Scottish Water
Always serving Scotland

Water treatment

Second level

Description of module

This topic is about some of Scottish Water's most important work, and so it is one of the most detailed modules. It could form a substantial part of a term's work

The module centres on how water is made safe to drink, but before that, there are activities to build on children's knowledge of the water cycle and there is an introduction to bacteria. The module finishes with a summative assessment, but with a twist!

Main experiences and outcomes

Sciences

I can apply my knowledge of how water changes state to help me understand the processes involved in the water cycle in nature over time.
SCN 2-05a

By investigating some body systems and potential problems which they may develop, I can make informed decisions to help me to maintain my health and wellbeing.
SCN 2-12a

I have investigated different water samples from the environment and explored methods that can be used to clean and conserve water and I am aware of the properties and uses of water.
SCN 2-18a

Social studies

I can discuss the environmental impact of human activity and suggest ways in which we can live in a more environmentally-responsible way.
SOC 2-08a

I can consider the advantages and disadvantages of a proposed land use development and discuss the impact this may have on the community.
SOC 2-08b

By comparing my local area with a contrasting area outside Britain, I can investigate the main features of weather and climate, discussing the impact on living things.
SOC 2-12a

To extend my mental map and sense of place, I can interpret information from different types of maps and am beginning to locate key features within Scotland, UK, Europe or the wider world.
SOC 2-14a

Technologies

I explore and experiment with the features and functions of computer technology and I can use what I learn to support and enhance my learning in different contexts.
TCH 2-04a

Through discovery and imagination, I can develop and use problem-solving strategies to construct models.
TCH 2-14a

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Activity 1

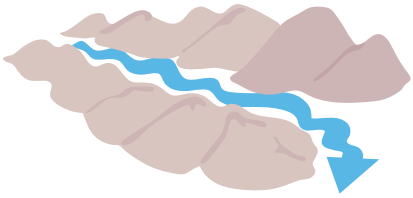
Learning intention
- Pupils understand that water runs down from hills to rivers, which can be dammed

Success criterion
- Pupils can draw a picture of a dam and reservoir, and label it correctly

Suggestions for teachers

1 Resource sheets 1 and 2

Show resource sheets 1 and 2 on the IWB, or as printouts. Discuss how rain falls, runs down, and collects in rivers and lakes and finally flows out to sea.



2 Rain in hilly regions

Explain why there is more rain in hilly areas, e.g. "The hilly regions see more rain as clouds have a greater chance of forming there and higher altitudes always receive cooler temperatures." Could also mention the 'rain shadow' and why that would not be a good place to have a reservoir.

3 Water in the wild

Collect water from puddles and let it settle in order to show that water 'in the wild' is impure. This activity could be in the form of a challenge: ask the pupils to discover the best way of getting water out of a puddle; sucking straight through a tube is not allowed (explaining the health reasons why would be a good learning point). Some methods might be: using a sponge, designing a scoop, a pooter. Designing a fair test to find the fastest or most efficient method would take this a stage further.

4 Reservoirs and dams

Groups of pupils could use the sand and water trays to construct an efficient reservoir and dam. They will quickly understand the need for strong construction materials.

5 Researching

Groups of children research from the Internet or books to find pictures of dams and reservoirs.

6 Labelling a picture

Drawing a labelled picture of a reservoir and dam could be an assessment tool for this module.

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Activity 2

Learning intention
- Pupils understand that there is usually more rain in hilly areas of Britain, and so these are good places to have reservoirs (but this is not the sole consideration)

Success criterion
- Pupils show understanding in their responses to the concept cartoon

Suggestions for teachers

1 Higher ground
Look at maps of Britain on resource sheet 3, one shows areas of high ground and the other shows areas of high rainfall. Any previous work done on the water cycle or weather is valuable here, otherwise a very simple explanation will do, such as a demonstration of a wet sponge approaching Britain and dropping its water.

2 Cities of Scotland
An enrichment of the above. Pupils mark some cities of Scotland and their own school on the map and then mark the annual rainfall in these areas. The Met Office provides a range of free data for educational use - **www.metoffice.gov.uk/education**

A display could be made of measuring cylinders showing the actual depth of water in a year and/or groups could draw cylinders of appropriate lengths and stick them on a map.

3 Concept cartoon
Carry out the concept cartoon activity using resource sheet 4. Divide class into groups and ask each group to decide which statements they agree or disagree with. The answers are not clear-cut, but the debate will demonstrate which children have really grasped the ideas, and which points need further clarification.

The children's comments are:
- There's more rain in the west because that's where the clouds come from.
- Aberdeen could get its water from Shetland – there's lots of rain there!
- There are loads of lochs in Scotland. That proves there's a lot of rain.
- It's always raining here. Does that mean we live in the hills?
- I think Glasgow would be a good place to build a reservoir.

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Activity 3

Learning intention
- Pupils develop an overview of the water treatment process

Success criterion
- In discussion, pupils show an understanding of what happens at each stage of the process

Suggestions for teachers

The processes involved in taking water from the environment and purifying it for drinking are quite complex and technical, and so the following stages are quite gradual.

1 Water treatment

As a starting point, resource sheet 5 could be used to talk through the stages of water treatment with the children; they should already be familiar with the first half, but some time would need to be spent on the following processes:

- Raw water
- Screening
- Clarification
- Filtration
- Disinfection
- pH correction

More information can be found on the Scottish Water website:
www.scottishwater.co.uk/education

A video suitable for older/more able pupils about Glencorse water treatment works is available on the STEM Central website, visit:
http://www.educationscotland.gov.uk/stemcentral/contexts/water/video/watertreatmentvideo.asp

2 Video summary

The video at:
www.youtube.com/watch?v=9z14l51ISwg
has an excellent summary of the process, although the vocabulary is too technical for most pupils of this age. Teachers could perhaps let it run, stopping at important points and making sure the children know which part of the process is being shown. To reinforce this, the video could be shown again, stopping at five points to show each stage of the whole process. The children could draw pictures of what they see at these points.

3 Check understanding

This is a quick way to check pupils have understood the main stages of water treatment. Divide the class into small groups. Issue each group with labels of the stages of water treatment on separate pieces of paper. The pupils are tasked to put the stages into the correct order. To add more excitement, teams can race against each other to get the correct sequence first. To be confirmed as the winner, the group must describe the water treatment process to the rest of the class.

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Activity 3

Continued

4 Extension activity

Teachers might like to carry out an extension activity, where groups of pupils are given a local Ordnance Survey map and asked to plan a route for a hypothetical pipeline. A plastic overlay and suitable drywipe pen would allow different routes to be drawn and erased. Teachers would need to decide a start and finish point – perhaps a local loch as a start and the school as an end. The activity would be a useful context for discussing contours, because, ideally, the pipeline should run downhill to avoid costs for pumping. If pupils are familiar with map scales, they could measure the length of their systems.

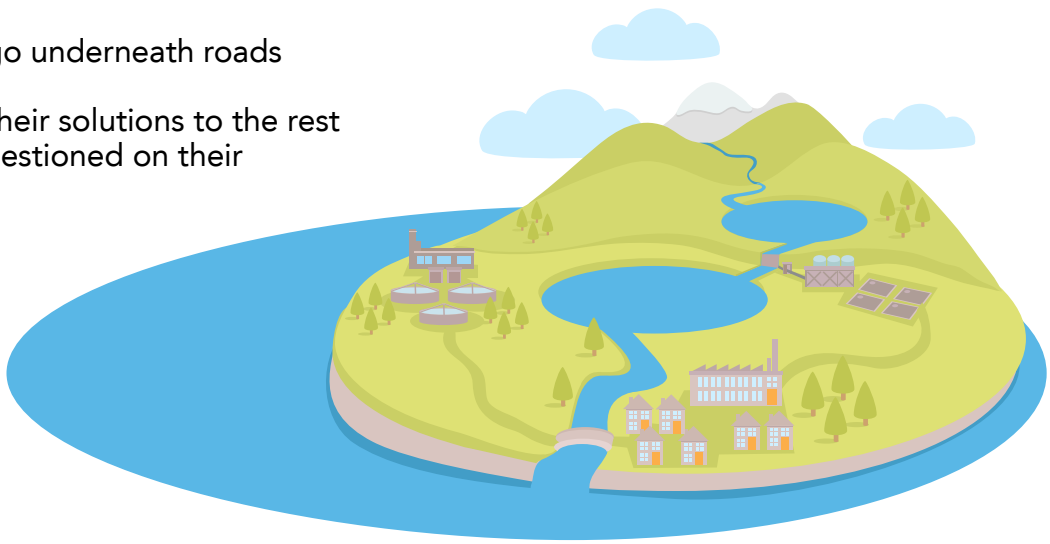
Other factors to consider include:

- pipelines cannot go through buildings
- if possible, areas of natural beauty should be avoided
- the straightest course is the cheapest
- digging up roads is inconvenient for motorists
- pipes can, and do, go underneath roads

Pupils could present their solutions to the rest of the class and be questioned on their decisions.

5 Alternative

An alternative to drawing on the pipeline might be to give each group, say, four plastic straws, which the children could cut and Blutak on to show the route. Useful maths could be included if the straws – pipes – could be costed at £100 per cm.



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Activity 4

Learning intention
- Pupils know that there are tiny living things in untreated water

Success criterion
- Pupils can describe and/or draw some bacteria, using appropriate vocabulary

Suggestions for teachers

1 Microscopes

Set up microscopes with some sample slides and explain that bacteria and (some) algae are even smaller than can be seen with the school microscopes. There is a useful minute long clip showing the size of bacteria at **www.bbc.co.uk/learningzone/clips/understanding-the-size-of-bacteria/2279.html**

This clip will demonstrate why it is so difficult to see bacteria, even under a microscope. If you can peel off the thin, transparent membrane from an onion (not the brown skin), a good microscope can show the cells - a good point for discussion. Other possible easy slides are: a line drawn in pencil, a fingernail, a hair, dust, wool, newspaper picture.

2 Photographs of bacteria

Look at photographs of bacteria. There are many on the Web, for example:

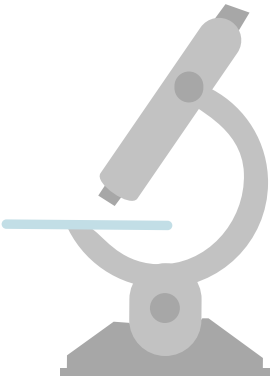
www.duskyswondersite.com/human-ingenuity-category/virus-and-bacteria-as-art

www.sciencephoto.com/media/206637/enlarge

www.istockphoto.com/stock-photo-1664264-helicobacter-pylori.php

3 Bacteria display

Pupils draw pictures of bacteria for a group display. These, cut out, could be mounted on the background of a drop of dirty water (tea stained?). More ambitiously, 3D models could be made for a ceiling mobile display. Art specialists will have ideas on what media and techniques to use.



4 Thought showering

Groups of children do a thought showering exercise to come up with words or phrases to describe bacteria (e.g. can make you ill, tiny, microscopic, beautiful, wriggle, some are dangerous…). These, written on 'stickies' could be attached to the picture display.

5 Homework

Homework activity – make a note of TV adverts that show killing bacteria, or cut out adverts from magazines.

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Activity 5

Learning intention
- Pupils understand that people in some parts of the world do not have access to clean drinking water

Success criterion
- Pupils can name some of these countries

Suggestions for teachers

1 Dirty water

Discuss with children the fact that one of the biggest causes of disease in the world is drinking dirty water, and it is the leading cause of death for children under the age of five.

UN Environmental Programme report: "Over half of the world's hospital beds are occupied by people suffering from illnesses linked with contaminated water, and more people die as a result of polluted water than are killed by all forms of violence including wars."

Show pupils resource sheets 6 and 7.

By referring to atlases, groups of children could discover the names of some of the countries of the world most in need of clean water. These could be displayed on a wall map. A follow-up would be for each group to discover one fascinating fact about each country to tell to the rest of the class.

2 Charity speaker

This might be a good point at which to ask a speaker to come in from a charity involved in improving water quality in the world – there are a few of these, like WaterAid and Action Water. Staff are often willing to speak in schools, and local authority staff may do so as well. Medical practitioners could also give their angle on the need for cleanliness, to protect against E.coli for example.

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Activity 6

Learning intention
- Pupils learn that filtration is a vital step in the treatment of the water they drink

Success criterion
- Pupils can describe the effects of different filters

Suggestions for teachers

1 Resource sheet 8

Resource sheet 8 may be used as a guide as it stands.

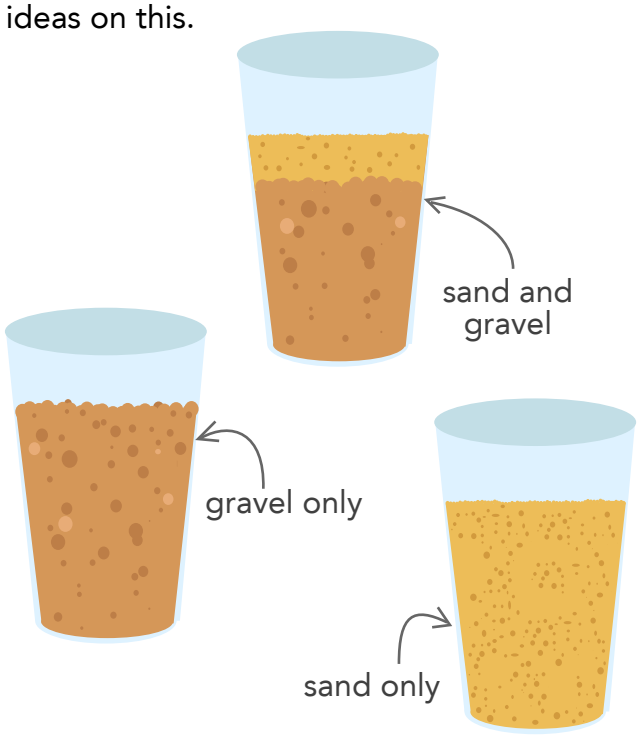
2 Further investigation

For more open investigations, or to add value to the above:

- Time-lapse photography or video could be used to record
- Pupils could be challenged to find better filters (cotton wool, cloth, J cloth, toilet tissue, paper, stones…)
- If kitchen roll is used, the trapped dirt can be shown clearly
- Photographs could be used to make a PowerPoint record of the experiment to show to another class, or at assembly
- A further investigation could be to find out what size holes are best in the plastic cups. Each group could choose a different set e.g. 3 x 1 cm diameter, 6 half centimetre, 10 x 2mm, then predict what would happen and compare with actual results

3 Filtered water

Discuss how the filtered water is not yet fit to drink: there are a number of other processes that would need to be carried out first. The point could be made visually by filling a bottle with the filtered water, and another identical bottle from the tap, and placing them side by side. Scottish Water provides a very high quality product. One of our campaign messages is: "Clear, fresh Scottish drinking water. Only available on tap in Scotland." This could be displayed along with a picture of a tap; see the Scottish Water website at **www.scottishwater.co.uk** for ideas on this.



Full experiment on resource sheet 8.

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Activity 7

Learning intention
- Pupils gain a better understanding of how clean water reaches their homes

Success criterion
- Pupils can draw a picture of their homes, or the school, showing how the mains water enters.

Suggestions for teachers

1 Resource sheet 9

Resource sheet 9 can be used to help explain how water is used in the home and how clean water gets to our homes.

2 Added value

To add value to this activity

- Set the pupils the homework task of finding out where the stop valve is where they live.
- Groups of children could go round the school – other staff willing – to list all of the uses to which water is put. This could be done under headings, e.g.: toilets, janitor's room, art room, kitchens, medical room and outside. The results could be shown on a wall presentation of a school plan.
- Discuss memories of inconvenience when water was interrupted at home and what can people do if the water was interrupted.
- Remind children of work done on killing bacteria. You may be able to smell the chlorine in water if you run mains water hard into a large jug and sniff. If you can, this is a good way of teaching how water is disinfected.

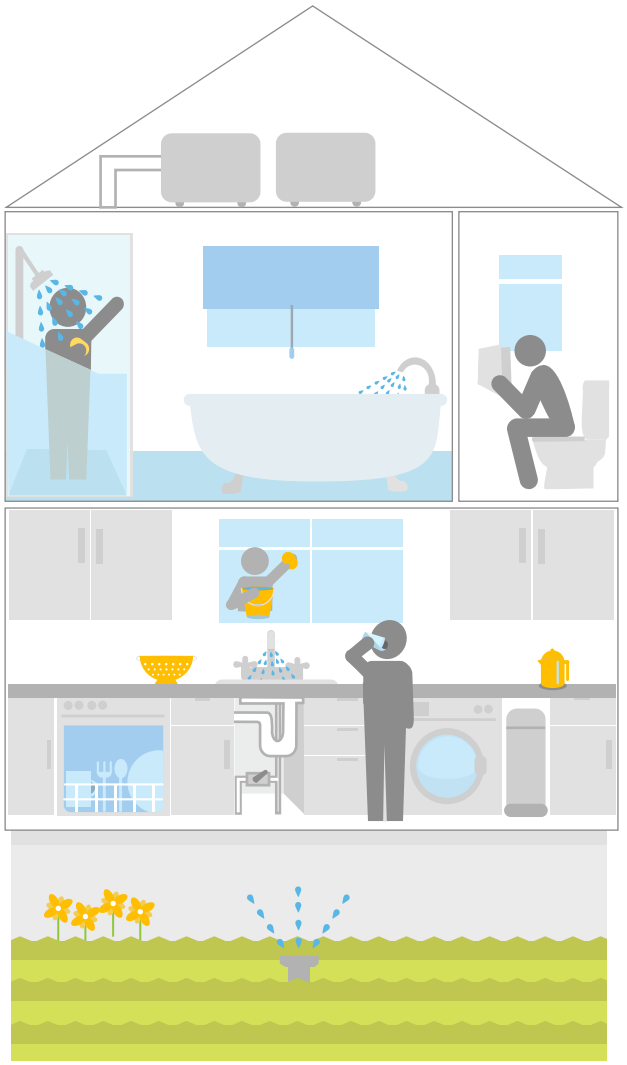

Image from resource sheet 9.

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Activity 8

Learning intention
- Pupils' knowledge is reinforced as they are reminded about the topic of providing clean water to homes

Success criterion
- Pupils are able to 'find the facts' on the sheet

Suggestions for teachers

1 Can you find the facts?

There are 7 of them!

Water in rivers is good to drink

Water can be filtered by sand

Many people in the world die from drinking dirty water

Bacteria are enormous

All bacteria are bad for you

Our drinking water is stored in reservoirs

Scotland gets plenty of rain

The east of Scotland is the wettest part

Sand is not a very good material for making a dam

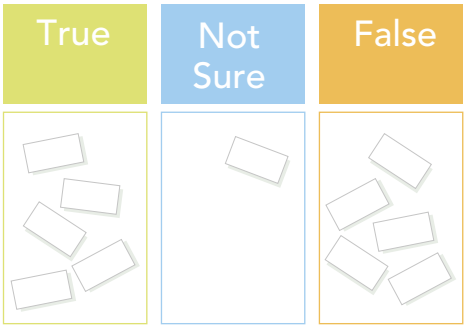
Microscopes let us see things that are very far away

Water comes to my house through a pipe

Water is very important

2 Cut the statements out

These statements could be cut out for each group, and pupils asked to arrange the slips into True, False and Not Sure. Each group could feed back to the class.



3 Make your own

Each group could come up with 2 more slips – one True and one False and then these used for a further quiz.

4 Talk about water

Groups could make up a talk about water, but deliberately insert one or two false statements into it. A volunteer 'newsreader' could give the talk to the rest of the class, and the other pupils have to try to spot the untruths. Alternatively (more creative, more fun, but far more difficult) the whole talk could be fantastic lies with just one fact in it.

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Activity 9

Learning intention
- Pupils develop an overview of the waste water treatment process

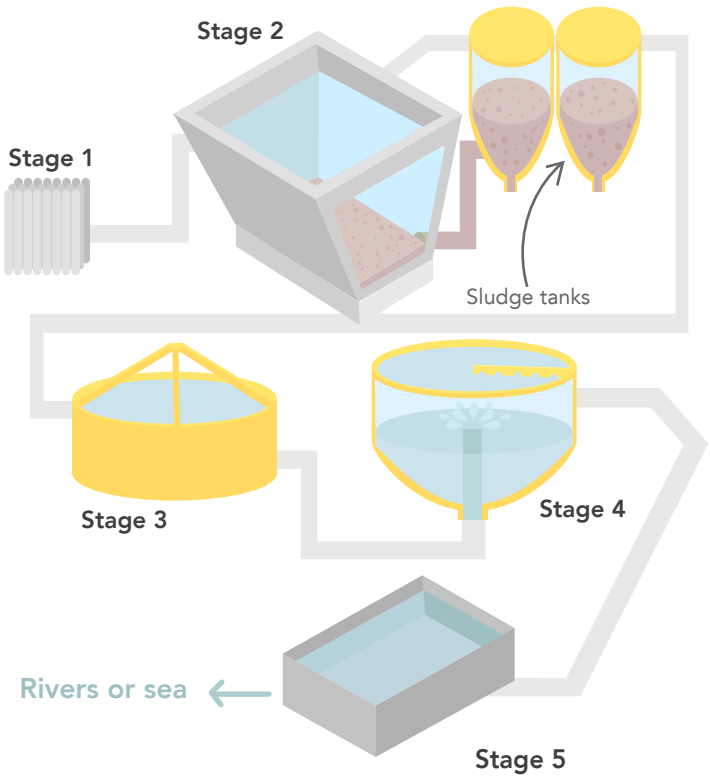
Success criterion
- In discussion, pupils show an understanding of what happens at each stage of the process

Suggestions for teachers

1 Waste water processes

To give a full picture, teachers might first like to briefly describe the processes of waste water treatment. Resource sheet 10 shows the treatment process in 5 stages.

Pupils should be able to understand what happens quite well as the process is similar to that of cleaning water for drinking purposes, in that larger rubbish is screened out, then smaller particles, and then the smallest particles settle out as sludge, after which 'good' bacteria clean the water. There is no addition of chlorine or pH correction because the water that emerges is not intended for drinking; it is simply returned to the environment.



The 5 stages of waste water treatment. Shown in full on resource sheet 10.

2 Check understanding

This is a quick way to check pupils have understood the main stages of waste water treatment. Divide the class into small groups. Issue each group with labels of the stages of waste water treatment on separate pieces of paper. The pupils are tasked to put the stages into the correct order. To add more excitement, teams can race against each other to get the correct sequence first. To be confirmed as the winner, the group must describe the waste water treatment process to the rest of the class.

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Resource sheet 1

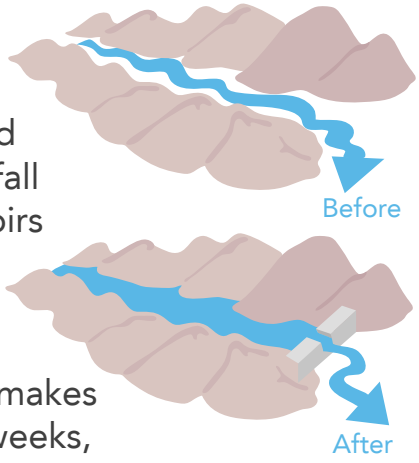
How is water collected for us to use?

1

It is easy to turn on the tap to get clean water, but a lot of things have to happen to allow us to do that.

First of all, water has to be taken away from its natural cycle.

Most of the water used today is collected and stored in man-made or natural lochs called reservoirs. Rainfall is highest in hilly areas, so this is where most reservoirs are.



Reservoirs are made by building a dam across the upper part of the river. The water then collects and makes a huge loch. So, even if it does not rain for several weeks, there will still be water available.

2

The dam has to be made of very strong, thick concrete to hold back the huge amount of water behind it. The amount of water flowing through the dam is controlled by opening and closing valves.

The Scottish Environment Protection Agency (SEPA) set minimum compensation flow rates from the dam to protect the environment such as fish, wildlife and plants downstream.

The water in the reservoir needs to be cleaned before it is ready for us to drink. The river has carried lots of bits of grit and dirt down with the water. Some of this grit and dirt will sink to the bottom of the reservoir as silt. This happens because the water in the reservoir is deep and still. The rest is removed at the water treatment works which makes the water clean and safe to drink.

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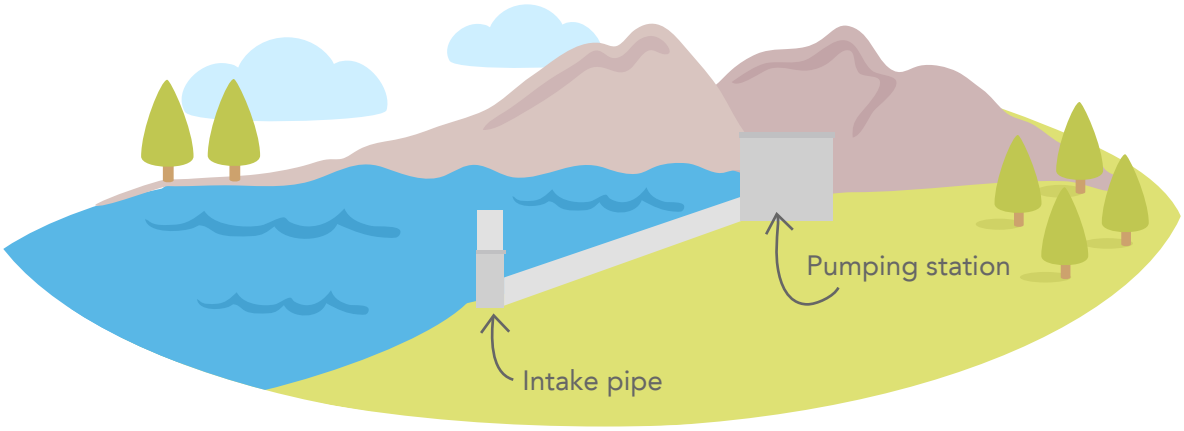
Resource sheet 2

How is water collected for us to use?

1

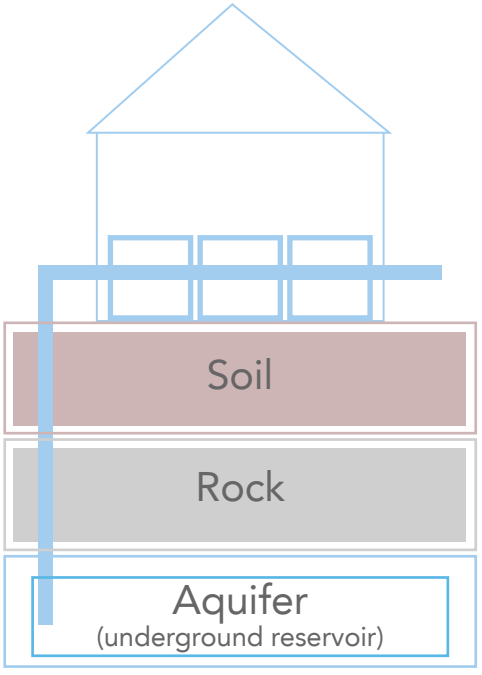
Sometimes we take water from natural lochs like Loch Lomond.



Sometimes a reservoir forms naturally underground. Rainwater soaks into the ground and through the rock below. It happens where there are rocks like chalk and limestone. They soak up a lot of water. They are a bit like underground sponges. The water then collects in a space between layers of rock. We call this an aquifer.

2

We collect water from the aquifer by drilling boreholes in the rock. The water is then pumped out. Wherever we get it from, all water must go to the water treatment works to be made safe and clean before it is piped to our taps. When clean water leaves the water treatment works it travels through large pipes called water mains which are buried underground. There is a water main under the road near your house and the water in your tap comes through a water supply pipe from that water main.



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Resource sheet 3

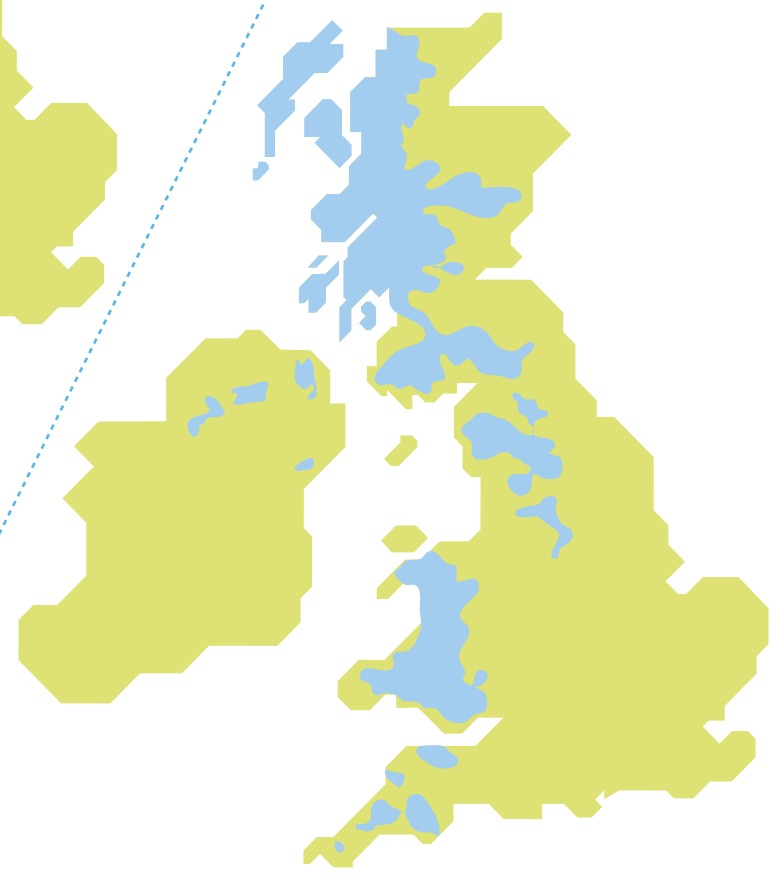
Maps

Look at the maps of Britain below. The first map shows areas of high ground and the second shows annual rainfall. What do you notice about these areas?

1

Areas of high ground.

2



Areas of high rainfall.

Source www.metoffice.gov.uk/

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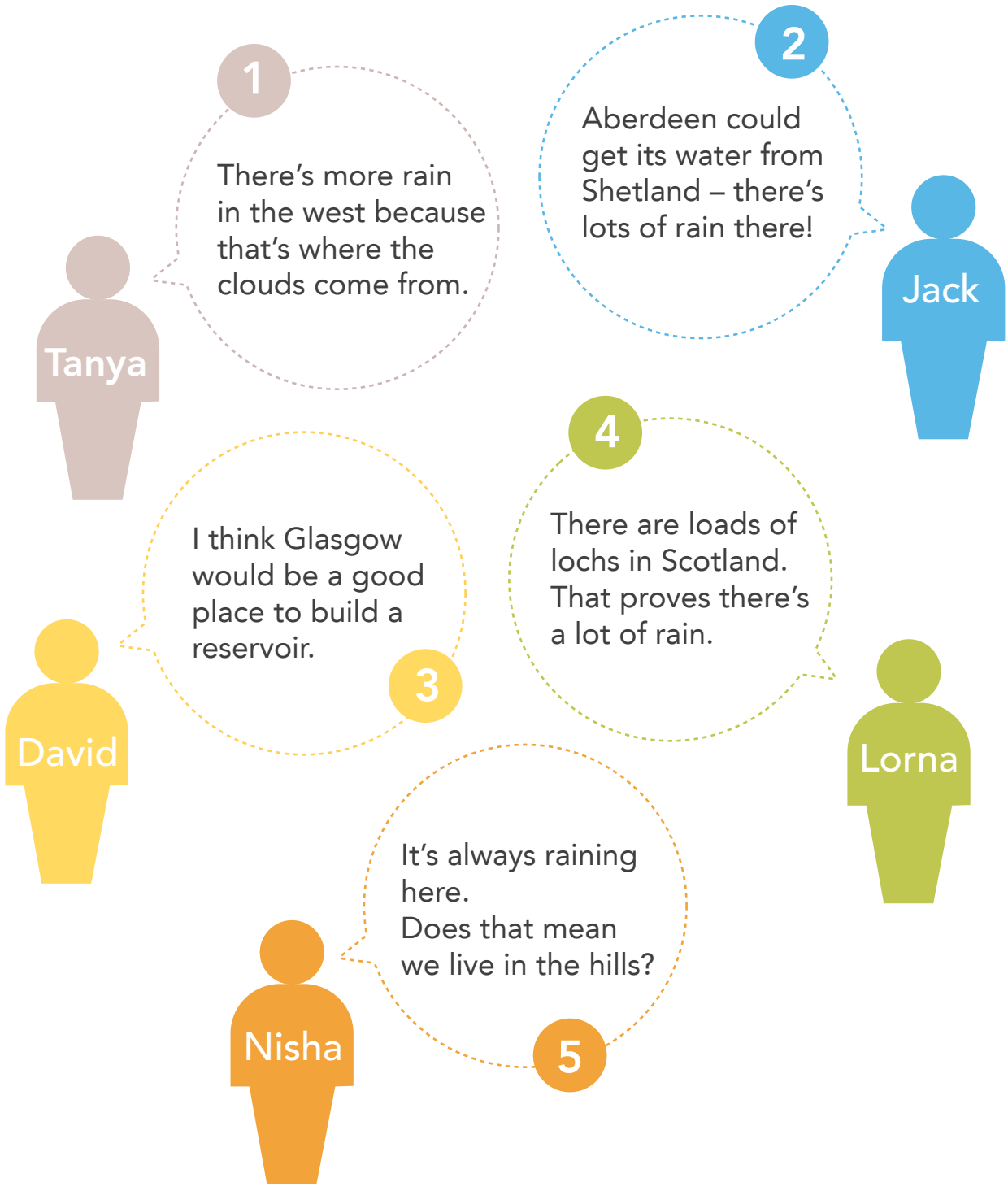
Resource sheet 4

Concept cartoon

Read the statements below. What do you think?
Which do you agree with or disagree with?



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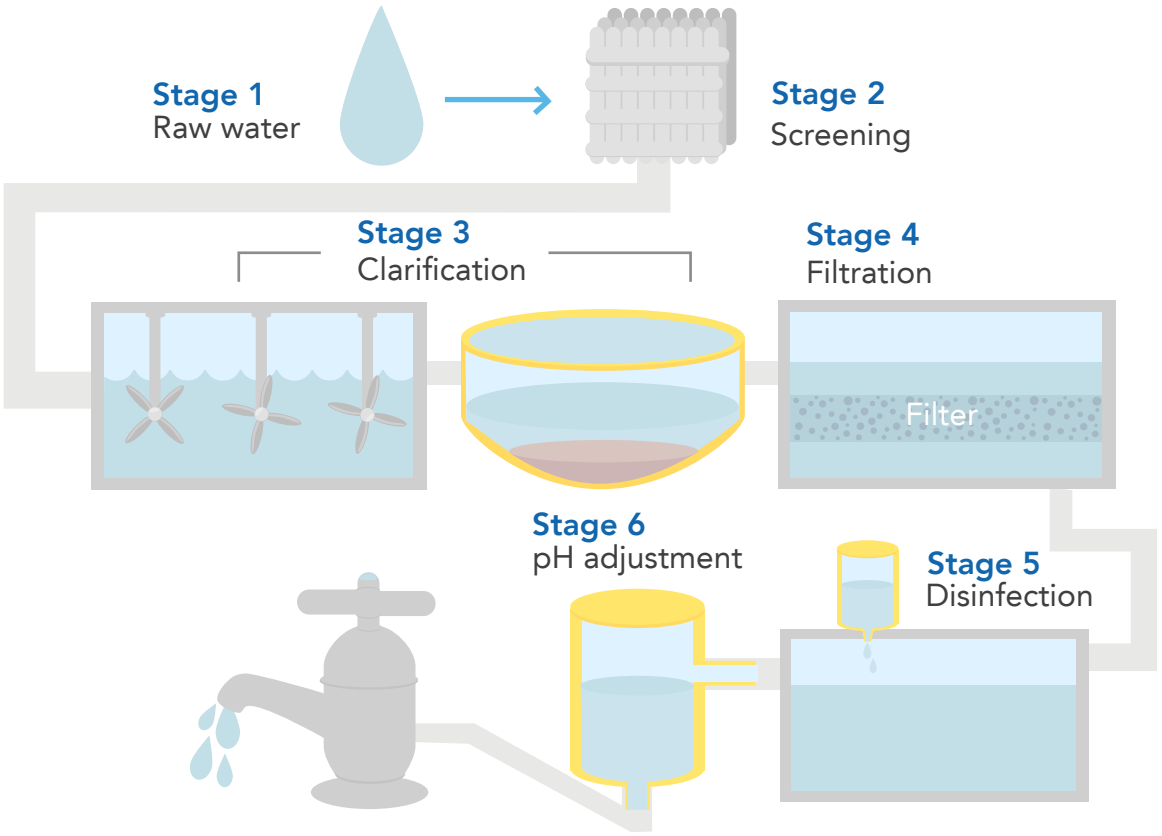
Resource sheet 5

Typical example of the water treatment process



Stage 1: Surface water is stored in reservoirs to provide a continuous supply to meet demand throughout the year.

Stage 2: Water is passed through mesh screens to remove debris, such as leaves, weeds and sticks.

Stage 3: Impurities in the water are removed.
Clarification includes:
- coagulation and flocculation
- sedimentation

Stage 4: Any impurities still left from the clarification stage are removed through filtration.

Stage 5: Disinfection is vital to ensure that water-borne diseases are eliminated, and that the drinking water that we supply to you meets the water supply regulations.

Stage 6: pH is a scientific term used to describe the acidity or alkalinity of a substance. We need to control the pH level of drinking water. If water is too acidic it may corrode metal pipes, and if it is too alkaline it may cause deposits to form inside the pipes.

The water is now safe to drink and use in our homes, schools and businesses.

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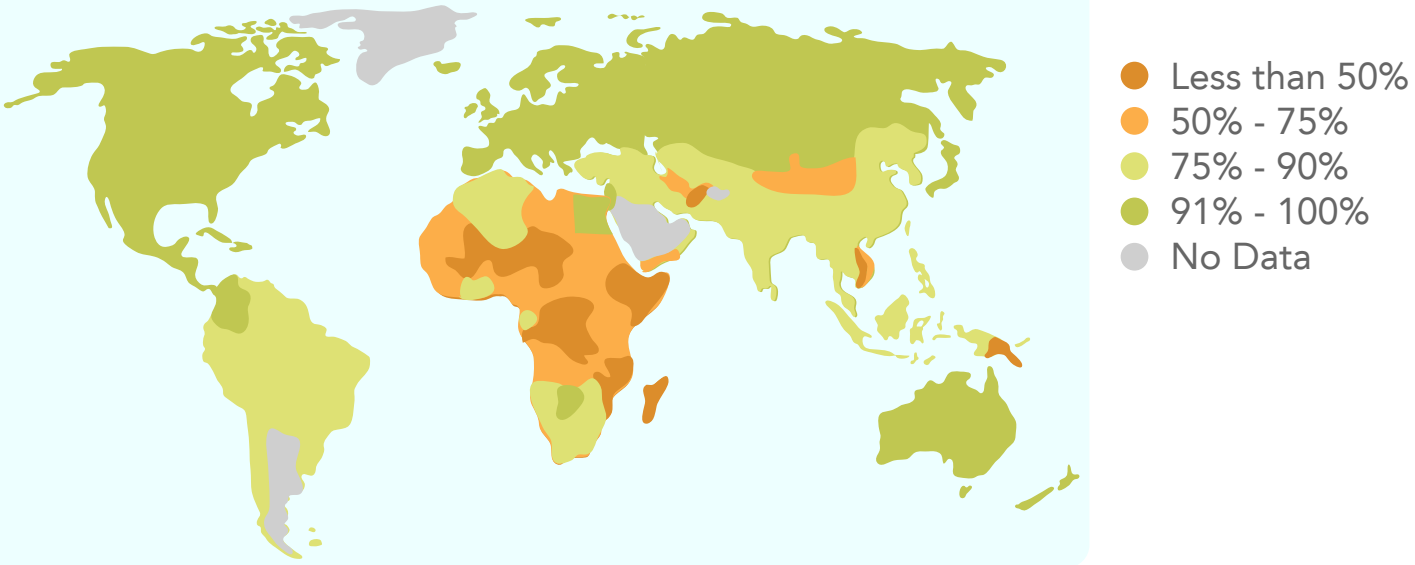
Resource sheet 6

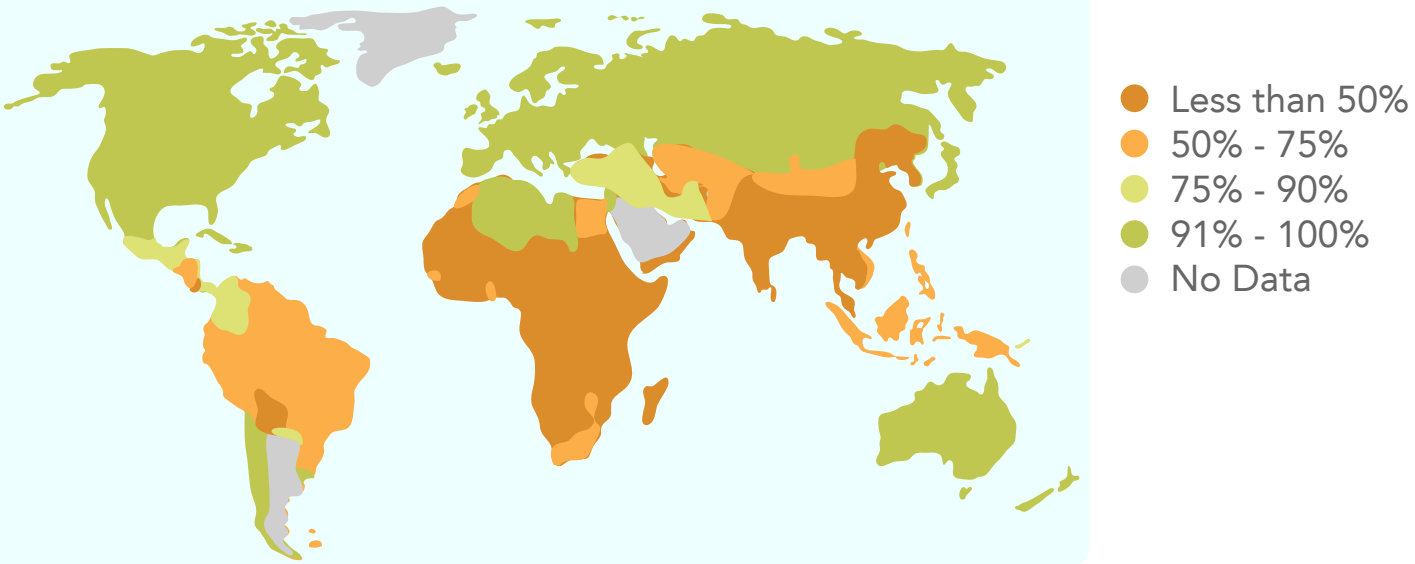
One of the biggest causes of disease in the world is drinking dirty water.
The two maps below show the countries of the world with improved drinking water and the countries with adequate sanitation.

Can you name any of the countries shown on the maps that are most in need of clean water?

Countries with **improved drinking water** (2002)



Countries with **adequate sanitation** (2002)



Source: wikibooks.org

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Resource sheet 7

Think about this...

1. Have you ever thought about how lucky you are to be able to turn on a tap and have all the water you need?
2. In the past people had to collect their water from ponds, streams, rivers or wells.
3. In some countries today, people still collect water this way.

Uganda's basic services are still very patchy, leaving millions of desperately poor people without safe water and sanitation.

Most people in **Papua New Guinea** live in the mountain areas, where less than half the population has water and sanitation.

Declining rainfall in **Zambia** is making water increasingly scarce, and over half the population has nowhere to go to the toilet.

On the huge island of **Madagascar** well over half the population has no safe water and only 11% have anywhere to go to the toilet.

For more information like this visit **www.wateraid.org/where-we-work**

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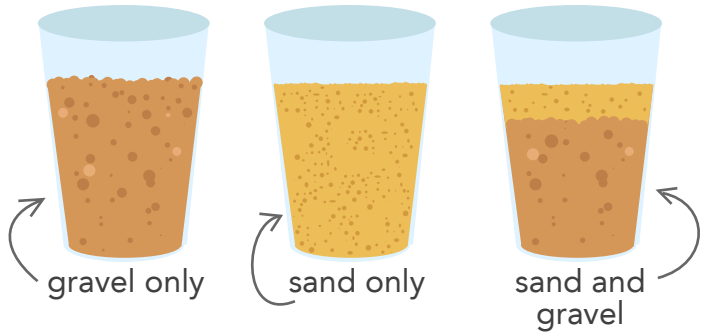
Resource sheet 8

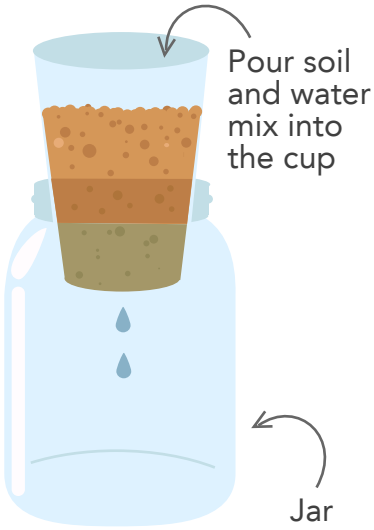
Fantastic filters - Can you make a filter to clean dirty water?

You will need:
- measuring jug with soil and water mixed up together
- some gravel
- some sand
- three plastic cups
- three empty jars

1 Fill your plastic cups like this:



Make some holes in the bottom of the plastic cups to allow the water to drip through.



2 Sit each cup over an empty jar.

3 Stir your water and soil mix together and carefully pour equal amounts into each cup.

4 Compare the water left in each jar.

Write up your experiment: What happened to the water poured into each jar?

Try to answer these questions:

1. Which material let the water through the fastest?

2. How clean was this water?

3. Which jar has the cleanest water?

4. What do you think has happened to the dirt in the water?

5. Which material do you think made the best filter? Why?

What happens at the water treatment works?

When raw water leaves the reservoir it goes to the water treatment works to be cleaned and made safe to drink. One way of cleaning water is to use sand and gravel filters to trap bits of dirt. These are often called slow sand filters. **Can you think why?**

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Resource sheet 9

How does clean water get to our homes?

When clean water leaves the **water treatment works** it travels through large **pipes** called **water mains** which are buried underground.

There is a water main under the road near your house and the water in your **tap** comes through a water supply pipe. This pipe is controlled with a **stop cock** which is placed on the **communication pipe**.

A **stop valve** in the house or sometimes in the garage, can be opened or closed to allow you to turn the **supply** from the water main to your house on or off. It's a bit like turning a tap on or off.

1 Look at the picture below. List the ways you can see water being used.

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2 Find and label:

- the **water main**
- the **stop valve**

3 Most of the time the stop valve is open as we are constantly using water at home.
Can you think of any reasons you might want to turn off the water coming into the house?

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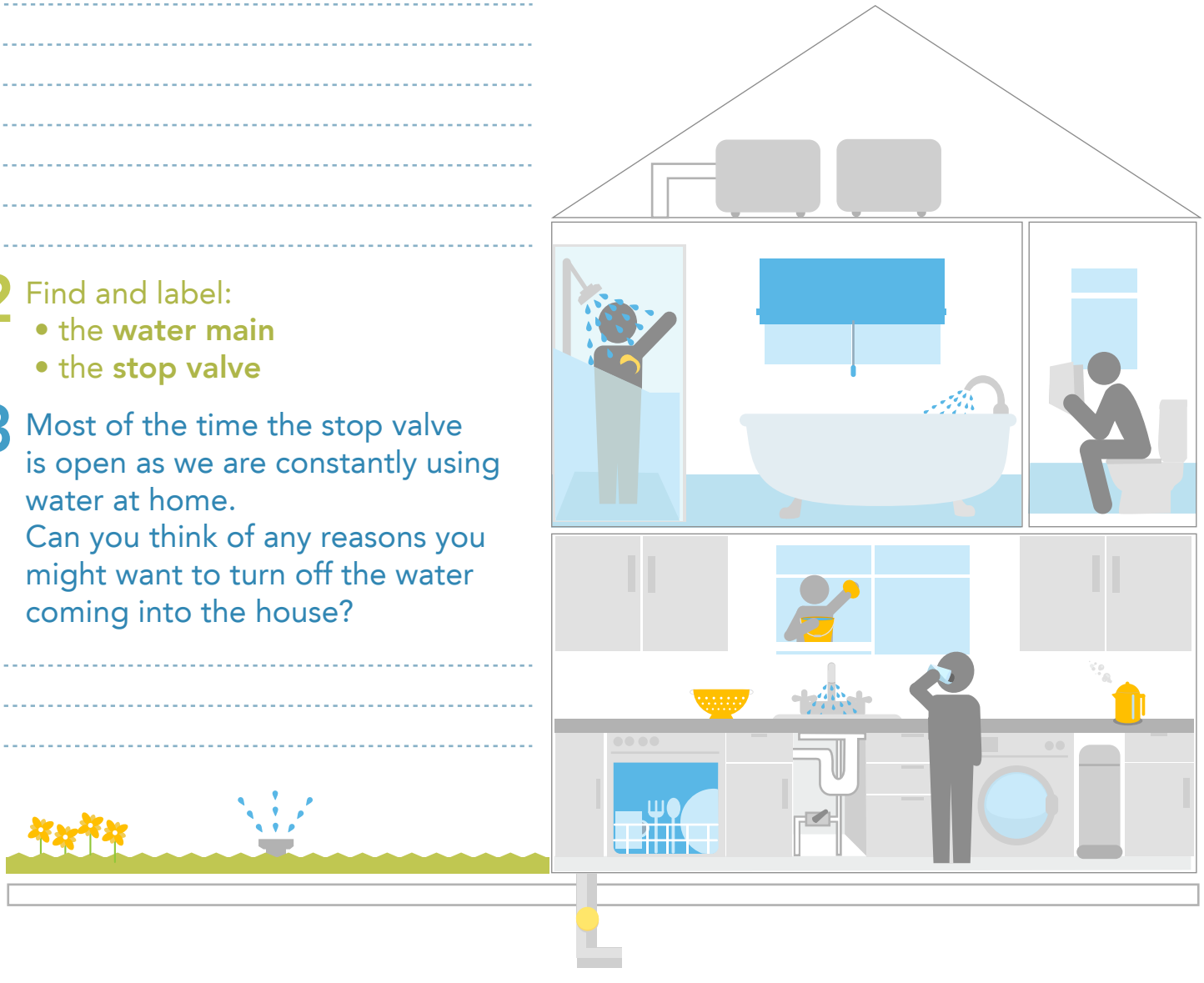

Scottish Water
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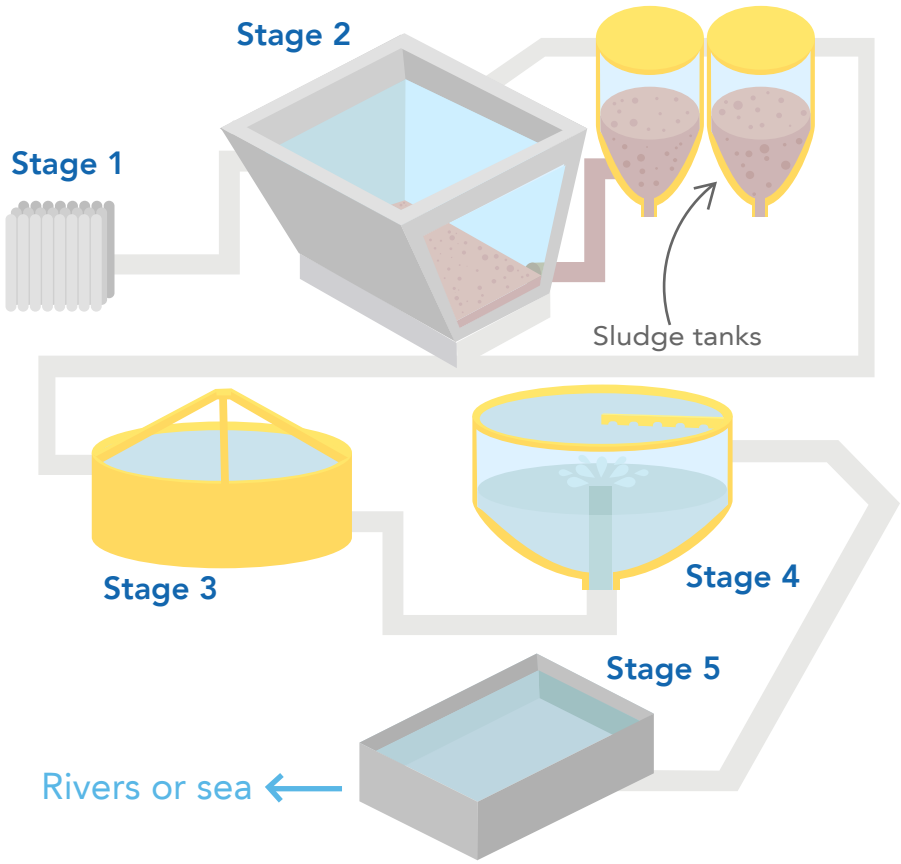
Water treatment

Resource sheet 10

The 5 stages of waste water treatment



Stage 1: Screens trap rubbish like rags, bits of wood and plastic.

Stage 2: Stones and grit are removed so they don't damage machinery.

Stage 3: The waste water rests in these tanks where any solids in the water sink to the bottom. The solids make a slimy mud called sludge. The sludge is pulled out into other tanks to be treated and made harmless. It can be used to make the soil better for growing plants or for burning to make electricity.

Stage 4: Good bugs (bacteria) grow in the tanks. They eat up any chemicals and other waste which could harm plants and animals.

Stage 5: The waste water is allowed to rest again. Large stirrers gently mix the liquid and the left over bits sink to the bottom of the tank.

Now that the treated waste water is much cleaner, it can be poured back in the river or the sea.