Technology brief

Selecting the water source

Selecting the right water source for a water supply is more than just a scientific decision; it has environmental, technical, social, economic and health impacts. This technology brief sets out some of the issues to consider.

A new tapstand. Timor-Leste. 2017

Water resources

Water occurs in many forms, such as groundwater, rivers, ice and clouds. These are the natural **water resources** we can use as a **source** for a water supply. Water varies in distribution, globally and locally; in quantity, from day to day, month to month and year to year; and in quality, from pure rainwater to salty seawater. A poor quality source will require **improvement** before it can be used.

While there is plenty of water globally, not all of it is easy to use. Over 94% of water is in the sea, about 4% is underground as groundwater, and around 1.7% is in ice sheets and glaciers. Approximately 0.02% is in ponds, lakes and wetlands, 0.006% is in the soil, and only 0.00008% is in rivers. Another 0.001% is in the atmosphere. There is also water in plants and animals.

The water cycle

Water moves from one form to another, through the **water cycle** – although this is a complex web rather than a circle. The amount of time spent in each form is the **rate of exchange**. After evaporating, water only spends ten days on average in the atmosphere as vapour and clouds before falling to the earth or sea as rain, snow, hail or dew, collectively called **precipitation**. Rain falling on soil may be evaporated again, run off to a river, or infiltrate into the ground, but it remains in the soil

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as moisture for about a year, so plants can survive for weeks without rain. Water that runs into a river flows down to the sea for 11 days on average (it may evaporate before then). Therefore, pollution in a river can be washed out quickly, but large lakes and groundwater take a long time to be flushed clean. Water stays in large lakes for around seven years. Groundwater can take about 5,000 years to be flushed through, though this varies a lot.

Understanding and controlling these natural forms of water is known as **water resource management**. Water supply professionals need to be able to work with water resource experts, as some resources (such as rainfall) vary a lot and others (such as groundwater) are hard to find, making measuring the amount of water available locally very complex.

Besides the physical forms, water resources can be grouped in other ways:

- **Blue water is water in rivers and lakes.**
- **Green water is in plants, animals and soil.**
- **Grey and black water is polluted wastewater.**

Another form is 'invisible' or virtual water. This is the water used to grow crops, raise livestock or make things, which is no longer present when the 'product' is eventually used.

A water source (or water point) is the point at which water can be accessed. A water resource is the wider body of water upon which a water source depends.

Water sources

The three main water resources – **rainwater**, **groundwater** and **surface water** (rivers, ponds and lakes) – can offer a water source that can be used by people. Ice melt also provides valuable supplies to river systems used by people. The source of the water is the point at which people **abstract** water from the natural water cycle and it enters the water supply system; for example:

- Rainwater can be collected on a clean surface and stored for use.
- Surface water can be diverted from lakes and rivers.
- Groundwater can be reached by drilling or digging down and then pumping it to the surface.

Sourcing water from other resources, such as plants, fog, seawater or re-using wastewater, requires more complex and expensive technology to obtain the same volume of water, so these are less commonly used. Where they are the only source available, detailed feasibility studies should be done to ensure they will be sustainable.

Water can be abstracted as it moves from one resource type to another. These sources share the properties of the two separate resources. For example:

- **Springs** form where groundwater reaches the surface.
- **Infiltration galleries** and **sand dams** are constructed to make use of the shallow groundwater next to and underneath rivers.

A hydrologist can analyse rainfall and river flow records. A hydrogeologist has specific expertise with groundwater.

There is no 'best' source for water; each option has strengths and weaknesses. The two main features are the quality and quantity of the water resource being considered. These features can be matched with people's needs. A poor match requires a lot of improvement. The closer the match, the more effective, efficient and sustainable the water supply will be.

Water quality

Water must be **safe** enough to drink – known as **potable** water. If the water is naturally clean, it does not need to be treated. This saves money and makes the water supply simpler to operate.

Rainwater

Rainwater is usually the cleanest water resource. It has been evaporated from water on the earth, leaving pollutants behind. It can get contaminated in the atmosphere if it is near an area with heavy industry, but generally is safe to drink if protected from pollution when collected and stored.

Groundwater

Water deep under the ground (subterranean groundwater) is often safe from surface pollution because it is protected by a layer of soil and rock. Groundwater is **recharged** by rainwater falling on the ground surface and soaking into the land. This **infiltration** acts as a filter. As groundwater flows very slowly, bacteria die off and some pollutants decay.

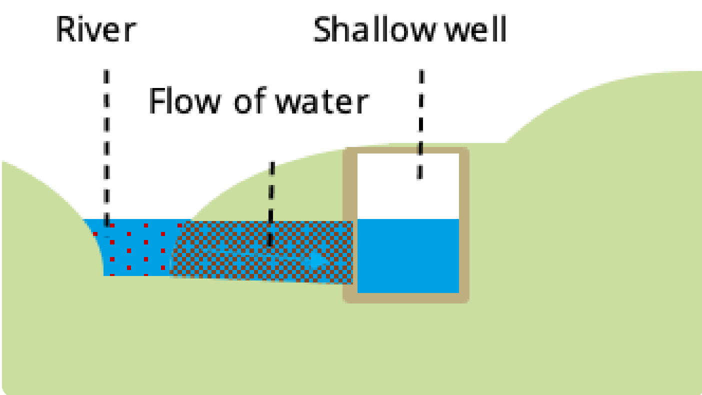
This natural protection can be weaker if the top of the groundwater (the **water table**) is near the ground surface. The filtration and die-off processes will not have much time to work. Holes in the ground, such as unlined pit latrines or natural cracks in some rocks, can reduce the distance to the water table, putting groundwater quality at risk.

While organic pollutants such as bacteria can be removed by infiltration, some chemicals do not degrade with time. If these reach the groundwater resource, they can damage it for many years, as they are not flushed out quickly. Groundwater in cities can retain a mixture of chemicals from past industries.

Groundwater spends a long time in contact with rocks, so chemicals in the rock can naturally dissolve into the water – this is called geogenic water contamination. These chemicals can affect the water’s taste or colour (such as iron), make it undrinkable (various salts), or cause health problems (such as arsenic or fluoride). While the water may be safe to drink in terms of bacteria, people may not want to use it due to the taste, colour or long-term health impacts.

Surface water

Of the three main resources used, surface water is the one that is normally most polluted. While rivers and lakes are fed by (clean) rainwater or groundwater, this quickly becomes contaminated. Every time it rains, water from the surrounding land washes pollutants into the river. Large lakes in industrial areas have been very polluted in the past and can take years to recover. While surface water is easy to access, the cost of treating it can make it a financially unsustainable water source.



Infiltration gallery

Hybrid sources

The strengths and weaknesses of two water resources can be exploited to form a hybrid source. **Springs** have the same water quality as the groundwater that supplies them. Once this water reaches the surface, however, it can become polluted, so the abstraction point needs to be just as the water reaches the surface. The weakest natural protection is immediately before the water reaches the surface, where the water table is very shallow.

Infiltration galleries and sand dams work in the opposite way. Water infiltrates into the ground below and next to a river, removing some of the pollutants in the surface water. A well next to a river will have cleaner water than the river. The groundwater further away may be cleaner still, but deeper, so harder to reach.

Water treatment

Water treatment consists of physical, chemical and biological methods to remove particles and bacterial and chemical contaminants. Chemical contaminants are particularly difficult to remove.

Treatment can be done at the community level for the whole water supply, or at the household level. Community-level treatment is preferable where possible, as it reduces the likelihood of possible misuse resulting in poor water quality.

It is important to consider financial and technical feasibility when selecting water treatment options. For example, the use of chemicals is generally not considered sustainable for remote rural water supply treatment, with simpler and more robust methods requiring less operation and maintenance and providing more sustainable solutions.

Women collecting water from a community Pond Sand Filter plant. Bangladesh.

Water quantity

Water needs to be available when it is required, so there is a **secure** supply. There are three elements to consider in relation to quantity:

- How much is available?
- Where is it available?
- When is it available?

Water distribution varies globally, with some areas wetter and some drier. Because of the water cycle, surface water and groundwater can be found outside areas with high rainfall.

Water in an inconvenient place needs to be moved to where people need it. Water that is only available at certain times needs to be stored, so people can use it when they want.

If it takes a long time to go and collect water, people will limit their water usage. Studies have shown that if it takes more than about 30 minutes to go and collect water (including time spent waiting and filling containers due to slow flows) then daily water consumption drops below the 15 to 20 litres per person recommended for good hygiene.

Each country has its own national standards and guidelines on the minimum daily water volume required for domestic use per person, which should be referred to when designing new water supply systems.

Rainwater

Globally, the rainwater resource varies considerably. This may mean there is insufficient water available locally. Within an area, however, one of rainwater's strengths as a source is that it falls everywhere. You can choose where to collect it, so harvesting rainwater at the household is possible. This minimises the distance needed to travel to reach the water source, removing the issue of collection time, reducing the burden of carrying water (often by women and girls) and making it safer to get water at night.

One of the characteristics of rainfall is that it varies both seasonally and from hour to hour. Even if the absolute amount available locally in an average year is sufficient for users, it needs to be stored in wet periods to provide a daily supply. Variations year to year mean in some dry years rainfall may not provide enough water – a situation that is getting harder to predict with the climate crisis. Often rainwater is used for drinking and cooking, with an additional resource (such as groundwater) being used for other domestic water needs.

Groundwater

This is the least variable water resource, with much less seasonal variation than rivers or rainfall and no daily changes. Its local distribution does allow some flexibility in where to site wells but the geology can limit the location. It is generally better than using rivers as a source. Water needs to be pumped to the surface (using a hand pump or mechanised pump).

Surface water

Rivers vary in flow between wet and dry seasons, but they are not as variable as rainfall, so often can be used as a water supply all year round if the flow is sufficient. They do not normally vary from day to day (except in extreme floods) so the flow is reliable and daily storage is not needed.

They can bring water from wetter areas to drier regions. A weakness can be the location. You have to go to the river to get the water or use pumps and pipes to bring the water closer to people. This is why some towns are built next to rivers. Rivers are easier to find and measure than other resources though, and access is straightforward.

Hybrid sources

Sand dams and infiltration galleries have fixed locations, but they exploit the storage aspects of groundwater, making the resource less variable than surface water or rain. Springs have fixed locations and can vary in flow more than the river downstream.

Comparing water sources

Selecting the cleanest water will minimise ongoing treatment costs. There is less work to do and less can go wrong. The nearest source may be the most convenient but may not always be available. Many issues need to be considered, which may make a polluted source or one further away preferable – even with the extra work. The strengths and weaknesses of a potential source have to match the social and economic resources of the people operating the water supply.

The table below compares various types of water sources on key selection factors based on broad assumptions about each type. In reality, these factors are highly location specific, so a localised comparison should be made for your project location, in combination with a detailed feasibility assessment for the selected water source and technology.

Sources must be selected in consultation with the community who will be using the system – they are best placed to know how the quantity and quality of various options varies throughout the seasons and years, as well as other factors such as ease of access and any land rights issues.

Selecting a water source depends on more than just the quality, availability and location of the resource. Sustainability, management, costs and equity of access should all influence this decision. The source should be both safe (good quality) and secure (reliable).

Nafissa and her sister Nassiratou collecting water at the new borehole constructed in the district of Samb Naaba, in the village of Loukou, commune of Tenkodogo, Centre-East region, Burkina Faso, May 2019.

Criteria	Rain water	Groundwater		Surface water
		Springs	Subterranean groundwater	
Quality	✓✓	✓	✓	✗
Proximity to households	✓✓	✓	✓	✗
Ease of construction	✓✓	✓✓	✗	✓
Quantity	✗	✓	✓✓	✓✓
Yearly variation	✗✗	✓✓	✓✓	✓
Daily variation	✗	✓✓	✓✓	✓✓

Useful resources

For more information about water security, see:

WaterAid (2012). Water security framework [online]. London, UK. Available at: https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/download-our-water-security-framework.pdf.

For more information about water safety, see:

Ross K, Winterford K and Willets J (2019). A guide to equitable water safety planning: Ensuring no one is left behind [online]. Geneva, Switzerland. World Health Organization. Available at: https://apps.who.int/iris/bitstream/handle/10665/311148/9789241515313-eng.pdf?ua=1.

WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation.

Part of a series of WaterAid technology briefs available at www.wateraid.org/uk/technology

WaterAid (2021). Technology brief: Appropriate technologies for sustainable and inclusive water and sanitation services. London. Available at: washmatters.wateraid.org/publications/technology-resources

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