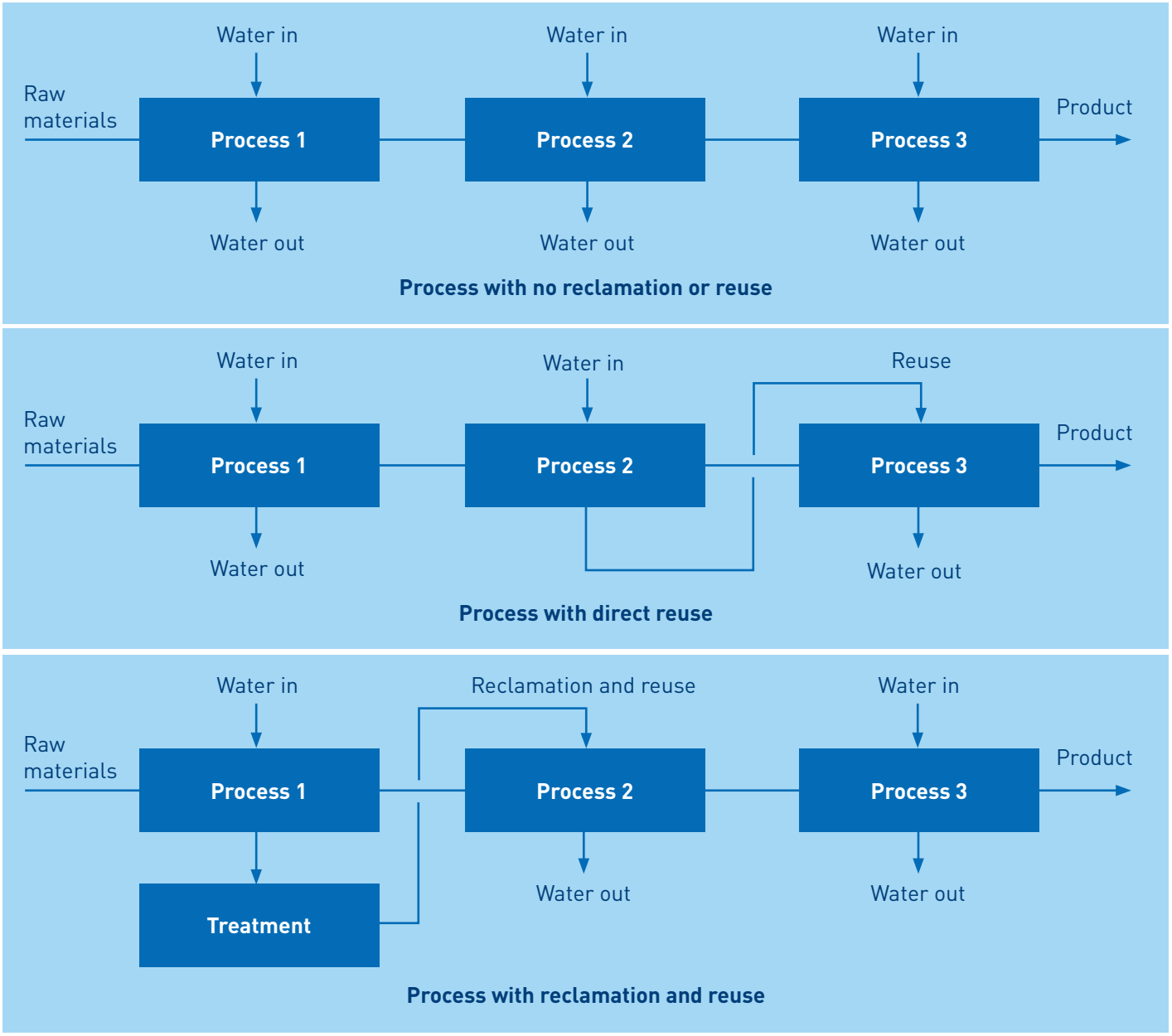
- can be reused directly, known as direct reuse; or
- may need to be treated before it can be reused, known as reclamation.

Since the water to be reused is very often wastewater, greywater (see page 9) or rainwater, it usually requires treatment before it can be reused.

The principles of direct reuse, and reclamation and reuse are illustrated in Figure 1.

Reclamation and reuse offer some of the best opportunities for improving water efficiency on commercial and industrial sites, often with considerable cost savings, particularly if product or energy recovery is possible.

Figure 1: Principles of direct reuse and reclamation and reuse



Source: Water Reuse - Issues, Technologies and Applications, Metcalf and Eddy

Hidden costs

By reusing water in a process, the need for water from another source, such as mains water, is reduced or eliminated.

Since most water used in industrial processes has to be treated before it is first used, recovering and reusing this water will retain its added value.

When assessing reclamation and reuse opportunities, it is important to understand the value of the water that is recovered and the savings to be made through the avoided use of mains water.

Typical costs for water are:

UK mains supply[1]	£0.59 – £1.75/m^3
Softened water	£1.00 – £2.16/m^3
Reverse osmosis (RO) treatment[2]	£1.51 – £3.83/m^3
Demineralised/deionised water	£2.53 – £3.70/m^3
Hot water (60°C) – gas heated[3]	£2.82 – £3.98/m^3
Hot water (60°C) – electrically heated[3]	£6.48 – £7.64/m^3
Condensate – gas heated[3 4]	£3.70 – £4.86/m^3

Remember that additional costs will also be incurred for disposal of any water to sewer, typically £0.54 – £2.67/m^3.

[1]UK mains supply based on standard 2010/11 tariffs
[2]Note this does not include capital and maintenance costs (e.g. membrane replacement) which can be significant for RO plant
[3]Energy costs at 3.6p/kWh for gas and 9.5p/kWh for electricity, using a boiler with 90% efficiency
[4]Excludes boiler-water conditioning chemical costs (e.g. oxygen scavenger/corrosion inhibitor/anti-foam)

Understanding where water is used

To identify opportunities for water reclamation and reuse, it is important to know:

- where the points of water use are around a site;
- the quantity and quality of water used at each point of use;
- where wastewater is generated; and
- the quantity and quality of wastewater generated at each point.

A water balance is a useful management tool for understanding where water is used on your site, for guidance see EN895 'A guide to developing a water balance' which is available on the WRAP website[5].

A water balance will help you consider the potential for reclamation or reuse opportunities of particular water or wastewater.

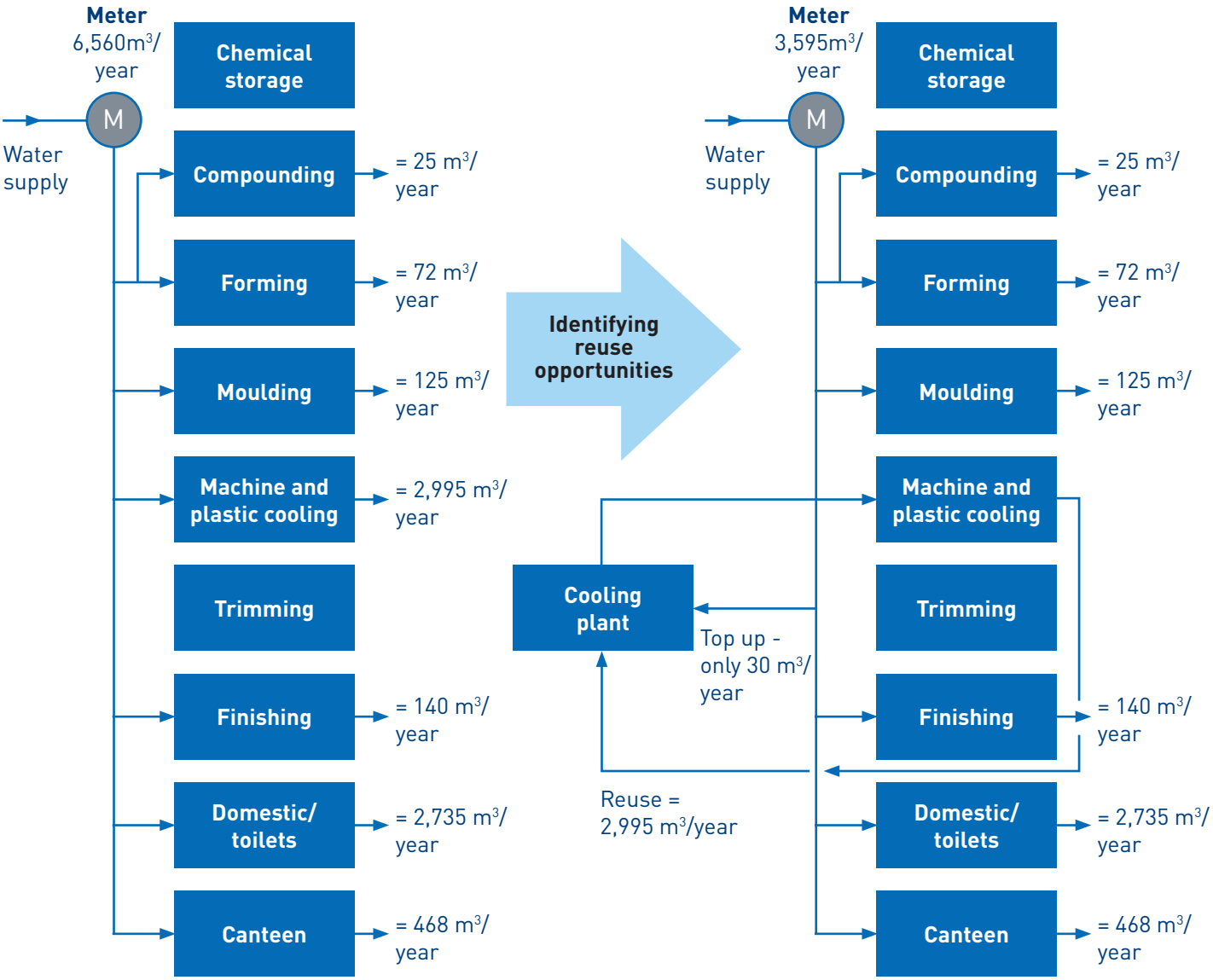
A simple water balance for a plastics factory is shown in Figure 2. By evaluating water reclamation opportunities, the potential to save up to 2,995 m^3 of water a year was highlighted through reusing the water to cool the machine and plastic.

Evaluating and implementing water reclamation and reuse opportunities is usually a straightforward process. It involves assessing the quantity and quality of water used, and the wastewater generated at each point and then considering reuse opportunities. Simple steps to evaluate and implement water reclamation and reuse opportunities are shown in Figure 3.

It is recommended that water consumption is measured before implementing any opportunities to establish a baseline – this will enable the benefits of the opportunities to be measured and monitored as they are implemented.

Common sources of water and wastewater, and their scope for reclamation or reuse are given in Table 1.

Figure 2: An annotated water balance to help identify opportunities for water reuse



[5] http://envirowise.wrap.org.uk

Figure 3: Steps to evaluate and implement water reclamation and reuse

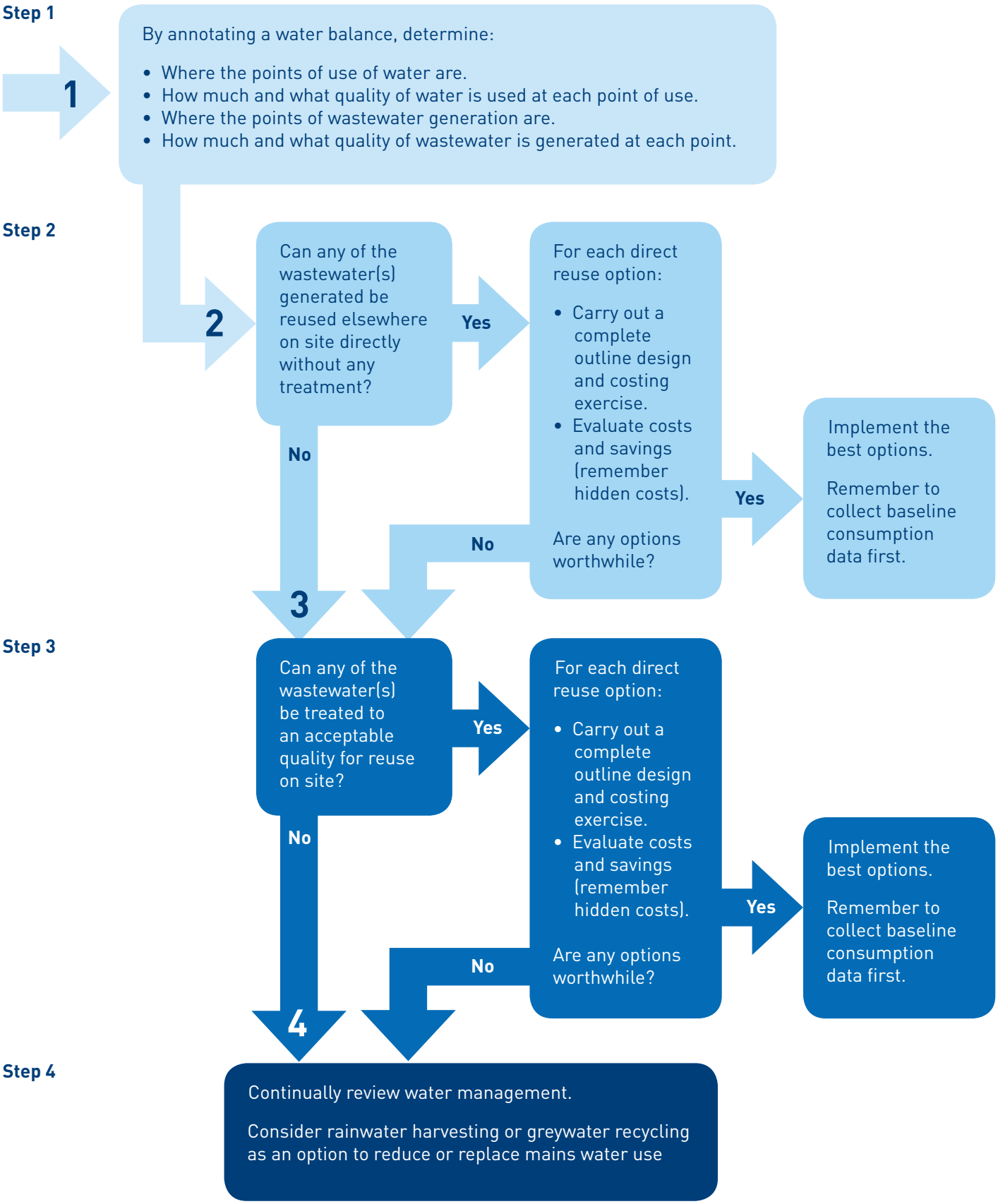


Table 1: Common water reclamation and reuse opportunities

Water or wastewater sources	Examples	Scope for direct reuse	Scope for reclamation and reuse
General			
Water treatment units	Filter backwash, wet sludge, chemical spillages, ion exchange regeneration	L	L
	Reject water from reverse osmosis treatment	H	NA
Storms/surface water run-off	Flow to surface water/effluent drains	L	L
Groundwater	High water table, borehole	M	H
Rainwater	From roofs	M	H
Vehicle maintenance	Vehicle/lorry washing wastewater	L	M
Site cleaning	Hose wastewater	L	L
Commercial			
Laundry	Effluent, steam, evaporation from dryers	L	M
	Final rinse water	H	NA
Kitchens	Effluent, steam, liquid waste	L	L
	Tunnel dishwashers (rinse water)	H	NA
Toilets/bathrooms/wash block	Sewage, steam	L	L
Swimming pool and leisure facilities	Wash block effluent, filter backwash water	L	L
Boiler/heating systems/ air-conditioning	Blowdown, condensate, steam	H	NA
Gardens and water features	Excess water run-off, overflows	H	NA
Industrial			
Cooling tower	Cooling water	H	NA
	Blowdown, evaporation, drift	L	L
Steam system	Steam leaks and relief valve discharges, boiler scale and sludge, blowdown	L	L
	Condensate	H	NA
Cooling	Once-through cooling water	M	H
Seal water	Liquid ring vacuum pump	M	H
	Pump gland	M	H
Process/production	Multi-stage rinsing	H	NA
Scrubbers/strippers	Once-through scrubber liquor	H	NA
Effluent treatment plant	Treated effluent	L	M

Key: L = Low, M = Medium, H = High, NA = Not usually appropriate

Actions

1. Determine the true cost of water used by taking the cost of treatment and heating into consideration.

2. Develop a water balance and annotate each point of water use with quality and quantity data.

3. Evaluate the opportunities for reclamation and reuse.

Direct reuse

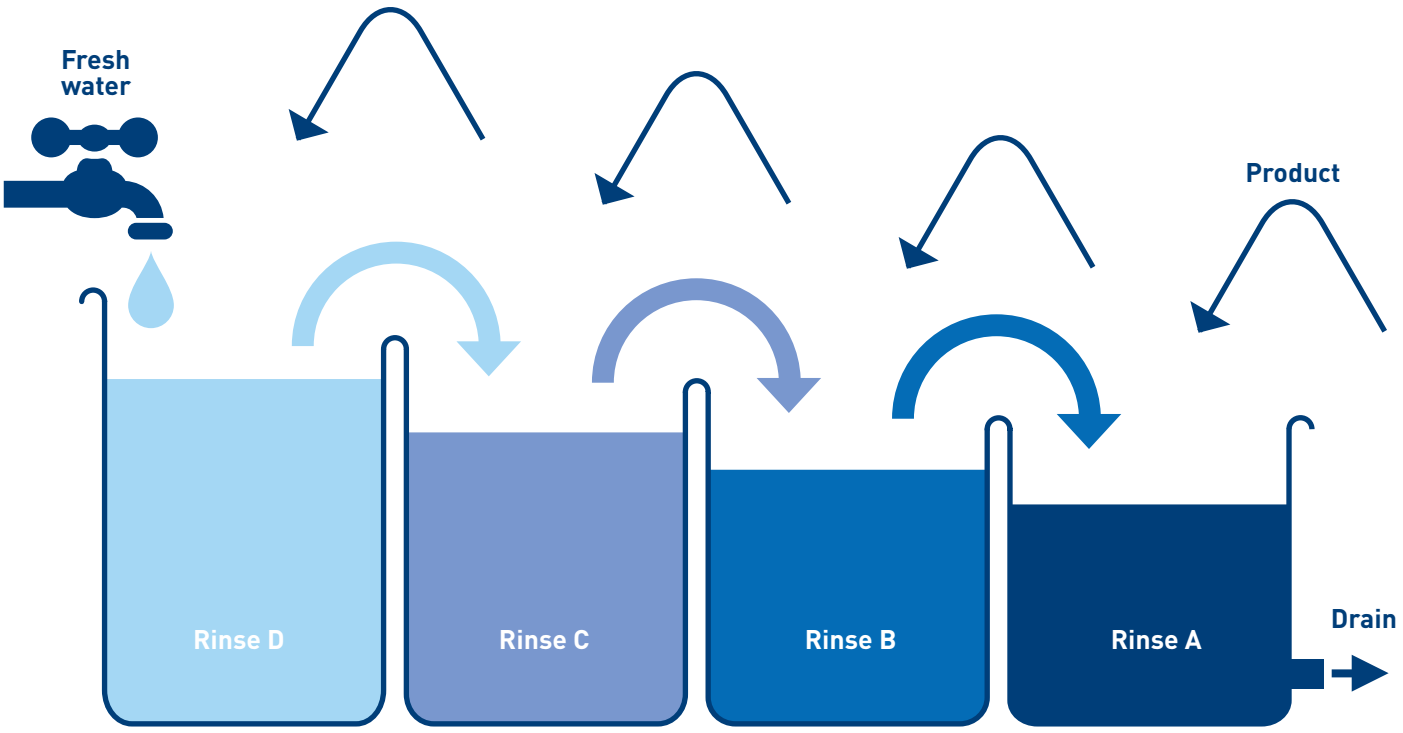
Although direct reuse may appear straightforward, it is important to consider:

- Water quality issues (aesthetic, microbial or physicochemical).
- The quantity of water available and whether it is sufficient to meet the volume required. This can be readily assessed using a water balance.
- Whether the amount of water available for reuse meets the required demand. If not, will water storage be required? If storage is required, it is important to determine the storage volume needed.
- Whether pumping is required to transport the water from the point of generation to the point of reuse.

Common examples of direct reuse include:

- Recycling cooling water rather than using it only once.
- Recovering final rinse water and reusing it for the initial rinse in cleaning operations.
- Countercurrent rinsing, which is illustrated in Figure 4. The product is first rinsed in dirty water (Rinse A) and then in progressively cleaner water, while the rinse water flows progressively from the last rinse (Rinse D) towards the first rinse (Rinse A).
- Recirculating seal water on liquid ring vacuum pumps. The pump may also become more efficient if the seal water is chilled.

Figure 4: Countercurrent rinsing



Actions

1. Identify any direct reuse opportunities and determine the potential water and cost savings.
2. Assess what system modifications need to be made (e.g. collection, pipework and storage).

Reclamation and reuse

During the reclamation process, water is usually treated to meet quality requirements.

The type of treatment required depends on the contaminants in the water that is to be reused.

Solids removal is probably the most common treatment required. This can be achieved by simple filtration (e.g. cartridge or sand filter), settlement (with and without chemical assistance), dissolved air flotation (DAF) or centrifugation.

Other contaminants may require particular treatment(s) – some common contaminants and possible treatment technologies for their removal are shown in Table 2. Membrane treatment technology has become a widely applied technology across a broad range of industries to reclaim and reuse water and product.

Table 2: Common treatment technologies and applicable techniques

	Technology type															
Substances for removal	**Adsorption**	**Ion exchange**	**Precipitation**	**Membrane technologies**	Reverse osmosis	Nanofiltration	Ultrafiltration	Pervaporation	**Electrical technologies**	Direct electrical processing	Electrocoagulation	Electrodialysis	Electrochemical ion exchange	**Evaporation**	**Distillation**	**Dissolved air flotation**	**Air/steam stripping**
Dissolved heavy metals																	
Monovalent ions (e.g. Ag^{+})		✓	✓		✓					✓	✓	✓	✓	✓			
Multivalent ions (e.g. Ni^{2+})		✓	✓		✓	✓				✓	✓	✓	✓	✓			
Complexed metals (e.g. Cu + EDTA)			✓		✓	✓				✓	✓	✓	✓	✓			
Dissolved anions																	
Non-metals (e.g. Cl, SO_4^{2-})			✓		✓	✓					✓	✓	✓	✓			
Metals (e.g. $Cr_2O_7^{2-}$)		✓	✓		✓	✓				✓	✓	✓	✓	✓			
Dissolved organics																	
Solvents	✓				✓			✓							✓		✓
Macromolecules (e.g. proteins)	✓				✓	✓	✓				✓			✓		✓	
General chemical oxygen demand (COD)	✓		✓		✓	✓	✓							✓		✓	
Colour	✓				✓	✓				✓	✓			✓			
Pesticides	✓				✓	✓											
Dissolved water in organics					✓	✓		✓						✓	✓		

Examples of reclamation and reuse include:

- recovery of electroplating rinse water and treatment via ion exchange to recover metal ions and water for reuse;
- recovery of water and fibre for reuse using settlement followed by biological treatment and high-rate lamella clarification in the paper industry (see Figure 5);
- membrane treatment of process water in dairies to recover milk fat and water for reuse (see Figure 6); and
- treatment of vehicle wash water for reuse in vehicle washing.

Figure 5: Treated water for reuse at a paper mill

Figure 6: Membrane treatment plant recovering evaporative condensate for reuse (courtesy United Milk, now Westbury Dairies)

Actions

1. Identify any potential water reuse opportunities if available water were treated.
2. Determine the potential water and cost savings.
3. Assess the level of treatment required and treatment options available.
4. Assess what system modifications need to be made to enable reuse (e.g. water collection, pipework and storage).

Rainwater harvesting

Rainwater harvesting is the most commonly considered alternative water source and it can be an effective way to reduce mains water usage and costs.

Collection and storage of rainwater can often provide a supply for low-quality water use, such as toilet flushing and cooling water, particularly as the 'soft' nature of the water means limescale deposit can be reduced. Rainwater from roofs is usually the easiest to collect.

Use the following equation to quantify the maximum water that can be harvested in a year:

Annual rainwater yield (Y) in m^3 = P x A x 80%

Where:

P = annual precipitation (in metres) from Met Office data (average rainfall in South East is 0.6 m/year)

A = collection area (m^2)

80% = the typical amount of rainwater collected each year, due to small losses in filtering and small amounts of rain that do not generate enough run off.

However, careful attention should be given to quality issues, any treatment required and the potential for cross-contamination. Rainwater harvesting systems should always be installed following the manufacturer's instructions. Some opportunities for rainwater harvesting are shown in Table 3.

Table 3: Common uses for rainwater harvesting projects and treatments

Water use	Quality required	Treatment options
• Nurseries, sports grounds, gardens • Toilet flushing • Cooling (boilers) • General cleaning • Filter backwashing	**Low:** Water is not required for consumption, and there is a very low risk of contact. Water should look clean and be odour free.	• First flush diverted • Coarse filter
• Laundry • Cleaning of equipment or process cleaning	**Medium:** Water is not used for consumption, and there is a low risk of contact. Water must be clean and odour free, but not necessarily sterile.	• All of the above, plus • Fine filter (possibly membrane filter)
• Food processing • Cleaning food processing equipment • Substitute wholesome supply	**High:** Water may be used for consumption, water must be clean, odour free and sterile.	• All of the above, plus • Pathogen removal and/or inactivation (e.g. UV equipment)

For further information, see EN896 'Reducing mains water use through rainwater harvesting', available on the WRAP website[6], or visit the UK Rainwater Harvesting Association's website[7]. Guidance on buying rainwater harvesting equipment is available from Defra's Sustainable Development web pages[8]. Guidance on the design, installation, testing and maintenance of rainwater harvesting systems is available from British Standards Institution (BS 8515:2009 Rainwater harvesting systems. Code of practice).

Actions

1. Assess how much rainfall could be collected (using the annual rainwater yield formula).
2. Evaluate whether this rainwater could be collected and used to supplement or replace another water supply.

Greywater recycling

Greywater refers to domestic wastewater from dishwashers, washing machines and bathroom washing facilities (baths, showers and washbasins).

Greywater excludes toilet wastewater and usually food wastes from kitchen sinks or waste macerators - these are described as blackwater.

Greywater typically contains lower levels of particulate and bacterial contamination than sewage, and often contains dissolved salts from soaps and detergents. As such, it should only be considered for low-grade use and not for applications where it may come into contact with foodstuffs or be released to surface water.

Ideally, greywater should be reused as soon as possible with minimal storage since it is often warm and storage may lead to bacterial or fungal growth, which presents a health risk. It may also go stale on prolonged standing, giving rise to odour.

Guidance on greywater systems is available from British Standards Institution (BS 8525-1:2010 Greywater systems. Code of practice).

[6] http://envirowise.wrap.org.uk
[7] www.ukrha.org
[8] www.defra.gov.uk/sustainable/government/advice/public/buying/products/construction/rain-harvesting.htm

Table 4: Opportunities for greywater recycling

Water use	Quality required	Treatment options
Toilet flushing	**Low:** Water is not used for consumption and there is low risk of contact.	Simple filtration may be required to remove hair and other material which could impair valves and valve sealing. Disinfection is also preferable.
Garden watering	**Low:** Provided water is not used on crops that will be eaten.	Only simple filtration may be required if used for tree and shrub watering; ideally by sub-surface means.

Actions

1. Assess how much greywater is produced on site.
2. Evaluate whether the greywater can be collected and used to supplement or replace another water supply.

Other considerations

PIPEWORK

It is always good practice to label pipework clearly so that pipes that do not carry wholesome water are readily distinguishable from those that do. Guidance on appropriate colour coding is given in BS 1710 'Specification for identification of pipelines and services' and also by the Water Regulations Advisory Service[9].

ENHANCED CAPITAL ALLOWANCES

The Enhanced Capital Allowance (ECA) scheme enables businesses to claim 100% first-year capital allowances in investment in water efficiency equipment (including rainwater harvesting equipment) named in the Water Technology List (WTL).

Water reuse systems, including membrane treatment technologies, are currently supported on the WTL - specifically, efficient membrane filtration equipment systems and efficient wastewater recovery and reuse systems. Due to the bespoke nature of these systems, it is the business making the investment in the technologies that makes an application to the WTL. If approved, a Certificate of Environmental Benefit will be issued to the company. Businesses making investments in 'off-the-shelf' products do not need to make an application. Instead, they can use the WTL to gather information about products they may be interested in purchasing that have been approved under the ECA scheme, and contact the manufacturers directly.

The following technologies are supported under the products list:

- cleaning in place equipment;
- efficient showers;
- efficient taps;
- efficient toilets;
- efficient washing machines;
- flow controllers;
- leakage detection equipment;
- meters and monitoring equipment;
- rainwater harvesting equipment;
- small-scale slurry and sludge dewatering equipment;
- vehicle washwater reclaim units;
- water efficient industrial cleaning equipment; and
- water management equipment for mechanical seals.

For more information see **www.businesslink.gov.uk/wtl**

[9] www.wras.co.uk

Waste & Resources Action Programme

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