REFRACTION MEDIA

MLA MEAT & LIVESTOCK AUSTRALIA

Water

our most precious resource

Study guide

TEACHER'S ★★★★★ RESOURCE

WATER: OUR MOST PRECIOUS RESOURCE

Sustainable and efficient use of water is a top priority for our nation, especially in farming – and Australia's cattle and sheep farmers are leading the way. Australia is a land of climatic and environmental extremes, ranging from lush tropical zones with heavy rainfall to the arid interior. This means that farming practices that work well in one region will not be appropriate for others. Farmers need to tailor their efforts to suit their local environment, rainfall patterns, stock needs and so on. A secure water supply is perhaps the most important consideration for any farming operation. It can be very hard to attain water security when the country goes through continual cycles of drought and flood. Add in the effects of a warming climate, with the potential for dramatic shifts in rainfall patterns, and it's easy to see that primary producers have a major challenge on their hands.

But it's a challenge that Australia's cattle and sheep farmers are meeting with passion and optimism. Better research and evaluation of water use is leading to major advances in the raising of cattle and sheep, the provision of feed, and of course water storage and distribution. These innovations are combining the best of new scientific knowledge with the wisdom and experience of generations of farming families.

In this study guide, you'll learn about many of the ways in which Australia's cattle and sheep farmers are securing the future of Australian farming, and therefore our food supply, through innovative and shrewd use of our most precious resource: water.

MEAT & LIVESTOCK AUSTRALIA FOR A SUSTAINABLE FUTURE

Meat & Livestock Australia is an initiative by Australian cattle and sheep farmers, along with the broader industry, to deliver sustainable farming by 2020. It's a commitment to take positive action, both big and small, to continually improve the way farmers operate, and to improve sustainability throughout the red meat supply chain.

Sustainability isn't a new thing – the whole Australian cattle and sheep industry has been investing in environmental research and development for many years. It continues to invest more than $13 million every year in research and development to reduce the industry's environmental impact through improved farming practices.

As caretakers of the land, farmers are committed to leaving it in better shape than when they found it by improving efficiency and reducing resources used. Apart from harnessing the latest technology and science to reduce farming's footprint, Meat & Livestock Australia is also about sharing ideas, celebrating successes and providing a focal point for environmental, social and ethical farming action to ensure we all enjoy a sustainable food supply into the future.

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HOW TO USE THE GUIDE

The notes in this study guide offer both variety and flexibility of use for the differentiated classroom. You and your students can choose to use all or any of the five sections – although it is recommended to use them in sequence, along with all or a few of the activities within each section.

THE 'FIVE Es' MODEL

This guide employs the 'Five Es' instructional model designed by Biological Sciences Curriculum Study, an educational research group in Colorado. It has been found to be extremely effective in engaging students in learning science and technology. It follows a constructivist or inquiry-based approach to learning, in which students build new ideas on top of the information they have acquired through previous experience. Its components are:

Engage Students are asked to make connections between past and present learning experiences and become fully engaged in the topic to be learned.

Explore Students actively explore the concept or topic being taught. It is an informal process where the students should have fun manipulating ideas or equipment and discovering things about the topic.

Explain This is a more formal phase where the theory behind the concept is taught. Terms are defined and explanations given to models and theories.

Elaborate Students develop a deeper understanding of sections of the topic.

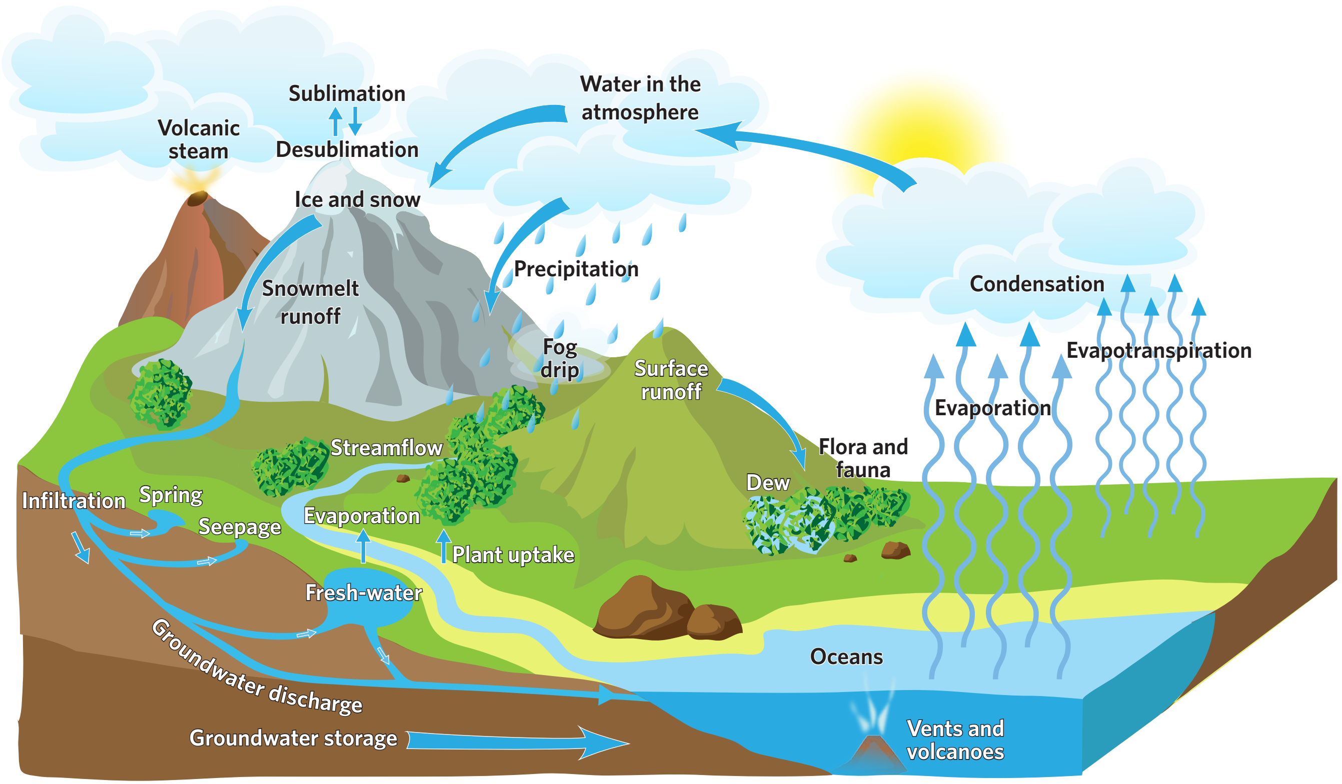
Evaluate Teacher and students evaluate what they have learned in each section.

Using water wisely

Water is critical to cattle and sheep farming. Not only is water consumption essential for the health of the animals, but it's also vital for maintaining healthy pastures – and therefore a sustainable food source for livestock.

REMEMBER THE WATER CYCLE?

In nature, water continually cycles through the biosphere, atmosphere, lithosphere and hydrosphere. As it does, it can exist in any of the three states of matter: solid, liquid and gas. Follow the arrows in the diagram below to show the paths that water can follow as it cycles.



FERN BALE

Timeline of water events

November 2006 The Perth desalination plant is completed, with Western Australia becoming the country's first state to use desalination as a major public water source.

2006 Lowest recorded influx of water into the Murray–Darling Basin.

2008 Genetically modified drought-tolerant wheat is developed in Victoria. It returns yields up to 20% higher than non-genetically modified control varieties.

2009 64,076 gigalitres of water is extracted from the environment and used within the Australian economy from 2009 to 2010.

2010 The Australian Bureau of Statistics reports that rainfall has increased nationwide from 1900 to 2010, although specific areas have experienced a decrease since 1960.

IS WATER A RENEWABLE OR NON-RENEWABLE RESOURCE?
The water cycle shows how rain recycles by running off into the sea, then evaporating to form clouds that will eventually lead to precipitation that can fall on land. Within the cycle, water can be stored as ice, or underground in a water table.

If groundwater is pumped up from a water table, or surface water is taken from a lake, faster than it can be replaced by the natural water cycle, then its use is considered non-renewable.

However, if rainwater can be collected and used before it evaporates, then its use is considered renewable. The more rainwater can be used before it evaporates, the smaller the impact on the water cycle.

There are three main areas to be considered when examining water usage in the cattle and sheep industry:

- In the paddock: Australian cattle and sheep farmers are committed to continually improving their on-farm water efficiency. They do this by taking actions such as creating efficient watering points for livestock (for example, designated troughs for animals to drink from) and maintaining healthy soils and pastures to minimise run-off (and therefore loss of water) during rain.

Water used to raise Australian livestock is generally not diverted water, meaning it primarily comes from dams and river systems rather than town water supplies, and cannot be used for other purposes, such as human consumption.

- In the feedlot: Like farms, water use on cattle feedlots primarily relates to water consumption by animals. However, water is also used for feed processing, washing cattle and managing effluent. To reduce water use, the grain-fed beef industry is investing in several initiatives – including reusing water, and minimising water used when processing cattle feed.

- In processing: In beef and lamb processing plants, water is mostly used to ensure food safety and hygiene during operations. The industry is making major investments to improve water efficiency, including reusing and recycling water.

HOW MUCH WATER IS USED TO PRODUCE BEEF AND LAMB?
According to a 2009 University of New South Wales red meat production 'life-cycle assessment' (LCA), it takes between 130 and 540 L of water to produce a kilogram of beef (see Article 2 in the Explain section – Measuring the water footprint of agriculture from 'paddock to plate'). This LCA measured the use of diverted water (that is, water that could be used for other purposes, such as human consumption) by the cattle and sheep industry, taking into account drinking water for stock, growing feed (when irrigation is used), cleaning and processing.

Occasionally, claims are made that large volumes of water, up to 50,000 L, are required to produce one kilogram of beef. These claims arise from the use of 'virtual' water figures, which attribute every drop of rain that falls on a cattle or sheep property to the production of beef and lamb, rather than taking into consideration that most rainwater on a property will end up in soils, groundwater and natural waterways, whether cattle or sheep are present or not.

April 2012
The millennium drought (the 2000s drought), is officially declared finished. Since 2001, the government provided $4.5 billion in exceptional circumstances assistance.

November 2012
The Murray–Darling Basin Plan is signed off by Tony Burke (Minister for Sustainability, Environment, Water, Population and Communities) and passed in parliament later that month.

January 2013
Cyclone Oswald causes flooding in Queensland and New South Wales, alongside severe storms and tornados. Many areas saw new rainfall records set for the whole of January.

Virtual water figures do not provide a measure of environmental impact, and do not give an accurate indication of the amount of water that could have been used for purposes other than producing a kilogram of meat. For this reason, LCAs provide a far more accurate measure of the livestock industry's water use.

WATER EFFICIENCY IN THE PADDOCK

Australia's unpredictable rain patterns and extended periods of drought mean efficient water management is essential for cattle and sheep farmers. Farmers rely heavily on water-efficient grazing practices to make the most of the water available.

Through grazing management strategies, farmers manage the frequency and intensity of grazing to make the best use of their pastures – balancing the needs of the grazing animal, the pasture and the environment.

WATER – AN ESSENTIAL RESOURCE

As with humans, in on-farm livestock production, the single biggest use of water is for drinking by the animals. Water makes up 60%–70% of the body weight of cattle and sheep, and is essential for maintaining their physiological function.

Water is also an essential resource for establishing and maintaining healthy pastures for Australia's cattle and sheep to graze.

WATER MANAGEMENT

Cattle and sheep farmers do many things to influence the water balance in their grazing systems. Healthy soils and adequate nutrients are two of the basic elements of any successful grazing system. Healthy soils drive higher pasture productivity and benefit the environment, through more efficient use of water and nutrients in the paddock, and lower risk of run-off, erosion and deep drainage.

A comprehensive survey of the environmental practices of Australian cattle and sheep farmers in 2010 found that farmers are increasingly monitoring and managing their water use:

- 55% of farmers had installed additional watering points to replace water for stock from natural watercourses, with 61% of Queensland producers installing water points.
- 86% of farmers monitored the level of water tables on their properties.

WATER-SAVING RESEARCH

The cattle and sheep industry is investing in research to help the industry become more water-efficient, using levies paid by individual cattle and sheep farmers.

Research topics include: improving water use in grazing systems; addressing soil erosion; dry-land salinity and soil acidification; and improving the drought tolerance of plant species through DNA technology. These are outlined below.

RESEARCH PROJECT: THE WATER CYCLE AND GRAZING LANDS

Poor land condition resulting from unsustainable grazing practices can reduce farm profitability and increase water, sediment and associated nutrient loads flowing from properties and catchments into downstream ecosystems, a study has found.

This project builds on a 10-year field study evaluating the impact of grazing practices on a 13 km^2 sub-catchment of the Burdekin River, Queensland, which flows to the Great Barrier Reef. This research will help clarify how better grazing management, on country starting in very poor condition, can progressively reduce run-off, sediment and nutrient loads.

CSIRO WATER FOOTPRINTING TOOL

To gain a better understanding of water used in Australian beef and lamb production, a water footprinting project is being undertaken by Australia's national science agency, the CSIRO (see Article 2 in the Explain section, p24). This project is looking at the relative values of water, depending on where it is accessed from and whether the water used is diverted from other needs or uses, such as human consumption.

WATER EFFICIENCY IN FEEDLOTS

There are about 600 accredited feedlots in Australia. They are generally located near grass-fed cattle farms and grain supplies, and have access to a supply of reliable, affordable and good-quality water.

Of the various uses for water on feedlots, drinking water for cattle is the most significant, with an average of 50–60 L consumed per head each day.

Other water used on feedlots is for feed processing, cattle wash-down, effluent management, general cleaning and operation of staff and office amenities.

SOURCES OF WATER

The most recent survey by the Australian Lot Feeders' Association (ALFA) found that 29% of grain-fed cattle farms across New South Wales, Queensland and Victoria are solely dependent on surface water, and 49% dependent on groundwater, with the remaining 22% able to access both.

Surface water comes from rivers, lakes and dams, while groundwater is from aquifers beneath the ground. Groundwater is often pressurised and therefore reaches the surface of its own accord once holes (bores) are drilled into the aquifer. Windmills and electric pumps are also used to access groundwater.

WATER-SAVING INITIATIVES
The grain-fed cattle sector employs several strategies to reduce water usage. These include:

- Reusing water in cattle wash-down facilities.
- Covering dams to reduce evaporation.
- Restricting water use for feed processing.
- Using neighbouring coal seam gas development water.
- Reusing effluent water for dust suppression.

The industry is also researching other initiatives, such as treating effluent water for cattle to drink, and using water collected from rainfall more efficiently.

REDUCING WATER USE IN PROCESSING

In beef and lamb processing plants, water is primarily used to ensure food safety and hygiene during operations, and the industry is making major investments in improving water efficiency, including reusing and recycling water.

A desire to improve environmental performance combined with the impact of water restrictions during times of drought has led processing plants to implement strategies to reduce water consumption.

REDUCING WATER CONSUMPTION
More efficient water consumption by the meat processing industry not only results in financial savings, but also reduced wastewater volumes, making wastewater treatment and disposal easier and cheaper. Examples of positive strategies being adopted to reduce water consumption at processing facilities include:

- Using flow meters to monitor water usage
- Reusing water for cleaning yards and other applications
- Recovering rich organic compounds and nutrients from treated wastewater and solid wastes, to be transformed into fertilisers and soil conditioners
- Installing efficient and effective wastewater treatment processes

Useful websites

- Meat & Livestock Australia (MLA) is owned by Australian beef, sheep and goat producers and represents Australia's red meat and livestock industry. Educating young Australians about the red meat industry is very important to farmers, and this is why MLA make it a priority to offer teachers and students curriculum-linked resources and interactive activities as an aid to bring the farm into the classroom. Visit *goodmeat.com.au/education*
- At the website of the Australian Lot Feeders' Association, select the 'Industry information' tab and then click on 'Water' under the heading 'Briefing notes' to read about water issues: *feedlots.com.au*
- The website of the Australian Life Cycle Assessment Society: *alcas.asn.au*

Water use: the full facts

There are lots of misconceptions about the amount of water used on farms – getting the full picture requires detailed assessment of a wide range of factors.

Name: Brad Ridoutt

Location: CSIRO Sustainable Ecosystems, Melbourne

Web: *people.csiro.au/R/B/Brad-Ridoutt.aspx*

"You can't make generalisations because beef is produced in so many different ways."

MEASURING THE TOTAL environmental impact of water consumption – known as 'water footprinting' – is far more complicated than simply adding up the volume of water consumed from start to finish. That's the message Brad Ridoutt, principal research scientist in sustainable agriculture at Australia's national science agency, the CSIRO, is keen to get across.

As a leading expert in water footprinting, Ridoutt represents Australia on the global stage in the quest to design an international standard for assessing water use, whether it's in the production of a kilogram of beef or a packet of M&Ms.

The approach he is working on with the International Standards Organisation (ISO) is in the final draft stage and uses life-cycle assessment principles. This not only takes into account the water used in the production cycle, but also sets the resulting figure – expressed as H_2O-equivalent – in the context of true environmental impact. This includes water used in everything from producing diesel fuel for transport, to watering crops and livestock, as well as any water degraded as a result of the production process – for example, by pesticide run-off – and set in the context of the existing water stress of the region, based on a global average index.

The result is far more comprehensive and credible than traditional 'volume-metric' approaches that look only at water consumed, including any rain that fell on crops, Ridoutt says.

"The volume consumption approach led to all sorts of metrics being produced – numbers like 15,000 L of water to produce a kilogram of beef," says Ridoutt. "That's a bit of a nonsense really, because in many cases, there's no known environmental issue associated with the water being used." In other words, the rain will have fallen on the farms whether the farmers wanted it to or not, or used it or not.

In one study, published in the International Journal of Life Cycle Assessment in 2011, researchers including Ridoutt used the ISO approach to compare the water footprints of six unique beef production systems in New South Wales. These varied in several key ways, including: the age and size of cattle sent to market; the geography – for example, coastal or inland farms; and whether the cattle were raised on pastures or in feedlots. The resulting water footprints ranged from 3.3L to 221L of H_2O-equivalent per kilogram of "live-weight cattle at the farm gate".

This shows that "you can't make generalisations, because beef is produced in so many different ways, using so many different production systems, in so many different contexts," Ridoutt says. "It just doesn't make sense to make broad-brush generalisations about all beef products."

Ridoutt adds that for a life-cycle assessment approach to be comprehensive, it can't look at the water footprint alone.

"Life-cycle assessment, the scientific discipline, is about trying to look at environmental impacts in a holistic way, to avoid just pushing the problem upstream or downstream in the supply chain," he says.

For example, treating and recycling water might increase energy use, or a water- and energy-intensive farm might be producing more food on a smaller parcel of land, which is important on our increasingly crowded planet. "Arable land is itself a scarce resource," he says.

The answer lies in accurate measurements and successful compromise.

"If we're going to give anybody any sort of useful information to take pressure off water resources, we need to be a bit more sophisticated than just making simplistic statements about broad product categories, like livestock." – *Gemma Black*

A secure water supply

When their dams began to dry up, the Hannemanns knew they had to make drastic changes. The result is a super-efficient water catchment system where a single dam has the potential to replace 40.

WHEN THE DAMS supplying Andrea and Mark Hannemann's 100-year-old mixed crop and sheep farm in South Australia began to dry up, they had to resort to carting water in a truck from Cleve – a town 14 km away – at an annual freight cost of more than $10,000 to provide around $1,500 worth of water. "It was a really unsustainable practice," says Andrea, who with her husband Mark is the fourth generation to farm Mount Rough, located on South Australia's Eyre Peninsula.

"We were confident in our future in agriculture, but not in the future of our water," she says.

Throughout Mount Rough's history, with no mains water supply to fall back on, generations of farmers have always managed and regulated their own water supplies, capturing the average annual 400 mm of rainfall in 40 dams across the 2100-hectare property. However, as the Hannemanns evolved their farming practices to become more efficient and sustainable – moving to less intensive no-till cropping, resulting in healthier soil that absorbed more rainfall – there was an unexpected corollary. "We've improved the carbon content in our soil, which absorbs more water – so we're growing better crops on less water," Andrea explains. "But that water is now not running into the dams. That's where we ran into our water problems."

As the 21st-century custodians of Mount Rough, the Hannemanns were aware of the vulnerabilities their property faced in a changing climate. Not only had they been using best-practice no-till farming for more than a decade, but they also signed up to the federal government- and industry-funded Climate Champions program, which encourages and facilitates communication between farmers and researchers about managing climate change risks on their properties. The program involved the Hannemanns travelling around Australia with 36 other Australian farmers, learning how to manage sustainability and climate change risks on their farms.

During their travels, the Hannemanns noticed "bits and pieces" of new approaches to water harvesting, before coming up with their own system, implemented in 2009.

"Mark and I thought, we're not going to change the way we farm, so we have to change the way we catch water," Andrea says.

The new system is relatively simple – an 80m by 40m rectangular plastic catchment area, located at the highest point of the property (380 m above sea level), leading down into a 30 m^2, 3 m-deep plastic-lined dam with a plastic cover to prevent seepage and evaporation.

"It's just like an underground water tank really," Andrea explains. "We're just doing it on a big scale on our property."

Using the new system, the Hannemanns can collect up to 1.6 million litres of water, based on an average rainfall every year – more than their annual requirements – with almost no losses through seepage or evaporation. That's compared to up to 2m of annual evaporation in the 40 existing similarly sized dams that have serviced the property for a century. Further efficiencies are gained by gravitating the water through a pipe system throughout the property to troughs, turned on only when stock are present in particular paddocks.

The clean, fresh water enhances the health of the Hannemanns' sheep, and also provides for their spraying operations and general garden use.

"This one dam we've now got is so efficient, it has the potential to replace the other 40," Andrea says. "It's given us a self-sustainable, renewing water supply. It's given us peace of mind. We always know that we've got a good, clean, fresh water supply." – *Gemma Black*

"We're not going to change the way we farm, so we have to change the way we catch water."

Name: Andrea and Mark Hannemann

Location: Mount Rough, South Australia

Find out more at *goodmeat.com.au/education*

Name:
Celine Steinfeld
Location: University of New South Wales, Sydney

Where the water flows

Australia is a continent with extremes of climate – droughts and flooding rains – so it's vital we carefully study and manage our water resources.

THE 15-YEAR 'millennium drought', which stretched across southeastern Australia and lasted from 1996 until 2010, was broken by La Niña wet periods from 2010 to 2012, and in 2012 was officially declared to have ended. That year also saw the final approval of the Murray–Darling Basin Plan by federal parliament, setting out how water resources should be managed across the entire Basin into the future and determining how much water needed to be recovered from the irrigation industry. All this makes it an interesting time to be researching water, says Celine Steinfeld.

"The river system is primed with a few good years of rain, and governments in Australia have protected an increasing volume of water for the environment. It is critical that we have the knowledge to manage this water and sustain the rich biodiversity in our precious wetlands and rivers," says Steinfeld, a PhD candidate in river systems ecology at the University of New South Wales in Sydney.

Science is key to answering fundamental questions about how to manage water for the environment. Steinfeld is investigating the management of rivers that have been dammed for irrigation. She built a software tool called eWASH, which enables water managers to simulate different dam operations and examine their environmental effects.

Periods of flooding and drying are important for the environment, but there also exists the need to balance these extremes so that people can live and grow food and fibre on floodplains – which is why dams are usually created. Steinfeld is looking at how we can return the variability of water flows to rivers while still maintaining productive farming communities.

"Often, when flooding is reported on the news, you see the negative human impact, which is really important and often devastating, but another side of the story is that there's an entire ecosystem out there that's been waiting to have a drink," she says.

She believes we're heading in the right direction when it comes to managing dams to provide water to communities and ecosystems. One significant example is that as a result of the Basin plan, the Australian Government will invest about $10 billion in water purchase and irrigation infrastructure between 2007 and 2019. But there is plenty more to be done. This policy and management aspect of her research really appeals to Steinfeld.

"I think it's really important as a scientist to be involved in water policy, and science gives you a very unique way of communicating."

Loving the outdoors, Steinfeld fell naturally into environmental science while studying a bachelor of science (media and communications), at the University of New South Wales.

After focussing on wetland ecosystems in undergraduate studies, she got a new perspective on water issues while on exchange in Sweden, looking at cold-water ecology and hydropower.

She also loves to spend time in the ecosystems that she is working to protect. "In October 2010, I went kayaking through the Macquarie Marshes during the drought-breaking floods. In the baking heat of inland Australia, there was water as far as the eye could see, water birds were everywhere. I saw my first ibis chicks; they were really beautiful."

– *Fiona MacDonald and Carmel Wallis*

Steinfeld is looking at how we can return the variability of water flows to rivers while still maintaining productive farming communities.

Dry as a bone

Part A

Picture this scenario: It hasn't rained for months, it's the third year in a row with below-average rainfall, and Australia is in a constant state of drought. The ground is dry as a bone, the creeks are barely flowing, and the dams are drying up. You might expect it to be all doom and gloom on the land. But thanks to insights gained through new research, and using innovative farming practices, Australia's cattle and sheep farmers are successfully tackling this challenge head-on to more efficiently use water, now and into the future.

1. As a class, brainstorm the issues related to this scenario. Think about the different groups of people and businesses that such a situation would affect. List these on the whiteboard.

2. Get into small groups of about three or four people. Each team will represent one of the categories of people/businesses that the class identified (eg, farmers).

3. Brainstorm your group's thoughts about these issues: What is the problem for you? How are you affected by it? Is there anything you can do about it? Is there anything you could have done to prevent it? Record your ideas on a piece of paper to contribute to a class discussion.

4. Come together as a class and record the thoughts and ideas that each group came up with. Discuss your reactions to what others have suggested.

5 Move on to a more general discussion about food production in Australia. What sorts of foods do we produce here? What sorts of resources do we need a constant supply of to keep producing these foods?

Part B

'Meat & Livestock Australia' is a commitment by cattle and sheep producers to become more sustainable through industry initiatives. Take a look at a few of these initiatives below, aimed at saving water. Decide, as a class, which you think will have the biggest impact in terms of water efficiency. If there was only enough funding to support one of these initiatives, which do you think it should be? Give some reasons for your choice.


iSTOCK

1. REUSING WATER IN ABATTOIRS
Abattoirs use large amounts of water to ensure high food-safety standards. While the industry is working on considerably improving water recycling, extensive recycling is limited by stringent food safety regulations. Dry cleaning (water-free cleaning) and alternative sterilisation methods are currently being trialed to reduce water consumption.

2. ENVIRONMENTAL PERFORMANCE REVIEW FOR PROCESSING PLANTS
The environmental performance of the processing industry is being independently measured, to identify areas for improvement. At least 15 medium to large abattoirs are being included in the audit.

3. CLIMATE CHAMPIONS
Climate Champions are farmers who have been recruited to help improve communication between scientists and farmers about climate change. Climate Champions trial early research products and practices, and help other farmers in their region learn how to deal with increasing climate variability.

4. WATER FOOTPRINTING
To gain a better understanding of the environmental impact (footprint) of Australian beef and lamb production in terms of water use, the CSIRO is conducting 'water footprinting' research. The aim is to help businesses measure their water footprint and identify where changes can be made for improvement.

5. USING RECYCLED WATER FOR SUSTAINABLE FOOD PRODUCTION
This project is investigating water-recycling opportunities in a wide range of food producing industries. The focus is on addressing current industry challenges (including regulatory/policy pressures) and developing new strategies to increase consumer acceptance of water recycling.

Find out more about these and other industry initiatives at *goodmeat.com.au/education*


123RF

Teacher's information

TEACHER'S RESOURCE

The aim of the Explore section is for students to investigate some of the ideas around water usage and ponder their possible impacts on humans and the cattle and sheep industry. It is intended that students make their own discoveries as they work around the stations in the room. The table below lists the equipment and preparation required.

Station no.	Station activity	Materials list
1	Water usage challenge	Barbie or other doll with long hair, detergent, 1 mL pipette, beakers and measuring cylinders
2	The water cycle in a beaker	Watch glass, Bunsen burner, tripod, gauze mat, matches, ice
3	What is your water footprint?	Table of calculations – provided
4	Water harvesting	1 plastic bottle for each pair of students, scissors, string, sticky tape, mini-watering can (or equivalent, such as a spray bottle) and something to measure 200mL of water
5	Life-cycle analysis brainstorm	None needed

Station 1

[Task] Water usage challenge

1. Wet the doll's hair and 'wash' the doll's hair in 1 mL of detergent.
2. When the detergent is thoroughly mixed throughout the hair, rinse the detergent out of the doll's hair until there is none left. Do not throw any of the rinsing water out. Use a measuring cylinder to measure the volume of water you used to rinse the doll's hair.
3. Enter this volume of water as rinse #1 in the table below.
4. Wash the doll's hair again in 1 mL of detergent in exactly the same way as you did in step 1 above. Then rinse it all out, but this time, reduce the amount of water you use. Record the volume of water used for this second rinse as rinse #2 in the table below.
5. Repeat the washing and rinsing again in a way that further reduces the amount of water required to remove all the detergent. Record the volume of water used at rinse #3.

Rinse number	Volume of water needed to remove all the detergent
1	
2	
3	

6. What was your overall saving of water from rinse number 1 to rinse number 3?

___

7. List the methods you used to reduce the amount of water needed to rinse the detergent from the doll's hair.

___

___

___

___

___

Station 2

[Task] The water cycle in a beaker

1. Set up the Bunsen burner, tripod and gauze mat for heating.
2. Fill the beaker one-third full of water.
3. Place the beaker on the tripod over the Bunsen burner.
4. Place the watch glass over the top of the beaker.
5. Cover the watch glass with ice.
6. Light the Bunsen burner and heat the water.
7. Observe what happens inside the beaker as the water heats up.
8. You should see water vapour swirling around the beaker like clouds. What causes the clouds to appear?

___

9. What forms on the underside of the watch glass?

____

10. Can you apply the knowledge you have gained from this station to explain the water cycle in nature?

____

11. Was this a good simulation of the water cycle? Why or why not?

____

____

____

Station 3

[Task] What is your water footprint?

1. Work out an estimate of your household water consumption in a day by using the calculations in the table below.

Water activity	Water calculation (L)	Total water usage (L)
Shower Shower head uses 20L per minute	Estimate how many minutes your shower takes: __________ Number of minutes in the shower x 20 L ______minutes x 20 = _______L	
Toilet flush Single flush: 12L per flush Dual half flush: 3L per flush	Estimate how many times you flush the toilet a day: __________ Number of flushes x 12 L for full flush or 3 L for half flush. ______ x 12 or 3 = ________L	
Tooth brushing Brush teeth: 5L per minute Brush teeth/shave (tap off): 1L per minute	Did you brush your teeth with the tap on or off this morning? Estimate how long you brushed for __________ minutes Number of minutes brushing x 5 L (tap on) or 1 (tap off) _______ x 5 or 1 = ________L	

2. Based on these calculations, what was your total water consumption for the day?

____

3. What other activities do you use water for that are not accounted for on this list?

4. Estimate the water consumption for your whole family for a day.

5. List some ways you may be able to reduce your household water consumption.

Station 4

[Task] Water harvesting

1. Use a single plastic bottle to design a water harvesting device that will catch as much water as possible when it rains.

2. You can use sticky tape, scissors and string to help make your device.

3. When you have finished, pour exactly 200mL of water over your device to simulate rain, and measure how much your device collects.

4. If you have the opportunity, place your device outside until it rains. If it doesn't rain, find a way, approved by your teacher, to simulate rain using a watering can. Compare the class rain harvesting devices. Which ones caught the most rain? Which features did they have that allowed them to collect more water? What improvements could you make to harvest more rain?

Station 5
[Task] Life-cycle analysis brainstorm

LCA, or life-cycle analysis, is a way of evaluating the environmental impact of a product from 'paddock to plate' – from the extraction of raw materials used to make it, right through to its final disposal or consumption. An LCA approach can be used to work out the amount of water used to produce a particular product.

Imagine you have just brought home a hamburger with 'the lot' containing a beef patty, lettuce, tomato, cheese, mustard and onion, all on a sesame-seed bun. List as many different ways that you can think of, that water would have been used to prepare the hamburger for you to eat.

Life-cycle analysis

The climate challenge

Student literacy activities

In this section, we delve into the issues associated with water use in the cattle and sheep industries and explain some of the science involved. Students read a series of articles, then follow up with discussion topics and literacy activities linked to the articles. These include:

- Brainstorm.
- Glossary.
- Comprehension and summary.
- Questioning toolkit.

ARTICLES

1. No snow, more drought, climate report warns
Australia's climate could shift dramatically over the coming years, according to a recent report by climate scientists. First published on *COSMOS Online* on 11 August 2011.

2. Measuring the water footprint of agriculture from 'paddock to plate'
Science is being used to measure the environmental impacts of water use in crop and food production, helping industry become more sustainable. First published by CSIRO on 25 January 2011.

3. Farmer initiatives
Farmer-led initiatives to reduce water use and minimise the environmental impacts of food production are leading to some impressive results. Published on the Meat & Livestock Australia website: *goodmeat.com.au/education*

No snow, more drought, climate report warns

by Oliver Chan

AUSTRALIA'S CLIMATE COULD shift dramatically with five times as many droughts in southern Australia and no snow cover, according to a new report on the consequences of severe climate change.

The report, released by Australia's national science agency the CSIRO and the University of Melbourne at the Four Degrees or More climate change conference in Melbourne, reveals the effect of a global temperature increase of four degrees on the Australian climate and environment.

"It's important to note that although some climate change is inevitable, changes of the magnitude described here are still avoidable as long as we are able to significantly reduce global greenhouse emissions," said Penny Whetton, the senior principal research scientist leading the Better Scenarios project with the CSIRO Climate Adaptation Flagship in Clayton South, Victoria.

Discovering the changes

Researchers from the CSIRO and the University of Melbourne analysed the predictions of 23 currently available global climate models using data from the Coupled Model Intercomparison Project, a project that gathers data from around the world to make predictions on changes in world climate.

A statistical tool called a 'probability distribution model' was applied to the projected changes predicted by the models to find what changes would occur at certain levels.

These probability distribution functions were scaled to match scenarios of global warming for 2030 and 2070.

Climate predictions then and now

Previous projections by the CSIRO and the Bureau of Meteorology in 2007 predicted a temperature increase of at least 1°C by 2030. "If emissions are low, we anticipate warming of between 1.5°C and 2.5°C by 2070, with a best estimate of 1.8°C," Whetton said in 2007. "Under a high-emission scenario, the best estimate is 3.4°C, with a range between 2.2 to 5.0."

The 2007 report also predicted the effect of increasing levels of greenhouse gases on rainfall, showing decreases in overall and seasonal rainfall across Australia in the decades to come.

The new study gives a more solid prediction to the effects of a global climatic shift. If global temperatures increased by 4°C or more, it would result in temperature increases between 3°C and 5°C for coastal areas and 4°C to 6°C for inland Australia, the report shows.

In addition, global climate shifts would affect precipitation patterns, with snow cover falling to zero in most regions across the Australian Alps. More notably, the annual rainfall over southern Australia, particularly in winter and spring, would decrease by up to 50%.

"Unlike anything experienced before"

The combined decrease in rainfall with rising evaporation levels of between 5% and 20% would lead to droughts occurring up to five times more often in the southern regions of Australia, the study said.

"Rapid global warming of 4°C would be unlike anything experienced before by modern human societies – presenting us with huge challenges in our ability to adapt," Whetton said.

Steven Sherwood, an atmospheric physicist and co-director of the Climate Change Research Centre at the University of New South Wales in Sydney, said that while the report, "follows a fairly standard methodology" in summarising the predictions of climate models, the estimates "must be taken with a grain of salt" because of the variability between the 23 models. "They don't all predict the same outcome, so a large range can sometimes appear – but this probably represents the best we can do at the moment," he said.

Sherwood continued, "Of course there is no guarantee that the actual outcome will even be within this range, all the models could be off. But if the models are wrong, it is just as likely to be in the direction of underestimating change rather than overestimating it. Either way, it's better to be safe than sorry and we need to reduce greenhouse emissions now while we still can before it's too late."

Activities

Activity 1 – Brainstorm

[Task] Brainstorm the topic 'drought in Australia' by creating a mind map. Remember to show how the different words or terms you include are connected. Terms you might like to include are: drought, water, snow, rainfall, evaporation, global warming, predictions, challenges, solutions.

Drought in Australia

Activity 2 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	**Definition**
Climate	
Drought	
Precipitation	
Greenhouse emissions	
Global warming	
Climate change	
Evaporation levels	
Climate adaptation	
Predictions	
Probability	
Global climate models	
Variability	

Activity 3 – Summarise

[Task] Answer the following questions relating to the article.

1. Fill out the table provided to show how global warming of 4°C or more would affect Australia, according to the report featured in the article.

Conditions	Changes predicted for Australia
Temperature	
Snow cover	
Rainfall	
Drought	

2. If the prediction of more droughts in Australia comes true, what do you suppose this might mean for food production in Australia?

3. Explain what you think Steven Sherwood meant when he said "this probably represents the best we can do at the moment". What does this comment reflect about the nature of science and technology?

4. What hope do scientists quoted in the article offer readers, about what can be done about the climate challenges we face?

Activity 4 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *www.fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** What is drought? What are the consequences of drought? How is climate change likely to affect the availability of water in Australia? Why is water availability so important? How can we make sure we have enough water in the future?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** How will climate change affect Australia's ability to produce food? How can our food production industries make sure they continue to have enough water to operate? How can these industries be more efficient in their water use?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What would it be like to not have enough water? What if Australia did not have enough water to produce food for its people? What if every individual cut down on their use of water… would that help make sure Australia had enough water?	
Provocative questions Questions to challenge convention. **Questions** Will Australia end up in a constant state of drought? Will climate change be as bad as predicted… or worse? Do we take water for granted? Are we doing enough to protect our future supply of water? What are you prepared to do to minimise your water use?	

Measuring the water footprint of agriculture from 'paddock to plate'

A method for measuring the environmental impacts of water used in crop and food production is helping businesses develop more sustainable practices and consumers make wiser choices.

IN MANY PARTS of the world, fresh water is already a scarce and over-exploited natural resource. Agriculture is the largest consumer of freshwater globally. The way we manage and develop our agricultural industries and farming techniques has significant implications for global food security.

The CSIRO has helped develop a method for 'water footprinting' that allows businesses to measure the environmental impact of their water use, and identify where changes and savings can be made.

The method, based on a life-cycle assessment (LCA) approach, takes account of the type of water used (its source and quality) across the full life cycle of the product, as well as the local water scarcity (how much water is available) where the actual production and water use occurs.

Food producers, manufacturers and retailers can then identify where changes need to be made in the production cycle and along the supply chain to reduce their impact and improve the sustainability of our food systems.

How a water footprint is calculated

To calculate a water footprint, the source of water is split into categories such as natural rainfall over agricultural lands, and water taken from rivers, lakes and groundwater resources. Agricultural activities that capture rain, such as in farm dams, are also taken into account.

The impact of using this water is then considered in the context of local water scarcity, and expressed as an equivalent unit of water: H_2Oe ('e' stands for 'equivalent').This unit is similar to the unit of CO_2e used in carbon footprinting. Expressing water use in this way allows comparisons to be made between different products, production systems, or stages of a product's life cycle.

An example of applying the method

Work done with Mars Australia used an LCA approach to examine the water footprints of two key products, a 250 g bag of Peanut M&M's and a 575 g jar of Dolmio pasta sauce. Researchers analysed the entire production chain for these products, from agriculture, ingredient processing and food manufacturing through to the product use phase, packaging, and disposal of wastes.

The total amount of water required to produce the M&M's was 1153 L, compared to 202 L for Dolmio pasta sauce. However, when the type of water being used and the local water scarcity was taken into account, the water footprint of Dolmio sauce was more than 10 times greater than that of the M&M's (350 L vs 31 L H_2Oe). Within the life cycle of the pasta sauce, 97% of its potential to contribute to water scarcity was attributed to producing the agricultural ingredients required: mostly tomatoes.

By using the water footprinting approach, meaningful comparisons could be made between different products (pasta sauce and M&M's), and between different stages of a product's life cycle (eg, agriculture, processing). This meant that producers and food manufacturers could identify where they could best invest efforts to reduce water use and environmental impacts.

Cattle and sheep industry case studies

The LCA approach has also been used to estimate the amount of water used in the production of beef and lamb in Australia. This involves looking at water use throughout the entire supply chain, taking into account drinking water for the animals, as well as water used for growing their feed (when irrigation is used), cleaning (of animals, premises and equipment), and processing the meat.

A major research project in southern Australia has investigated the water use of three red meat suppliers. As well as studying the use of water on the three properties, scientists collected data on the weather and entered it into software packages capable of modelling detailed hydrological systems. The three suppliers used in the study were:

- An organic beef supplier in Victoria – a relatively small property on coastal land with an average annual rainfall of 940 mm. No irrigation supplies are required, so the main use of potable water is at the meat processing works.

- An export beef supplier in New South Wales – a large property running both sheep and cattle, with some crops grown as fodder. Average rainfall is 590 mm, with water supplies boosted by the availability of groundwater, a potable water network and an irrigation canal.

- A sheep-meat supplier in WA – a sheep grazing property that supplements its income by producing barley and wheat for sale. It receives an average of 460mm of rain, supplemented by a potable water network and groundwater supplies.

The results of the study showed that water used to produce red meat varies between 130L and 540L per kilogram of meat produced, depending on variables such as where the water came from, how it flowed in and out through the property, the water supply system at each property, and the year in which the data was collected.

Figure 1 shows the water flows for the Victorian farm in 2004 as a Sankey diagram. Note that most of the water moving in and out of the property is by local rain, shown on the left, and evapotranspiration (ET) shown on the right.

The results of this study demonstrate that water used in red meat production in Australia is less than 1000 L/kg. This is several orders of magnitude lower than some authors have suggested.

These results are comparable with those of some similar previous studies. In one Australian study, it was found that 209L/kg is used in the beef industry and 79L/kg for other meat products. By contrast, a U.S. study estimated that water use was 3682 L/kg, but noted that this was high due to the amount of water needed to irrigate the feed supplies.

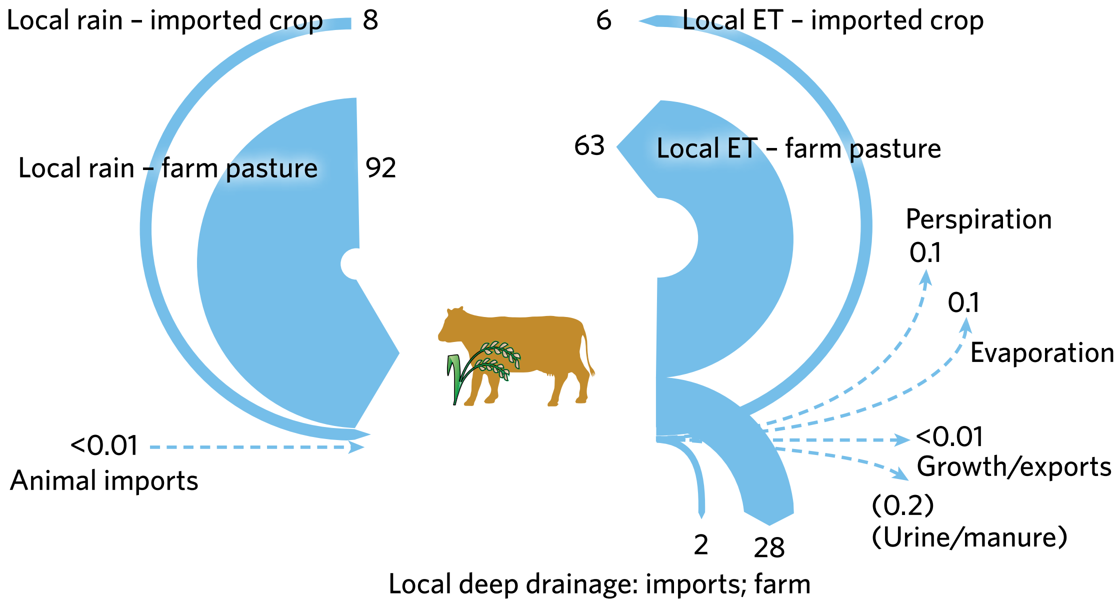


Figure 1: Annual water flows for the Victorian property in 2004 (%)

Two key factors that cause big differences in the results of different studies are the treatment of rain, and the feed production process.

The first factor, the treatment of rain, is often assumed by researchers to be a simple matter of either including or excluding the amount of rainfall on farm properties in their calculations. Properties that produce beef and lamb are open systems – rain is a kind of dispersed renewable resource, which, like oxygen, is supplied by natural processes and is there no matter how the property is run. In the southern Australian study reported here, the amount of rainfall on the three properties was included in the LCA, whereas in many other studies rainfall is not included.

The second factor is the feed production process. Most of the grain and fodder crops used in the three red meat supply chains studied in Australia are produced by 'dryland cropping', which relies on natural rainfall to water the crops. In other places, such as the U.S., collected surface water in lakes, rivers and dams is more readily available, and so irrigation of crops grown as cattle fodder is more common, meaning that much more water is used on the property.

For the full article 'Accounting for water use in Australian red meat production', visit http://link.springer.com/article/10.1007/s11367-010-0161-x/fulltext.html

Activity 1 – Brainstorm

[Task] How much do you know about water and how we use it? Take a quick quiz to find out.

1. Three quarters of the Earth is covered in water. What percentage of this is fresh? __________

2. Which holds the biggest quantity of fresh water: all the world's rivers combined, or clouds and water vapour? ____________

3. How many litres of water does Australia use each year? _________________________

4. Which is highest: agricultural or domestic water use? ___________________________

5. How many litres of water does it take to produce a pair of blue jeans? _____________

6. What is water made up of? ____

7. Does the Earth have more, less, or the same water as 1000 years ago? _____________

8. How does water reach the Earth? ____

9. Once evaporated, how many days does a water molecule spend in the air? __________

10. How many days can a human survive without any water? ________________________

(answers on page 31)

Activity 2 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	**Definition**
Environmental impacts	
Sustainable practices	
Food security	
Water footprinting	
Carbon footprinting	
Life-cycle assessment	
Water scarcity	
Production cycle	
Supply chain	

Term	**Definition**
Hydrological	
Potable	
Groundwater	
Irrigation	
Variables	
Evapotranspiration	
Fodder	
Renewable resource	

Activity 3 – Summarise

[Task] Answer the following questions relating to the article.

1. What is water footprinting?

2. Why would businesses want to measure their water footprint?

3. What do the letters LCA stand for?

4. Identify two things that the LCA approach to water footprinting takes into account, when calculating the amount of water used to produce a product.

5. In the work done by Mars Australia, why was the LCA water footprint of Dolmio sauce bigger than that of M&M's, even though producing the pasta sauce used less water?

6. For the southern Australia water footprinting study:

a) List all the sources of water used on the properties.

b) Suggest the main ways this water would be used on the properties.

c) Suggest why the Victorian property does not need irrigation, but the NSW property does.

7. Why do the results of studies estimating the amount of water used to produce red meat vary so much?

8. According to Figure 1, how much water in total is lost from the property by evapotranspiration (ET)?

9. How do you think knowing their water footprint can help farmers run their farm in a more environmentally sustainable way?

Activity 4 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA. *www.fno.org/nov97/toolkit.html*

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** What is water footprinting? Why is it done? Is water footprinting important?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What does it mean to take an LCA approach to water footprinting? What are the advantages of taking an LCA approach? Does it make sense to calculate water use this way?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What if scientists can't agree on what makes the level of water use by an industry, or a product, acceptable or unacceptable, will it make a difference to the amount of water that is saved? What if we don't know which method of water footprinting was used to calculate the LCA, is it still worthwhile comparing results?	
Provocative questions Questions to challenge convention. **Questions** Does it matter how much water an industry uses? Does it matter how accurate water footprint calculations are? Why should consumers care about the amount of water used to produce certain products?	

Brainstorm answers

1. About 2.5% (most of which is frozen).
2. Clouds and water vapour.
3. About 19,000 billion litres (19,000 gigalitres).
4. Agricultural.
5. Almost 11,000L (most of this is used to irrigate and fertilise cotton crops).
6. Hydrogen and oxygen (H_2O).
7. The same – it gets continually recycled (in the water cycle).
8. Through rain, hail and snow.
9. About 10 days.
10. Usually less than seven.

Farmer initiatives

Case study: Radford Meats

WE ARE A SECOND-GENERATION family-owned Gippsland meat processor, with 65 years of history in Victoria. We are the largest processor of Meat Standards Australia (MSA) graded beef in Victoria, and one of only six in Australia certified to process certified organic livestock for domestic consumption.

We are driven by a commitment to quality and industry excellence, the need to adapt to sustainability challenges and capture strategic growth opportunities. Through the implementation of our environmental improvement plan in late 2005 to December 2010, we have achieved significant improvements in the following areas:

- Total water consumption per tonne of production has reduced by 52% and is about one third of the industry average.
- Electricity consumption per tonne is down by 4% and gas consumption by 22%.
- Motor fuel consumption per tonne has reduced 20%.

Over this five-year period, production has also expanded, with annual certified organic production increasing 195%

Activity 1 – Brainstorm

[Task] Brainstorm how you could reduce your own environmental impact (think of it as your personal environmental improvement plan). This could include making changes to the things you do (or don't do) at home and/or school, or other parts of your lifestyle. Fill out the table below to record your thoughts – try to think of three things you could do in each area.

REDUCING MY ENVIRONMENTAL IMPACT

Area	Changes I could make to be more sustainable
Water use	1 2 3
Electricity use	1 2 3
Fuel use	1 2 3
Other	1 2 3

Activity 2 – Glossary

[Task] Define some of the scientific terms used in the article, using the table provided.

Term	**Definition**
Certified organic livestock	
Domestic consumption	
Environmental improvement plan	

Activity 3 – Summarise

[Task] Answer the following questions relating to the article.

1. Why do you think Radford Meats is trying to improve its environmental performance?

2. If you could ask the business owners a question, what would it be?

Activity 4 – Questioning Toolkit

[Task] Write your ideas and opinions relating to each of the different types of questions.

Inspired by Jamie McKenzie's Questioning Toolkit. Further reading on questioning toolkits: McKenzie, Jamie (2000) Beyond Technology, FNO Press, Bellingham, Washington, USA.
www.fno.org/nov97/toolkit.html

Type of question	Your ideas and opinions
Essential questions These are the most important and central questions. They probe the deepest issues that confront us and can be difficult to answer. **Questions** What does it mean to be 'environmentally conscious'? Why are the cattle and sheep industries trying to reduce their environmental impact?	
Subsidiary questions These questions help us to manage our information by finding the most relevant details. **Questions** What sorts of things can cattle and sheep farmers do to reduce their environmental impact? Are farmer initiatives important to help ensure that food production in Australia is sustainable?	

Type of question	Your ideas and opinions
Hypothetical questions Questions designed to explore the possibilities, the 'what ifs?' They are useful when we want to test our hunches. **Questions** What if industry does nothing to reduce its environmental impact? Will the cattle and sheep industries be sustainable if they do not reduce their use of water and other resources?	
Provocative questions Questions to challenge convention. **Questions** Do we need to be 'environmentally conscious'? Can we afford to carry on in a 'business as usual' way? If you owned a business, would you have an environmental improvement plan?	

Activity 5 – Bringing it all together

1. Create a mind map, or some other type of graphic, to show the relationship between the three articles.
2. List five big issues that you have learnt about from the articles.
3. List five questions that you now have, after reading the articles.

About the Refraction science matrix

What is the Refraction Science Matrix?
A learning matrix such as the Refraction Science Matrix is a flexible classroom tool designed to meet the needs of a variety of different learning styles across different levels of capabilities. Students learn in may different ways; some are suited to hands-on activities, others are strong visual learners, some enjoy intellectually challenging, independent hands-off activities, while others need more guidance. The matrix provides a smorgasbord of science learning activities from which teachers and/or students can choose.

TEACHER'S ★★★★★ RESOURCE

Can I use the matrix for one or two lessons, or for a whole unit of study?
Either! The matrix is designed to be time flexible as well as educationally flexible. A time frame for each activity is suggested on the matrix. Choose to complete one activity, or as many as you like.

Is there room for student negotiation?
Yes! Students can be given a copy of the matrix and choose their own activities, or design their own activities in consultation with their classroom teacher.

Can I use the matrix for a class assessment?
Yes! You can set up a point system - perhaps one lesson equals one point. Students can be given a number of points to complete. If they choose less demanding activities, they will have to complete more of them.

What do the column headings mean?

1. Read and revise
Designed to enhance student comprehension of information.
2. Read and relate
Gives the student the opportunity to apply or transfer their learning into a unique format.
3. Read and review
Requires the more challenging tasks of analysing and/or assessing information to create and express new ideas and opinions.

What do the row headings mean?

Row heading	Description of activity
Scientific procedure	Hands-on activities that follow scientific method. Includes experiments and surveys. Great for kinaesthetic and logical learners, as well as budding scientists.
Science philosophy	Thinking about science and its role in society. Includes discussion of ethical issues, debates and hypothetical situations. An important part of science in the 21st century.
Being creative with science	For all those imaginative students with a creative flair. Great for visual and musical learners and those who like to be innovative with the written word.
Science time travel	Here we consider scientific and technological development as a linear process by looking back in time or travelling creatively into the future.
'Me' the scientist	Personalising the science experience in order to engage students more deeply.
Communicating with graphics	Using images to communicate complex science ideas.
ICT	Exploring the topic using computers and the Internet.

	1. Read and revise	2. Read and relate	3. Read and review
Scientific procedure	Water is lost from the leaves of plants through a process known as transpiration. Conduct two quick investigations to examine transpiration. See Linked Activity 1.	Contaminated water on farms can be treated to make it fit for consumption. Conduct Linked Activity 2 to model water treatment.	Valuable water can be lost from farming properties through evaporation, such as from dams. Conduct an experiment to test an evaporation reducing device, or an evaporation reducing process, that you have designed that could be applied to a model dam (such as water in a petri dish). Don't forget to control all your variables other than the one you are testing. Write up your findings as a full scientific report.
Science philosophy	Do you think it is environmentally irresponsible for consumers to create high demand for food products that have a huge water footprint? Why or why not?	Should humans in developed countries value clean water more than they do on a day-to-day basis? Why or why not? Give reasons for your response.	Explore the ethics of water use in food production. Is it ethical to use potable water for agriculture? When is it okay to use recycled water (eg, in abattoirs; to wash animals; for drinking water)? Do some research and prepare a report that includes your recommendations about what should/should not be allowed.
Being creative with science	Design a poster, mural or pamphlet that helps make people aware of some of the initiatives Australian cattle and sheep farmers have come up with to improve their environmental performance.	Write a magazine article about what life is like for Australian cattle and sheep farmers. What sorts of pressures are they under? What do they love about what they do?	You have been invited onto a TV show for young inventors to demonstrate a new water saving or water recycling invention for the cattle and sheep industry that you have designed. Draw or build a prototype of your idea and provide a full description of how it works.
Science time travel	Use what you have read to prepare a report that forecasts the future of cattle and sheep farming in Australia. What might farming involve in 10 or 20 years' time? How might it be harder or easier? How might the way water is used be different?	Imagine you are a water molecule going through the water cycle. Write a story that tells of all the places in the world you go, the changes of state you go through, and how long you spend in each state of matter.	Imagine a future where clean drinking water is the most expensive commodity on the planet – more expensive than precious metals or jewels. What will be some of the consequences and challenges in this new world? What do the high costs of water mean for farmers and the public that consume their products?
'Me' the scientist	Make a trip to your local river, pond or beach to investigate human impacts in terms of littering, pollution, etc. If you find rubbish there, collect it in a plastic bag and put it in the bin (where it belongs!). Remember to wear gloves and always be careful near water.	Is water a renewable or non-renewable resource? Create a classroom activity for your peers, in which they need to identify which sources of water are renewable and which are non-renewable.	Imagine that you are a water scientist who has just been appointed as the new federal Minister for Water. You know there is a crisis looming in the country. What is your plan of action, particularly for the livestock industry? Write a report for the Prime Minister with your recommendations on what the government should do to help livestock farmers avoid a major crisis. You might want to consult previous government actions during major droughts to help you.
Communicating with graphics	Water in feedlots is used for stock drinking purposes, dust suppression, feed processing, cattle washdown, effluent management, general cleaning, and staff and office amenities. Represent this information visually.	Create a flow chart showing the uses of water from the paddock to the plate. Start with water used to farm the sheep, transport and process the meat, prepare the meat for the butcher or supermarket fridge, to buying and cooking the meat at home before eating.	Create a visual chart to show how water is used at school or home. Now come up with an environmental improvement plan (like the one mentioned by the farmer from Radford meats), aimed at reducing water use and improving sustainability.
ICT	Design a quick multiple-choice quiz that can be completed on a computer, which tests readers on some of the information in one or more of the three articles.	Water-saving initiatives in the cattle and sheep industry include reusing water in cattle washing, covering dams to reduce evaporation, using neighbouring coal seam gas development water, and reusing effluent water for dust suppression. Other initiatives can be found at goodmeat.com.au/education. Create a Powerpoint or Prezi presentation or video to highlight at least five of these so the general public are aware of what is being done by industry to manage drought related issues.	Do some research and create a web page or blog about water and Australia's cattle and sheep industries. Make sure you outline the main issues and how these are being addressed. Describe the science behind the issues.

Activity 1

TRANSPIRATION

BACKGROUND INFORMATION

Plants take up water from the soil and transport some of it to the cells where it is needed to keep the plant hydrated. Water that is not used by the plant is lost from its leaves into the atmosphere through tiny holes, known as stomata, on the underside of leaves. This process is known as transpiration.

In this investigation, you will use coloured water to track the path that water takes as it moves up the plant and out through the leaves during transpiration. A bag is placed over one set of leaves to harvest the water lost by transpiration. In a second version of the experiment, leaves of a tree on the school ground can also be bagged overnight and checked for transpiration.

AIM

To investigate evidence of water loss from the leaves of a plant during transpiration.

MATERIALS

- 100 mL measuring cylinder
- 1 stalk of celery
- 2 clear plastic bags
- red food dye
- razor blade
- sticky tape
- cutting board
- plasticine

RISK ANALYSIS

Complete the following risk analysis for this investigation.

Risk	Precaution	Consequence
Sharp broken glass	Check glassware for cracks before starting, place test tubes in a test tube rack, do not leave glassware near the end of the bench, notify teacher of any broken glass immediately	
Sharp razor blade		

METHOD

1. Place the celery stalk in the 100 mL cylinder. It may be necessary to trim the end of the stalk so that its diameter is small enough to fit into the measuring cylinder.
2. Enclose the leafy part of the celery stalk completely with the clear plastic bag. Secure the bag with sticky tape. Ensure there are no gaps for air to escape, and be careful not to damage any part of the plant during handling.
3. Add water to the measuring cylinder with the celery up to the 90 mL mark on the measuring cylinder.
4. Add 10 mL of dye to the measuring cylinder with the celery so that the dye and water mixture comes up to the 100 mL mark.
5. Seal the opening of the cylinder with the plasticine so that no air can escape.
6. Stand the measuring cylinder in a well-lit position.
7. Take the second clear plastic bag outside to the nearest tree and enclose several leaves inside the plastic bag.
8. Seal the end of the plastic bag around the branch of the leaves that are inside the plastic bag with sticky tape so that it is as airtight as possible.
9. Leave both plastic bags until the next lesson.

RESULTS

1. In the space provided, make a scientific drawing of the celery to show:

a. the level of dye solution in the measuring cylinder at the beginning and end of the experiment;
b. the condition of the leaves in the celery stalk;
c. what you observed on the inside of the plastic bag.

2. Make a scientific drawing of the bagged leaves on the tree showing:

a. the condition of the leaves inside the bag;
b. what you observed on the inside of the plastic bag.

DISCUSSION

1. How did you know from this experiment that water is given off from the leaves of the celery and the leaves of the tree?

2. In the celery investigation, did the dye transpire from the leaves as well as the water? How can you tell?

3. Why was the measuring cylinder sealed with plasticine?

4. What is transpiration? Describe it in your own words.

CONCLUSION

Write a conclusion that responds to your aim and summarises your results.

Activity 2

WATER TREATMENT

BACKGROUND INFORMATION

Where does the water that farmers and their stock consume every day come from? Their drinking water mostly comes from rainfall, and the dams or rivers in their catchment area. These water supplies can be affected by human impacts such as storm water, industrial waste, fertilisers and disease-causing micro-organisms. Due to this pollution, the water must be treated to make it suitable for consumption.

There are six main processes involved in water treatment plants. These are: screening, aeration, coagulation, sedimentation, filtration and disinfection. This experiment will provide a model for these processes in the laboratory. This is only a simulation of water treatment – the water you end up with will not be safe to consume due to the use of concentrated solutions.

AIM

To model the steps involved in water treatment, to produce cleaner water.

MATERIALS

- a range of materials to make your wastewater. For example, toilet paper, tissues, tea leaves, grass, dirt, sand
- 2 large jars (250 mL) with lids
- 2 x 250mL beakers
- sieve
- alum (potassium aluminium sulfate)
- plastic pipette
- filter paper
- filter funnel
- stirring rod
- spatula
- UV lamp
- bleach

RISK ANALYSIS

Complete the following risk analysis for this investigation.

Risk	Precaution	Consequence
UV lamp		
Bleach		
Glass stirring rod – sharp broken glass		
Alum		
UV lamp		

METHOD

1. Make your 'wastewater' by mixing in some tea leaves, toilet paper, dirt, sand and grass with water in a jar. Keep half the sample of your wastewater in the second jar to use as a comparison at the end of the experiment.

2. **Screening.** Pass your wastewater through a sieve to strain out the biggest items.

3. **Aeration.** This process adds oxygen to the water and allows gases trapped in the water to escape. The oxygen will be used by 'good' bacteria in the water to break down any organic materials found in the water.

   a. Shake the jar vigorously for one minute.

   b. Pour the wastewater into a beaker, then pour it back and forth between containers approximately 15 times. This process should eliminate the bubbles in the water. Finish with the water in the jar.

4. **Coagulation.** This process will take out the large suspended particles of dirt by binding them chemically with the potassium aluminium sulfate (alum). The material formed by this process is called the floc. The floc becomes insoluble and is then easily removed from the solution.

   a. Add three spatulas full of alum to your wastewater in the jar.

   b Stir the mixture for approximately five minutes. You should see particles start to clump together to form large particles.

5. **Sedimentation.** This process is where the large particles in the wastewater, including the floc, are allowed to settle on the bottom of the jar. (In a treatment plant the large particles that are collected on the bottom settle and the water above is drained off to then go onto the next step of filtration.)

   a. You will need to allow the water to stand for approximately 20 minutes, or overnight if you can finish the investigation the following day.

   b. When the sediment has settled to the bottom of the jar, pour the water off into one of the beakers. Be careful not to disturb the settled particles at the bottom of the jar.

   c. Use the pipette to remove any water close to the sediment and place it in the beaker with the rest of the water.

6. **Filtration.** This step involves the removal of leftover sediment and other particles that may be left in the wastewater after sedimentation. Filtration may be performed several times during the process.

   a. Set up the equipment as shown in Figure 1.

   b. After the sediment has formed on the bottom of the beaker, carefully decant the liquid above it into another beaker.

   c. Slowly pour this solution through the filter apparatus.

   d. Once the solution has been through the filter once change the filter paper and pour the solution through again. In a real treatment plant, the filter is usually composed of layers of varying sized sand particles and pebbles, which filter out the water as it runs through. (You could model this by using a PET bottle that has had the bottom cut off. Invert the bottle into a large beaker. Wrap filter paper over the cap end of the bottle and secure with an elastic band. Pour in a layer of small pebbles, then coarse sand, then finally on top fine sand. Pour the wastewater though this.)

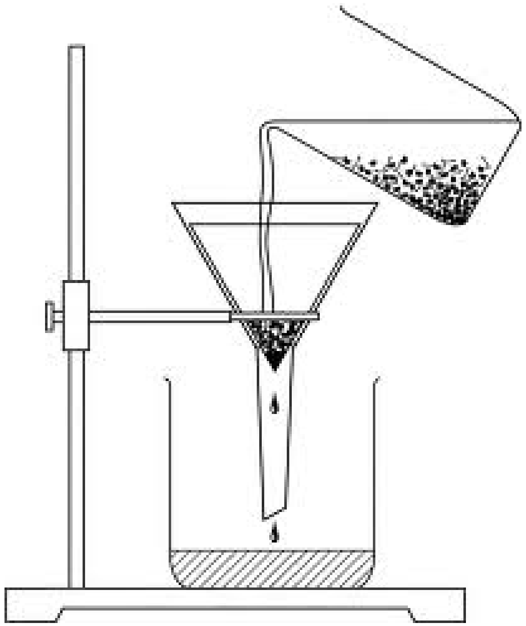


Figure 1: The set-up of filtering apparatus.

7. **Disinfection.** This is the final process that will kill any microorganisms left in the water.

   a.Place the UV lamp over the beaker of water for 10 minutes.

   b.Add ½ teaspoon of ammonia (bleach) to the wastewater.

RESULTS

Design a table to compare the original contaminated wastewater with the treated water.

DISCUSSION

1. Did you have any difficulties when conducting this investigation, if so, how did you overcome them?

2. How effective was your water treatment process? What else might you need to do to make the water fit for consumption?

3. How do you think water treatment scientists might test to see if the treated water is safe for consumption?

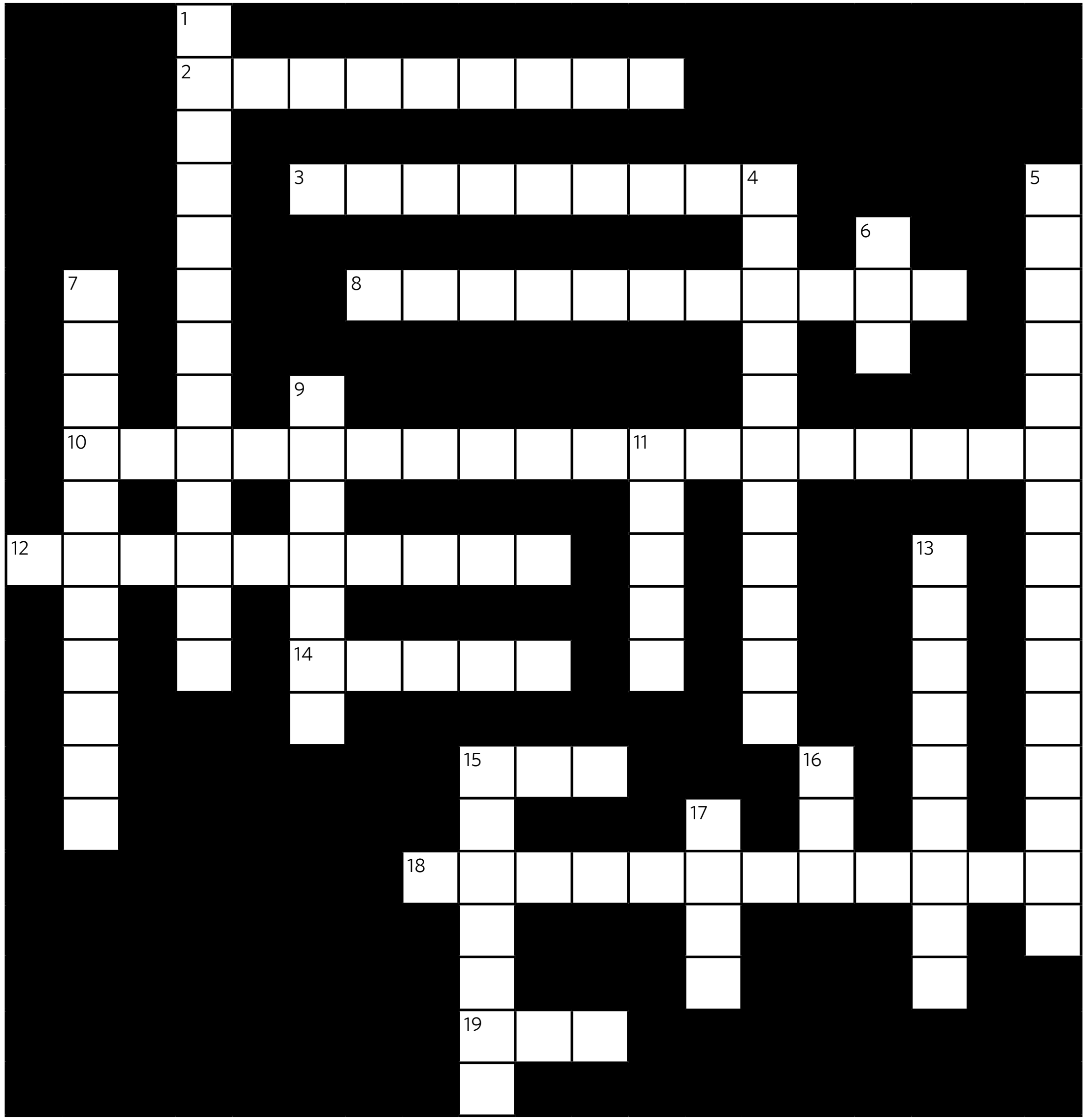
4. What do you think the benefits are of using this model to demonstrate water treatment?

5. What do you think the limitations are of using this model to demonstrate water treatment?

CONCLUSION

(Write a conclusion that responds to your aim and summarises your results.)

Crossword



Across

2. Reusing water so it doesn't go to waste.
3. Resource that doesn't run out.
8. The use of water in an environmentally conscious way.
10. ET.
12. When land is supplied with water via ditches or channels.
14. Standard unit measurement of liquid water.
15. Collection of water in an artificial reservoir.
18. A process that occurs in rain clouds.
19. The chemical symbol for water.

(answers on page 49)

Down

1. Loss of water from the leaves of a plant.
4. A stage in the water cycle.
5. When natural rainwater waters the crop.
6. Meat and livestock industry.
7. Bureau that gathers information on the weather.
9. Drinkable.
11. From paddock to __________ .
13. The amount of water used to produce goods.
15. A likely consequence of severe climate change in southern Australia.
16. Life-cycle assessment.
17. A type of precipitation.

Water use DIY quiz

1. Ask each student to call out a word or term that relates to water in the cattle and sheep industries (eg, water harvesting, drought, drinking water). Record these on the board.
2. Each student is to pick five words/terms from the board and write a definition for each.
3. Each student is to pick another five words/terms from the board, and write a paragraph about the cattle/sheep industry that uses as many of these words as possible.
4. Students create their own concept map, or some other type of diagram, to show what they have learned about water use and the production of beef and lamb in Australia. They are to use as many words/terms from the board as possible, and show the connections between them.

Class debate

1. Choose one of the following questions to use as the topic for a class debate:

   a) Farmers in Australia will always have enough water to provide for their animals and crops

   b) Everyone needs to be careful about how much water they use, not just businesses

   c) The cattle and sheep industries in Australia need to continue to become more water efficient
2. Divide the class into two groups. Group 1 will debate the affirmative and Group 2 will debate the opposing view.
3. Appoint an adjudicator, or an adjudicating team to decide which debating team presented the most compelling argument.

Group presentations

1. Place students into small groups, within which they will work to prepare and give a short presentation to the class (members should have a few minutes each to talk).
2. Allocate a topic to each group (or have them choose their own), based on the activities they have been doing in this unit (eg, water use on cattle/sheep farms; reducing water use on farms; water footprinting; water harvesting; drought and cattle/sheep farming).
3. Give each group a mark for their overall presentation, and each group member an individual mark for their part of the talk.

4. The following generic rubric can be used to assess the student presentations:

Criteria	4	3	2	1	Marks
Use of class time for research	Worked extremely well during classes assigned for working on the project	Worked well in class time assigned for working of project	Worked well some days but needed teacher assistance to stay focussed and on task the rest of the time	Needed teacher assistance to stay focussed and on task most of the time	
Depth of scientific information	Excellent, detailed scientific information about topic; used own words to convey a good understanding	Good scientific information about topic; used own words to convey understanding	Satisfactory scientific information about topic; used own words to convey a satisfactory understanding	Some scientific information included; much missing information	
Presentation	Using notes only as a guide and maintaining good eye contact	Referring to notes only occasionally and maintaining good eye contact	Reading from notes with some eye contact	Reading mostly from notes with some eye contact	
Group visual aids	Includes the effective use of well-presented aid(s) that can be easily seen and support the presentation	Included a well-presented visual aid	Includes visual aids that can be seen but are not used effectively or do not support the presentation	Included poor visual aids	
Variety of resources	Researches information from three or more sources, including both Internet and paper	Used two resources only	Located resources with guidance	Class textbook was the only resource used	
Bibliography			Select and use appropriate methods to acknowledge sources of information; a full bibliography correctly written	Bibliography present but not correctly written	
Total marks					

Personal review of unit

Personal summary	Where to now?
Make a dot-point summary, or a mind map, of all the things you learned during this unit of work. Highlight those things you found the most interesting.	Write at least five questions that have come up while you have been studying this unit of work, to which you would like to know the answers.
Something ethical	**Something political**
List as many ethical issues as you can think of that came up during this unit of work, and propose ways that some of these issues might be addressed.	If you were a leader in Australia today, what changes would you make to ensure our food production was never threatened by a lack of water?

Crossword answers

Across

2. Recycling
3. Renewable
8. Sustainable
10. Evapotranspiration
12. Irrigation
14. Litre
15. Dam
18. Condensation
19. H_2O

Down

1. Transpiration
4. Evaporation
5. Dryland cropping
6. MLI
7. Meteorology
9. Potable
11. Plate
13. Footprint
15. Drought
16. LCA
17. Snow