Australian Government
Department of Sustainability, Environment, Water, Population and Communities

The Murray-Darling Basin

Balancing the priorities of agriculture and the environment

Teacher guide and lesson plans

Lower secondary

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BIG IDEA

How do we ensure that Australia's water use is sustainable?

Dilemma

The Murray-Darling Basin river system supports the production of food, fibre and other products that are vital to Australia's economy and the existence of many rural communities is closely tied to the availability of the water that flows through this system. The health of the river and ecosystems connected to the system are under threat due to environmental changes and human demands on a highly variable system. How do we manage the conflicting needs for water so that it is fairly distributed and the health of the river system is improved and secured for future generations?

The Murray-Darling Basin

Overview

The Murray-Darling Basin is the catchment for the Murray and Darling rivers and their tributaries. The Basin also has considerable groundwater resources. Rainfall is highly variable from year to year and rainfall run-off also varies greatly across the Basin. Since the early 1900s construction of large-scale water storages on the Basin's rivers has been undertaken to enable year-round access to water even through extended dry periods. For example, since the Hume Dam was completed in 1936, the Murray River has had a continuous flow throughout its length.

The Basin is important to Australia's economy, providing about one-third of the total output for natural resource-based industries, worth billions of dollars a year. However, the extraction and diversion of water has led to a deterioration in the health of the river system. The wetlands connected to the rivers serve an important biological function in maintaining river system health. Changes to waterflows and vegetation have also greatly affected these assets of environmental significance.

The Basin is also of significant cultural value. Members of some 43 Aboriginal nations have lived in the region over many thousands of years. Local Aboriginal people have a spiritual connection to the land, water and environment. The sustainable management of the Basin is complex and involves balancing economic, political, social, cultural and environmental needs.

The Murray-Darling Basin

At a glance

Guiding investigations	Lessons	Outcomes
1 Where is the Murray- Darling Basin and what are the key relationships among the Basin, its climate and its land use?	1.1 Where in Australia is the Murray-Darling Basin?	Students identify the extent of the Murray-Darling Basin, its rivers, features and places of interest and build an appreciation of its diversity.
	1.2 How does climate influence life in the Murray- Darling Basin?	Students identify patterns between annual rainfall and settlement, and land use for food production.
	1.3 How is land use linked to levels of water consumption?	Students relate water consumption levels to the significant output of produce across the Murray-Darling Basin
2 How important is the Murray- Darling Basin as a food- producing region and what are the consequences for managing its water resources?	2.1 Why is the management of the Murray-Darling Basin's water resources such a complex issue?	Students identify the importance of the Murray-Darling Basin to Australia's food and fibre production and exports, the trend of world population growth and the implications for managing the Murray-Darling Basin's water resources. Students begin to understand the complexity of the issues surrounding water use and the health of the Murray-Darling river system.
	2.2 What is the value to our society of agriculture in the Murray-Darling Basin?	Students identify their connections to the Murray-Darling Basin and explore the socio-economic impacts of agricultural activity in the Basin for the broad community.
	2.3 What is the value of primary industry to communities within the Murray-Darling Basin?	Students relate water consumption levels to the significant output of produce across the Murray-Darling Basin. Students compare two irrigation regions, Mildura and Colleambally, to describe the importance of water to the regions and their communities by exploring one town from each region.
	2.4 Long-term investigation (growing small crops using dry-farming and irrigation-farming methods)	As an extension activity, students plan, implement and report on a small comparative crop growing experiment to understand more about water management in farming.
3 How does the Murray- Darling Basin work as a system?	3.1 What are the natural components of the Murray- Darling Basin system?	Students describe the natural components of the Murray-Darling Basin river system and explore their role and function.
	3.2 How are parts of the Murray-Darling Basin river system connected?	Students describe the interrelationships among parts of the natural system.

Guiding investigations	Lessons	Outcomes
4 What effects have humans had on the Murray-Darling Basin river system?	4.1 Altering the flow of rivers: extraction, diversion and storage	Students describe ways in which humans alter the patterns of waterflows in rivers in the Murray-Darling Basin.
	4.2 How does regulating a river affect fish populations?	Students describe the impact of developments that regulate waterflow on fish populations. They research the distribution and abundance of fish species over time. Scientific data is used to draw conclusions about how regulating waterflow affects fish populations.
	4.3 What is the effect of removing natural vegetation?	Students relate increased salinity to clearance of natural vegetation and planting with shallower rooted plants such as crops and grasses. They explore impacts of changes to riparian vegetation.
5 What is, and can be done, to address the current issues?	5.1 How do we make better use of the water we have?	Students describe ways that people have come to use water more efficiently.
	5.2 How are environmental flows impacting on the health of the Murray and Darling rivers, and wetlands of environmental and cultural significance?	Students describe local Aboriginal peoples' connections to the Murray-Darling Basin, its environmentally and culturally significant assets, and the benefits of environmental flows to river health.
	5.3 How do we balance environmental, economic and social demands on the Murray-Darling Basin?	Students describe the importance of the Murray-Darling Basin and the wide-ranging points of view in regard to its use.
6 How do we take responsibility for sustainable water use?	6.1 What can I do to ensure our water is secured for the future?	Students describe ways they can use water more efficiently. They explore the Water Efficiency Labelling and Standards (WELS), a labelling system that reflects water use in some household items. Students apply their understandings and take action in their local environment.

Australian Curriculum links

Science – Year 7		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Biological sciences • Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions **Chemical sciences** • Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques **Earth and space sciences** • Some of Earth's resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Nature and development of science** • Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world • Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations • Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management	**Questioning and predicting** • Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge **Planning and conducting** • Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed • In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions **Evaluating** • Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

<table>
<tr><th colspan="2">Geography (from Shape of the Australian Curriculum: Geography)</th></tr>
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Geographical knowledge and understanding

Year 7

Weather and water

- the hydrologic cycle describes the movement of water between the atmosphere, land and oceans
- weather can be a hazard, but the risks can be reduced through human adjustment to the conditions presented
- water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses

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Geographical inquiry and skills

Developing a geographical question

- observation can lead to questions for investigation

Planning a geographical inquiry

- some geographical features can be explained by cause and effect relationships with other places

Collecting, evaluating and managing information

- primary and secondary data must be evaluated for accuracy and bias before being analysed
- census data can be used to describe the growth, movement and characteristics of the populations of places
- information collected in a survey should be evaluated for reliability

Making sense of the information

- mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships

Communicating

- each type of communication has conventions that should usually be followed for communication to be effective
- the climate of place can be represented by a graph of average monthly temperature and precipitation

Planning and implementing actions

- finding a way of resolving a problem depends on an understanding of the causes of that problem

Reflecting on the investigation

- each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

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INVESTIGATION 1

Where is the Murray-Darling Basin and what are the key relationships among the Basin, its climate and its land use?

Introduction

The Murray-Darling Basin covers a significant area equal to about 14 per cent of the continent. It spans four states including southern Queensland, much of New South Wales, over more than half of Victoria and the south-east of South Australia. The Basin is commonly referred to as Australia's food bowl as the region produces a significant amount of the nation's food. Settlement patterns are linked to land use and the availability of resources which are influenced by climate. Climate is variable from place to place within the Basin and from time to time.

According to figures from the Australian Bureau of Statistics, over two million people were living in the Basin in 2006. At that time the majority of the Basin population lived in New South Wales (39 per cent) and Victoria (29 per cent). Ten per cent of people living in the Basin were employed in the agricultural industry. Nearly 40 per cent of all Australian farmers lived in the Basin. In 2005–06, 66 per cent (7,720 gigalitres) of Australia's agricultural water was consumed for agricultural production in the Basin.

Water and the Murray-Darling Basin – A Statistical Profile, 2000–01 to 2005–06 Australian Bureau of Statistics released August 2008

Climatic zones vary across the Basin. In the far north, in southern Queensland, sub-tropical conditions exist. The eastern uplands of the Basin generally experience cool, humid conditions. The country of the Snowy Mountains has alpine conditions. The south-east of the Basin experiences a temperate climate whereas the western plains experiences a hot, dry semi-arid and arid climate. Overall, the climate of the Murray-Darling Basin is relatively dry compared to other regions of Australia. However the Basin experiences a highly variable rainfall with periods of floods and extended dry periods. Major flooding can affect large areas of the Basin because it is made up of huge expanses of floodplains, which are naturally low-lying. Over-bank flows inundate these floodplains and can cause widespread damage to communities while, at the same time, replenishing wetlands and river systems.

The rain that falls in the Murray-Darling Basin catchment is often subject to high evaporation rates leaving a small percentage to drain into the ground or flow across the surface as runoff. The 20-year average annual rainfall in the Murray-Darling Basin from 1980 to 1999 was between 350 and 650 millimetres (Bureau of Meteorology, 2000).

Science – Year 7	
Science Understanding **Earth and space sciences** • Some of Earth’s resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Science Inquiry Skills** **Questioning and predicting** • Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate **Evaluating** • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • the hydrologic cycle describes the movement of water between the atmosphere, land and oceans • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed • census data can be used to describe the growth, movement and characteristics of the populations of places • information collected in a survey should be evaluated for reliability **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships **Communicating** • each type of communication has conventions that should usually be followed for communication to be effective • the climate of place can be represented by a graph of average monthly temperature and precipitation **Planning and implementing actions** • finding a way of resolving a problem depends on an understanding of the causes of that problem **Reflecting on the investigation** • each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

Lessons

Lesson 1.1
Where in Australia is the Murray-Darling Basin?

Outcome

Students identify the extent of the Murray-Darling Basin, its rivers, features and places of interest and build an appreciation of its diversity.

Background

The Murray-Darling Basin is the catchment for the Murray and Darling Rivers and their many tributaries. The Basin extends from north of Roma in Queensland to Goolwa in South Australia and includes three quarters of New South Wales and half of Victoria. The Basin covers one-seventh (14 per cent) of the Australian continent.

Resources and preparation

Figures, graphs, maps and tables

Map 1.1 Extent of the Murray-Darling Basin

Student worksheet/handout

Student worksheet 1.1 The Murray-Darling Basin

Student handout 1.2 Places of interest in the Murray-Darling Basin

Materials

Australian atlas

Large pieces of paper

References

Australian Government, Department of Sustainability, Environment, Water, Population and Communities, Indigenous involvement in environmental and heritage management, www.environment.gov.au/soe/2006/publications/ integrative/indigenous/lake-victoria.html

CSIRO, Water availability in the Condamine-Balone, 2008, www.clw.csiro.au/publications/waterforahealthycountry/mdbsy/pdf/condamine-snapshot.pdf

Discover Murray River, Goolwa barrages, www.murrayriver.com.au/river-towns/barrages

Discover Murray River, The Murray:

A river worth saving: The Murray-Darling Basin, www.murrayriver.com.au/about-the-murray/the-murray-a-river-worth-saving

Gallery of images, MDBA, http://images.mdba.gov.au

The Living Murray, Barmah-Millewa Forest, http://www.mdba.gov.au/programs/tlm/icon_sites/barmah_millewa

Murray-Darling Basin Authority, Gallery of images, http://images.mdba.gov.au

Murray-Darling Basin Authority, The Living Murray, http://www.mdba.gov.au/programs/tlm/icon_sites

Murray-Darling Basin Authority, More about the people and the regions of the Basin, http://www.mdba.gov.au/programs/tlm/icon_sites

NSW Government Office of Water, Menindee Lakes fact sheet, www.water.nsw.gov.au/ArticleDocuments/34/menindee_lakes_factsheet. pdf.aspx

Renmark Paringa, Visitor Information Centre, The first irrigation colony in Australia, www.visitrenmark.com/html/renmark-irrigation-history.html

River Murray Urban Users Committee, Overview of the Murray including the Murray-Darling Basin, www.murrayusers.sa.gov.au/MUUC-OldVersion/irrigation.htm

River Murray Water, Lake Victoria: The cultural significance of Lake Victoria, http://www.mdba.gov.au/services/publications/more-information?publicationid=123

Lesson outline

- Students show where they believe the Murray-Darling Basin extends on a map of Australia. Alternatively, students sketch the outline of Australia and indicate where they think the boundary of the Murray-Darling Basin extends.
- Show Map 1.1, which demonstrates the Basin boundary. How does it compare to the students' predictions? What do students observe about the size of the Basin and its coverage across states of Australia? The Murray-Darling Basin covers approximately one-seventh (14 per cent) of Australia.
- Use Map 1.1 to identify different locations. Ask students whether they have visited any of these locations or know about them. Have them describe their recollections and ideas.
- Provide Student worksheet 1.1, which is an outline map of the Basin. Students use an atlas to label the major rivers. They then locate the places of interest described in Student handout 1.2. Students could search the internet for images of the sites and match an image of the location to its description. On a large sheet of paper students, glue their map in place and link the photographs and descriptions to the appropriate locations on the map using the scale to work out the relative position.
- View a range of photographs of the Murray-Darling Basin as an extension to the mapping activity. The photographs could include natural landscapes, areas of cultural importance and human activity such as settlements, agriculture, irrigation and recreation. Places of interest can be added to their map of the Basin. Refer to gallery of images, MDBA http://images.mdba. gov.au.
- Set the task of creating a promotional brochure or poster to attract people to live, work or visit the Murray-Darling Basin. Students include a map of the Basin and describe features that would attract people to the region.

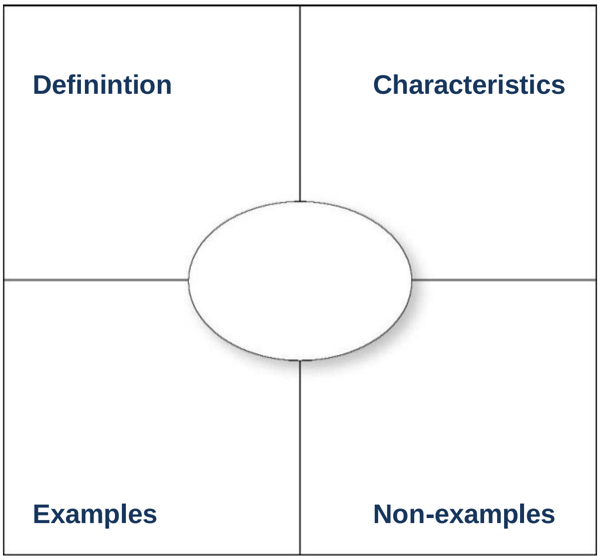
1.1 Extent of the Murray-Darling Basin

Developing Vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as 'irrigation', and on the back of the card its meaning – 'diverting water for farming'. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

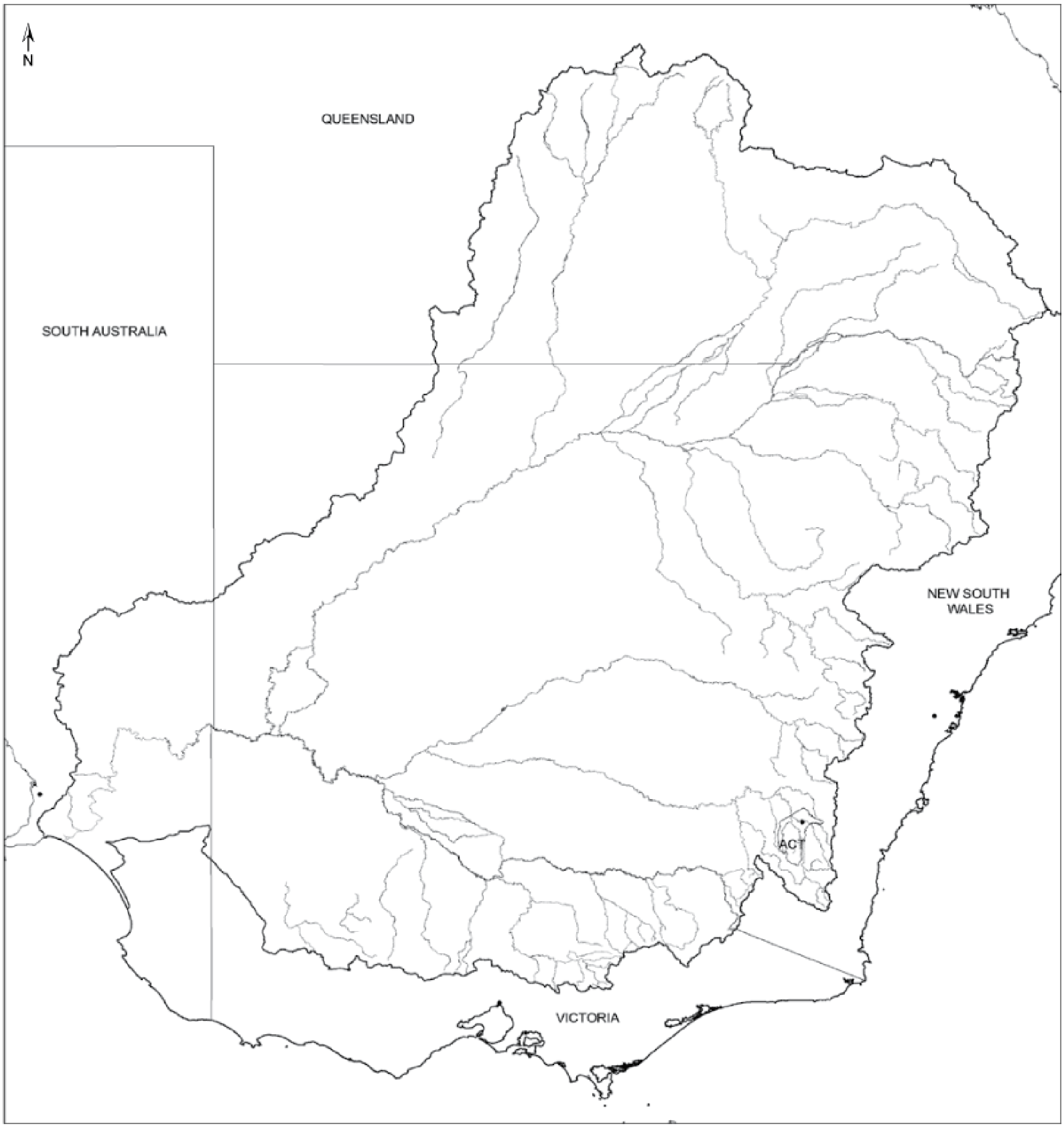
Unfamiliar terms may include underlined glossary items.



Student Worksheet 1.1

The Murray-Darling Basin

1. Use an atlas to label the major rivers in the Basin.
2. Use Student handout 1.2 and an atlas to locate and plot the places of interest.



The Murray-Darling Basin

Student handout 1.2

Places of interest in the Murray-Darling Basin

Bourke, NSW This town on the Darling River is in a region that has extensive dryland pasture used for beef and sheep grazing.	**Hume Reservoir, Victoria/NSW** Located near Albury, this is the main water storage of the Murray River system. The reservoir supplies water along the Murray.
Dubbo, NSW This town is on the Macquarie River in a region that has extensive dryland pasture used for livestock grazing.	**Wentworth, NSW** This town is located at the junction of the Darling and the Murray rivers.
Lake Victoria, NSW This lake, located in south-western New South Wales, is the only substantial, ancient lake on the River Murray. It is now an important water storage. The lake was the location where many Aboriginal people were killed in clashes with European settlers. Aspects of its spiritual and cultural significance to Barkindji people include the presence of burial sites and the landscape itself.	**Dalby, Qld** This town is in a cotton-growing region located in the north of the Murray-Darling Basin.
Barmah-Millewa Forest, Victoria/NSW This forest is the largest river redgum forest in Australia, covering 66,000 hectares of floodplain between Tocumwal, Deniliquin and Echuca. The national park is jointly managed by Indigenous traditional owners.	**Menindee Lakes system, NSW** There are four main lakes in this system: Lake Menindee, Lake Cawndilla, Lake Pamamaroo, and Lake Wetherell. The lakes were originally a series of natural depressions that filled during floods. The system now stores water. The flow of water is regulated using weirs and channels.
Shepparton, Victoria This town has a large dairy and fruit growing industry.	**Goolwa, South Australia** This town is located near the mouth of the Murray River. A barrier was built across the Murray to prevent the inflow of sea water.
Renmark, South Australia Renmark was the first irrigation colony in Australia and was established in 1887 by the Canadian-born Chaffey Brothers.	

Lesson 1.2
How does climate influence life in the Murray-Darling Basin?

Outcome

Students identify patterns between annual rainfall and settlement, and land use for food production.

Background

From the previous lesson students may realise that the Murray-Darling Basin has different land uses and that proximity to water is important for settlement and crop production. In these lessons, students use spatial data to look for patterns between rainfall and settlement, and rainfall and distribution of types of food production. By studying data students realise that the climate of the Murray-Darling Basin is highly variable and that it affects daily life.

In 2005–06 the Murray-Darling Basin produced over one-third of Australia's food supply, making it Australia's most important agricultural area. The Murray-Darling Basin generates $15 billion per annum, which equates to 39 per cent of the national income derived from agricultural production. It produces 48 per cent of the nation's wheat, 100 per cent of its rice, 95 per cent of oranges, and 54 per cent of apples. The Murray-Darling Basin supports 28 per cent of the nation's cattle, 45 per cent of its sheep, and 62 per cent of its pigs. In 2004–05, 83 per cent of water consumed in the Murray-Darling Basin was consumed by the agriculture industry.

Water and the Murray-Darling Basin – A Statistical Profile, *2000–01 to 2005–06* Australian Bureau of Statistics released August 2008, page 2

Resources and preparation

Part A

Figures, graphs, maps and tables

Graph 1.1 Rainfall variability in the Murray-Darling Basin

Map 1.2 Australian annual mean rainfall (mm) 1900 to 2005

Map 1.3 Twenty-year average annual rainfall in the Murray-Darling Basin

Part B

Figures, graphs, maps and tables

Map 1.3 Twenty-year average annual rainfall in the Murray-Darling Basin

Map 1.4 Population density in the Murray-Darling Basin

Part C

Figures, graphs, maps and tables

Map 1.3 Twenty-year average annual rainfall in the Murray-Darling Basin

Map 1.5 Production of coarse grains in the Murray-Darling Basin

Map 1.6 Grazing areas for livestock in the Murray-Darling Basin

Map 1.7 Production of cereal crops in the Murray-Darling Basin

Map 1.8 Horticultural production in the Murray-Darling Basin

Student worksheet

Student worksheet 1.3 Rainfall and Food Production.

References

Australian Bureau of Statistics, Water and the Murray-Darling Basin – A Statistical Profile, 2000–01 to 2005–06, www.abs.gov.au/ausstats/abs@.nsf/mf/4610.0.55.007

Earth Observatory, Drought cycles in Australia, http://earthobservatory.nasa.gov/Features/WorldOfChange/australia_ndvi.php

Murray-Darling Basin Authority, About the Basin, www.mdba.gov.au/water/about_basin

Murray-Darling Basin Commission, Murray-Darling Basin eResources 2005, 'Some major agricultural commodities', www2.mdbc.gov.au/subs/eResource_book/chapter3/p3.htm

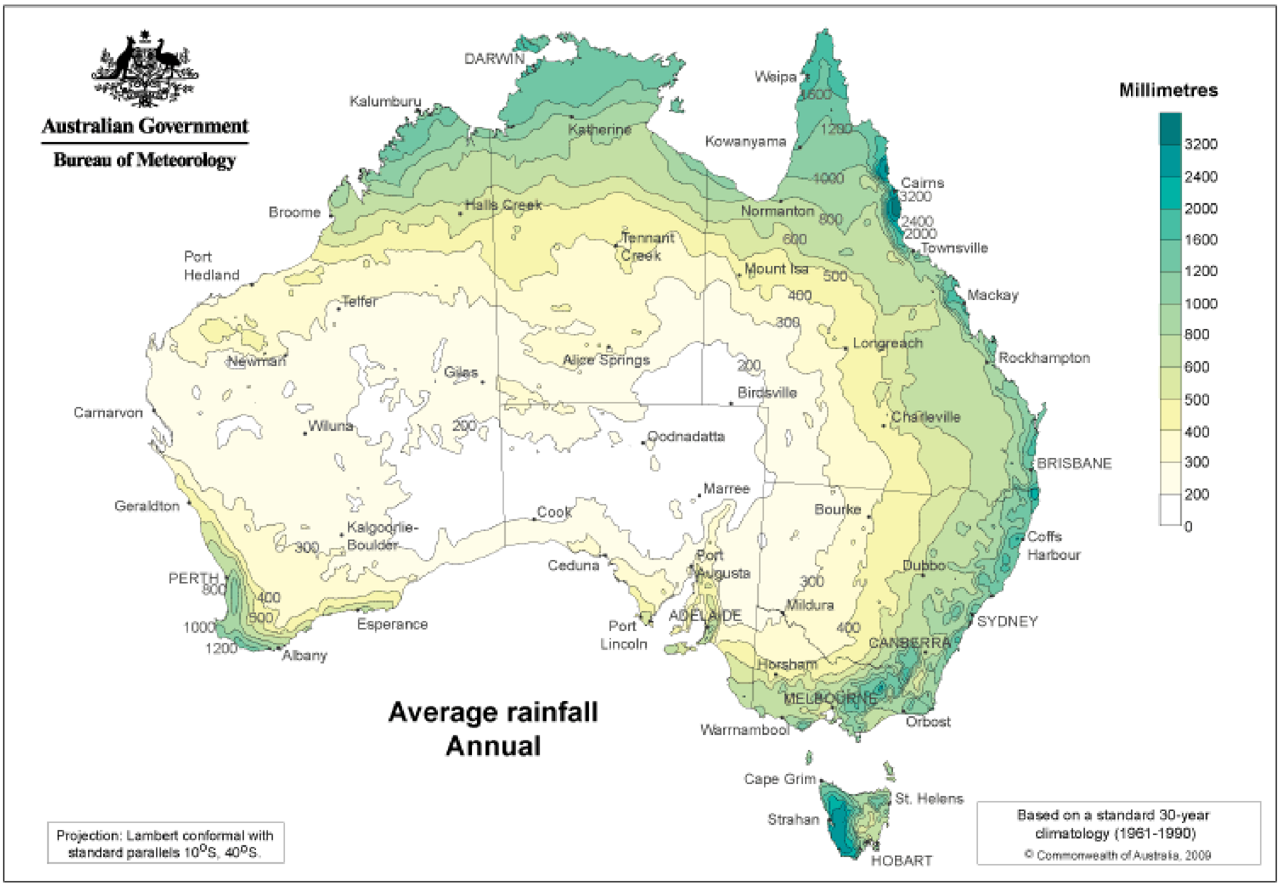
Murray-Darling Basin Commission, Surface water resources, www.mdba.gov.au/services/education-resources

National Water Commission, Australian water resources 2005, www.water.gov.au

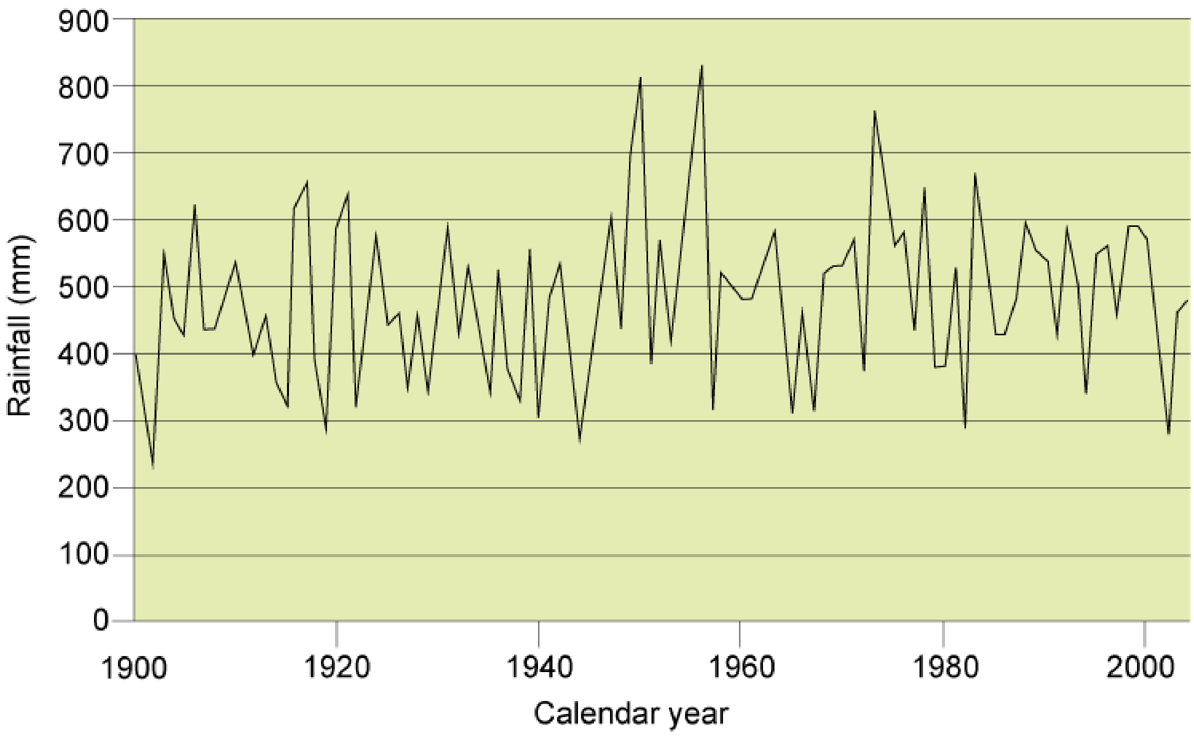
Lesson outline

Part A: Rainfall variability and temperature

- Provide students with Map 1.2, which shows the variation of rainfall across Australia. The bands of isohyets (lines drawn on a map connecting points having equal rainfall at a certain time or for a stated period) indicate average rainfall for those areas. So that students have a reference when discussing annual rainfall, start with identifying the annual rainfall for the region in which they live. Next refer students to spatial data describing average annual rainfall for the Murray-Darling Basin.
- Students can create their own annual average rainfall data map using the Bureau of Meteorology's website. View the average annual, seasonal and monthly rainfall at www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp .
- Interpret Graph 1.1. Discuss the range in millimetres of rainfall over the period 1900 to 2004. Ask students to predict the impact on riverflows over time. Compare Graph 1.1 to Map 1.3, which shows the 20-year average annual rainfall in the Murray-Darling Basin. Ask why it is important to view data over a long period, such as a century, rather than over a month or year.



Map 1.2 Australian annual mean rainfall (mm) 1900 to 2005

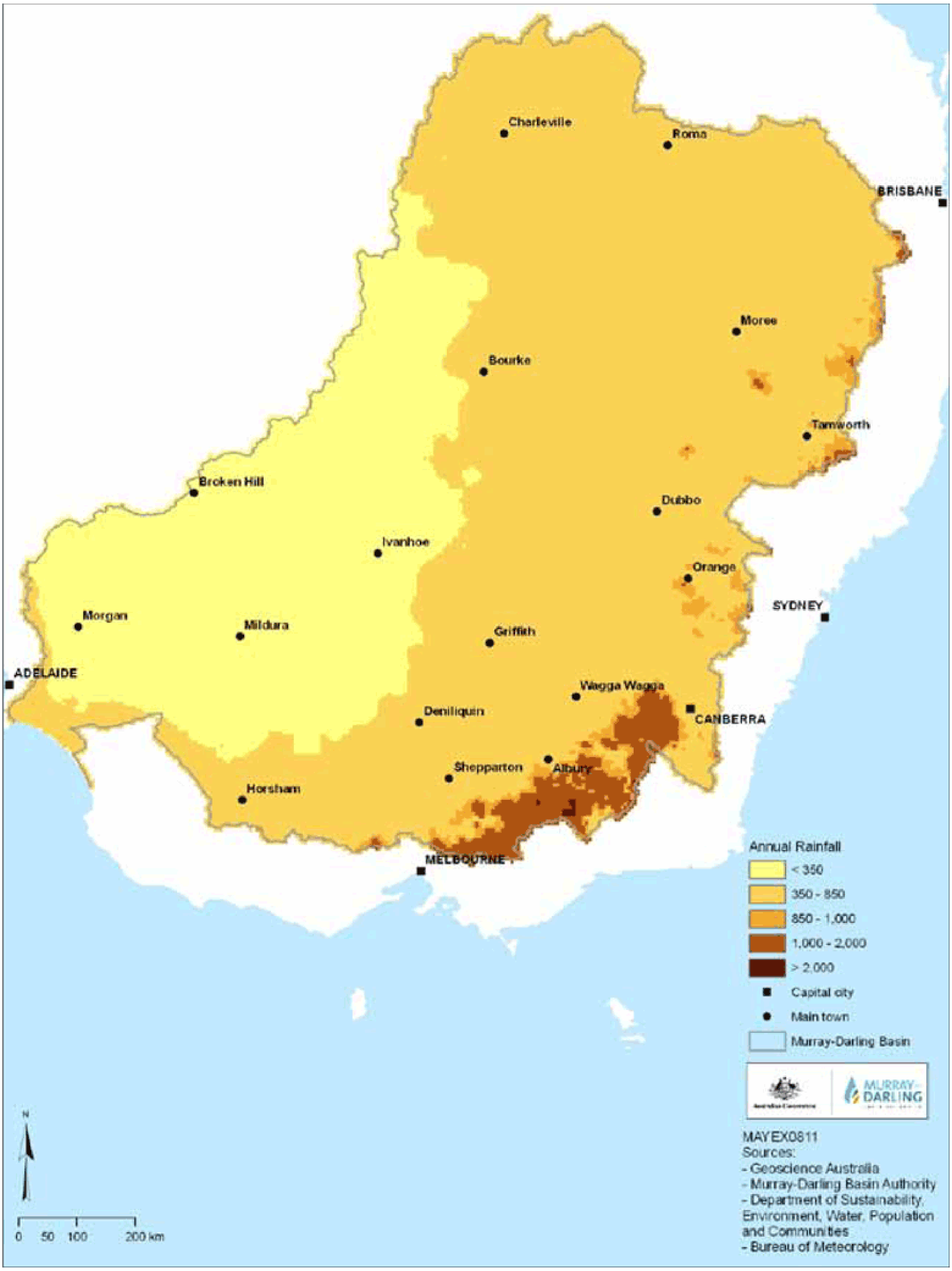


Graph 1.1 Rainfall variability in the Murray-Darling Basin

- Compare long-term climate data with current daily or monthly data. Provide students with access to the webpage, 'Daily rainfall totals for Australia' at www.bom.gov.au/jsp/awap/rain/index.jsp . View climate data over various time periods (1 day, 7 days, monthly, month-to-date, 3-monthly, 12-monthly, year-to-date and over 36 months). In particular, students can create an animated temperature loop to view changes over time. Students can also view rainfall data over time for the Murray-Darling Basin by selecting from the drop-down menu.
- Use Map 1.3 to view annual rainfall ranges in particular regions of the Basin. Encourage students to consider what this would mean for food production and people living within the region. Discuss the variability of rainfall and that heavy rains can occur in some years. Discuss the meaning of a semi-arid environment and the parts of the Basin to which this relates (average rainfall 300–600 mm). View the weather and climate data for 2010 to compare data for a record wet year at the Bureau of Meteorology's website: www.bom.gov.au/announcements/media_releases/climate/change/20110105.shtml .
- View satellite images of the Murray-Darling Basin to show vegetation changes over time. Interpret the changes in vegetation over a 10–year period by viewing the 10 images using the slideshow functionality. Link the cause of the changes to vegetation to variations in climate. Ask students to make predictions about dry or wet years based on the vegetation. They could consult other sources to check their predictions. Provide access to the Earth Observatory's website and view drought cycles in Australia at http://earthobservatory.nasa.gov/Features/WorldOfChange/australia_ndvi.php .
- Provide access to river-level data at the RiverSmart Australia website that tracks the flows of the Murray-Darling river system over time. Students can compare vegetation maps of the river prior to and after flood events at http://riversmart.net.au/Flowtracker.htm.
- Students summarise the data and write a blog article from the perspective of a community member from the Basin describing the impact of the climate on their lifestyle, including their work over time. Have students respond to each other's blogs.

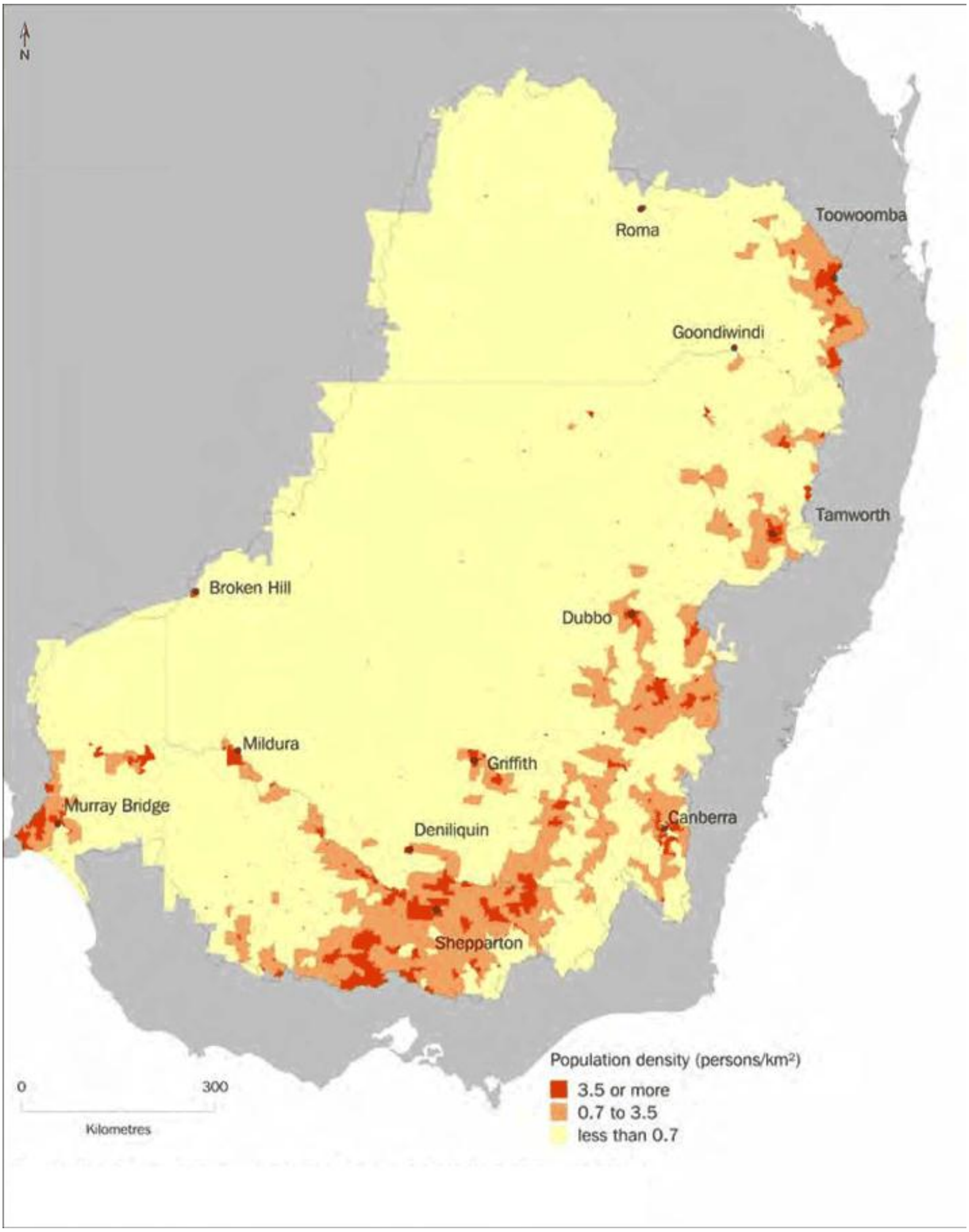
Part B: Looking for patterns in settlement and climate

- Show students Map 1.4 and discuss settlement across the region. As a comparison, the centre of Sydney has a population density of more than 4,000 people per square kilometre. Explain that approximately two million people live in the Murray-Darling Basin region.
- Compare Map 1.3 and Map 1.4. Identify any patterns between settlement and rainfall. Describe the climate of the parts of the Basin that have the highest population. What is common to many of these areas? Discuss features of arid, semi-arid and temperate climates.
- Ask: What has enabled settlement to progress in an area of variable rainfall? Relate this to the availability of water from the Darling and Murray rivers and their tributaries and the construction of large dams for water storage to overcome periods of extended dry.



Courtesy Murray-Darling Basin Authority

Map 1.3 Twenty-year average annual rainfall in the Murray-Darling Basin.

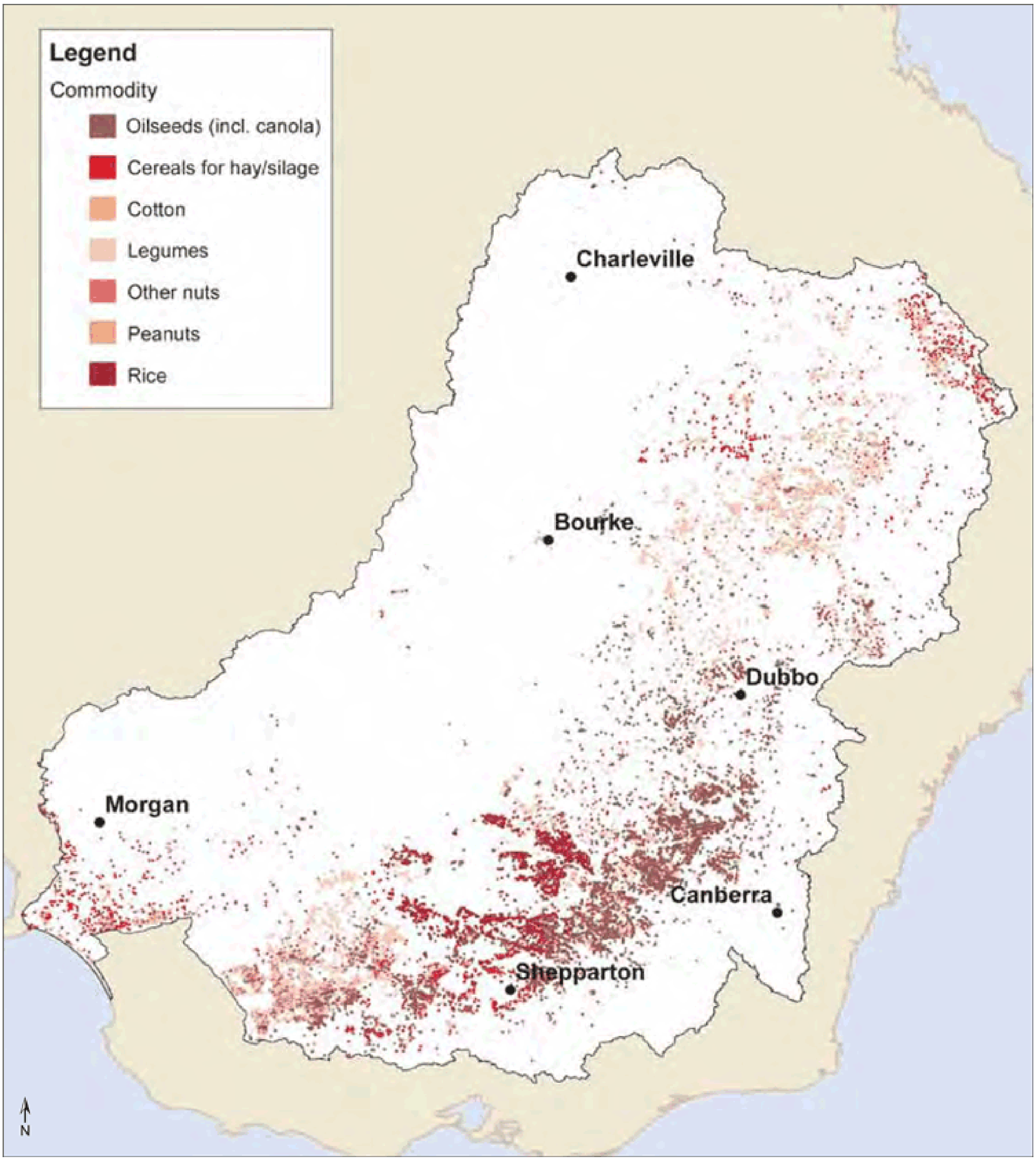


Courtesy Australian Bureau of Statistics

Map 1.4 Population density in the Murray-Darling Basin

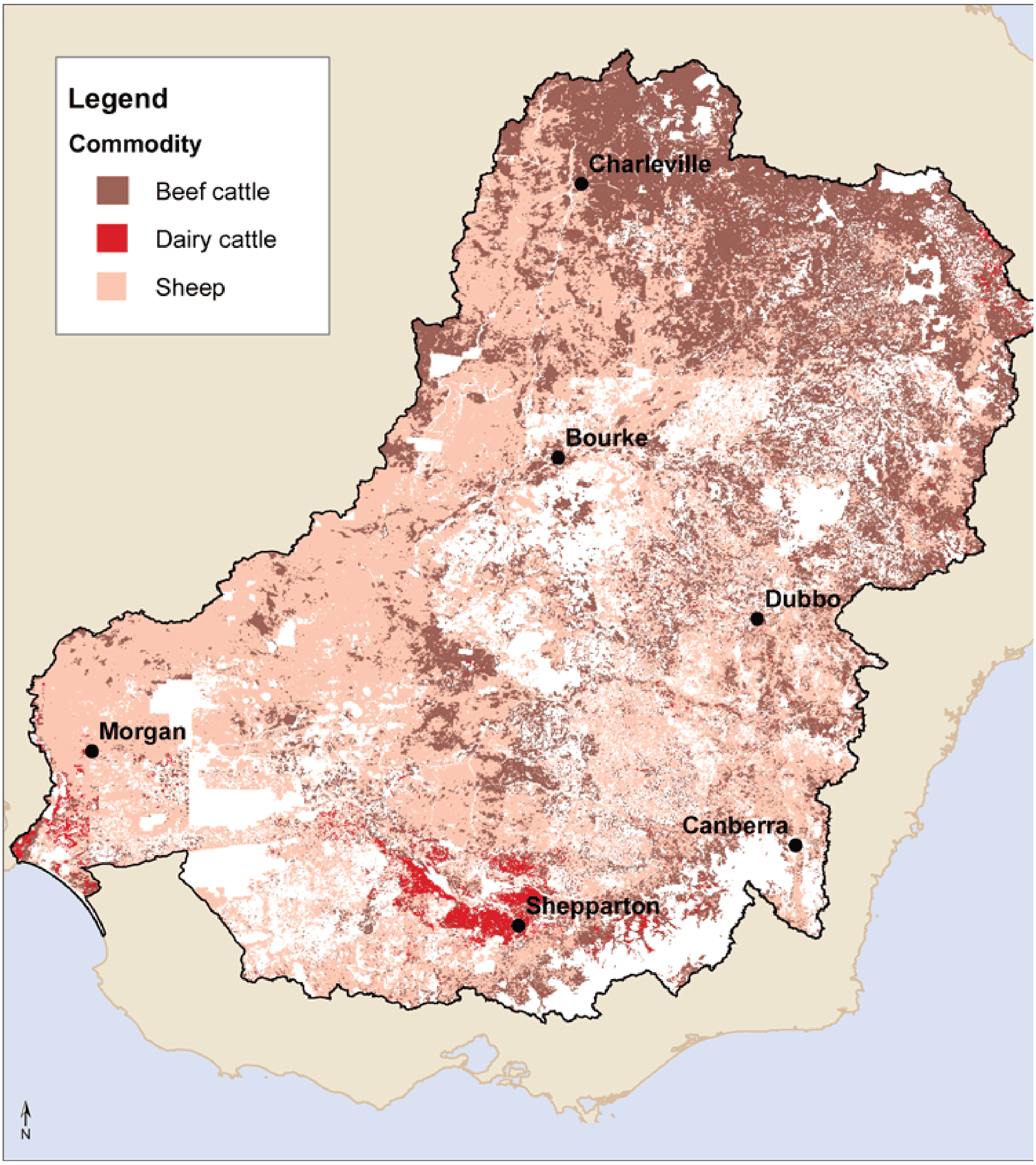
Part C: Looking for patterns in rainfall and food production

- For the activity on Student worksheet 1.3, students use Map 1.3 as the reference and compare it to Maps 1.5–1.8.
- Students look for patterns in the maps and answer the questions provided on the worksheet. Students look at a number of the relationships and then write a summary of the patterns found.



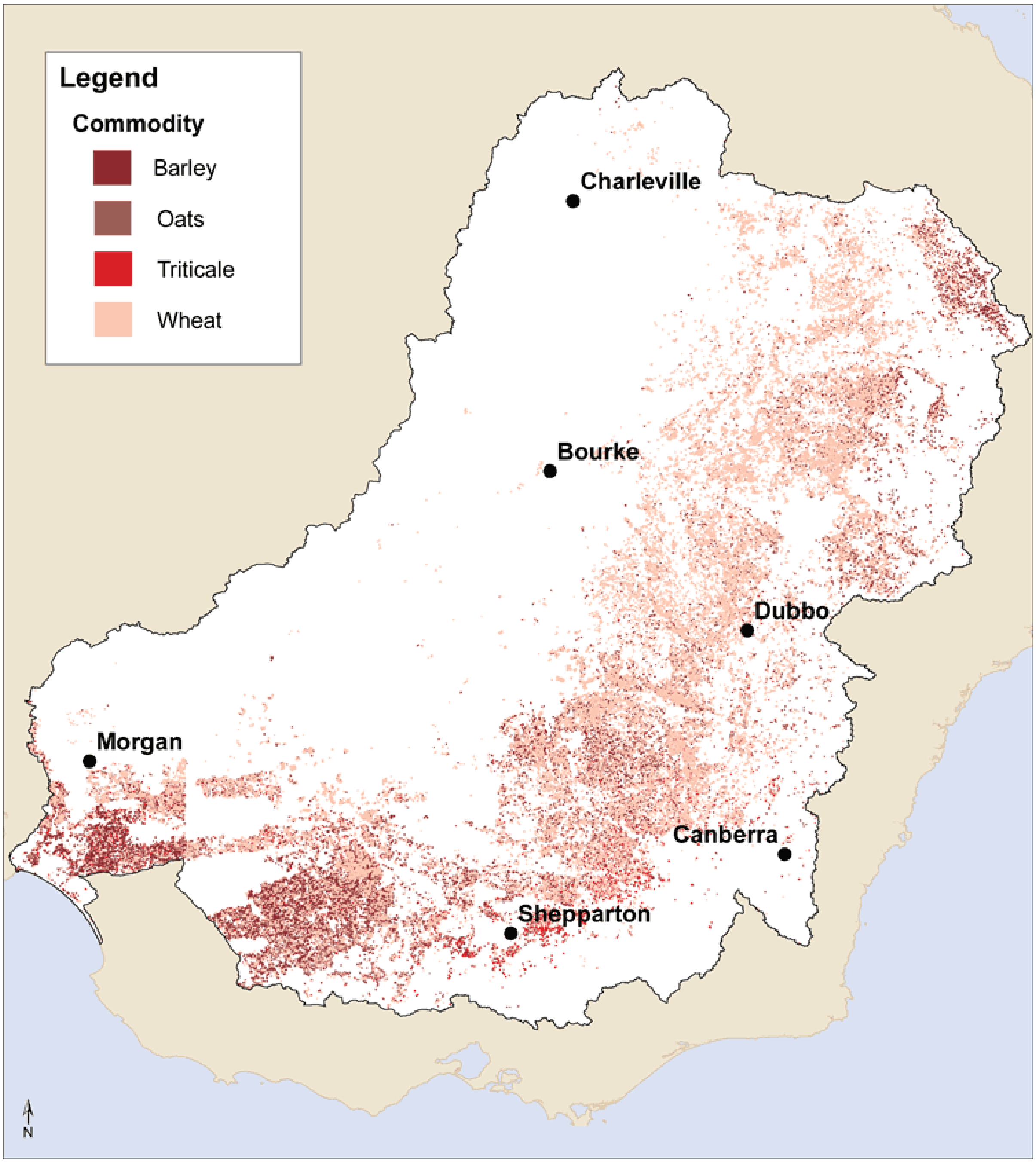
Maps courtesy Murray-Darling Basin Authority

Map 1.5 Production of coarse grains in the Murray-Darling Basin



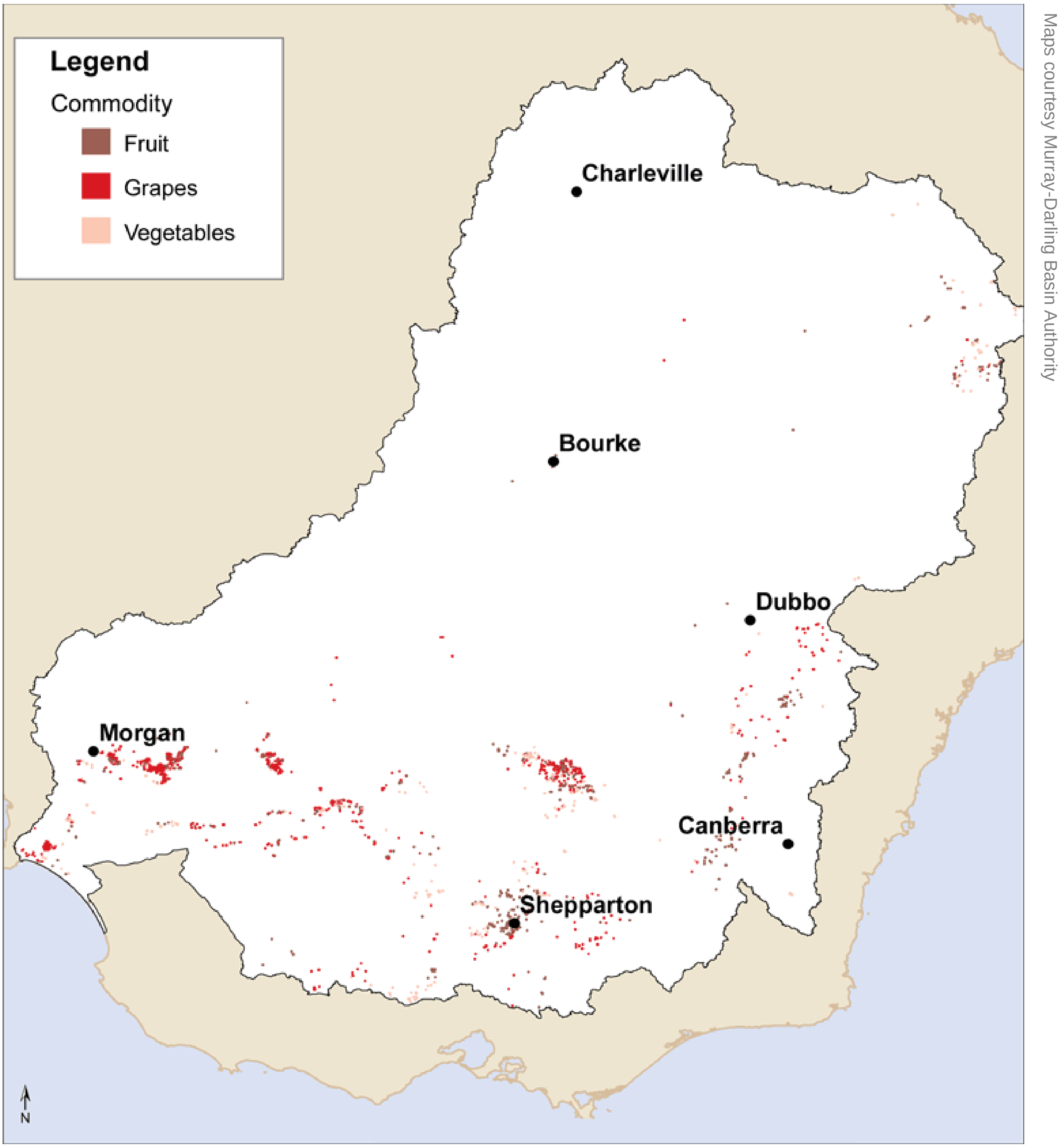
Maps courtesy Murray-Darling Basin Authority

Map 1.6 Grazing areas for livestock in the Murray-Darling Basin



Maps courtesy Murray-Darling Basin Authority

Map 1.7 Production of cereal crops in the Murray-Darling Basin



Map 1.8 Horticultural production in the Murray-Darling Basin

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Student worksheet 1.3

Rainfall and food production

Use Map 1.3 as the reference and compare that to Maps 1.5–1.8.

Questions

3. How would you describe the distribution of coarse grain and cereal crops across the Murray-Darling Basin?
4. How would you describe the distribution of livestock across the Murray-Darling Basin?
5. How would you describe the distribution of fruit and vegetables (horticulture) across the Murray-Darling Basin?
6. Are there any patterns between land use and annual average rainfall?

Summarise your findings:

Lesson 1.3
How is land use linked to levels of water consumption?

Outcome

Students relate water consumption levels to the significant output of produce across the Murray-Darling Basin.

Background

According to the Australian Bureau of Statistics in 2005–06, 7,720 gigalitres of water was consumed for agricultural production in the Murray-Darling-Basin, 66 per cent of Australia's agricultural water consumption.

Water availability in the Murray-Darling Basin is subject to large variations throughout the year, between years and over longer periods. To address these variations major water storages on the river system were constructed.

Over time, water diversions from the Murray-Darling Basin have increased to unsustainable levels. A cap was introduced in 1995 to limit the amount of water diverted from the Basin. The cap is equal to the volume of water that was diverted under 1993/1994 levels of development.

Resources and preparation

Part A

Figures, graphs, maps and tables

Map 1.1 Extent of the Murray-Darling Basin (review)

Map 1.9 Water consumption in gigalitres across Australia

Table 1.1 Estimated water use in megalitres per hectare for selected crops

Table 1.2 Global average virtual water content of selected products

Part B

Figures, graphs, maps and tables

Figure 1.1 Benefits of the Murray-Darling Basin

Graph 1.2 Growth in Murray-Darling Basin storages since 1920

References

ABS, Change in agricultural water use over time, www.abs.gov.au/ausstats/abs@.nsf/0/E08CBF7F165B2CC3CA2574A50014D2F5?opendocument

Ashton, D 2009, Irrigation in the Murray-Darling Basin: Regional estimates of gross value of irrigated production in 2006–07, Australian Bureau of Agricultural and Resource Economics, www.abare.gov.au/publications_html/landwater/landwater_09/IrrigationGVP.pdf

Australian Government, Map of regional water use, www.water.gov.au/MapPdfs/Fg32_Map_regional_water_use.pdf

Australian Government, Restoring the balance in the Murray-Darling Basin, Water for the future, www.environment.gov.au/water/publications/mdb/pubs/restoring-balance.pdf

Independent Audit Group, 1996, Setting the cap, Report of the Independent Audit Group, Murray-Darling Basin Ministerial Council, www.mdba.gov.au/programs/the-cap/cap-archives

Murray-Darling Basin Commission, The cap, www.mdba.gov.au/programs/the-cap

Murray-Darling Basin Commission, Murray-Darling Basin eResources 2005, www.mdba.gov.au/services/education-resources

Lesson outline

Part A: How much water is required in food production in the Murray-Darling Basin?

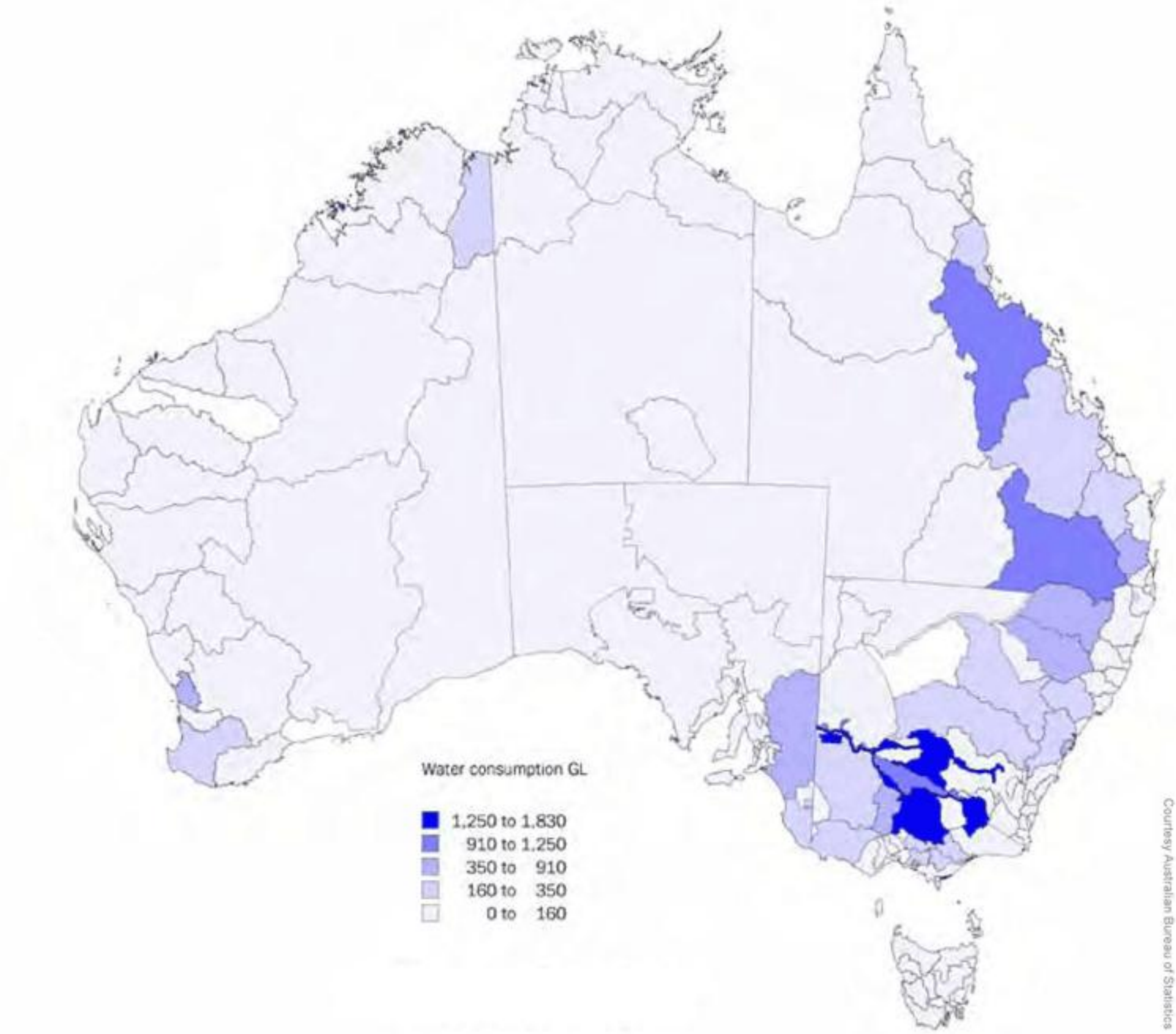
- Review the previous lesson which established that the Murray-Darling Basin experiences highly variable rainfall and that much of the Murray-Darling Basin is semi-arid.
- Refer to Map 1.9. Lead discussion about reasons for the Murray-Darling Basin having the highest water consumption in Australia.
- To ensure students get a sense of the amount of water being described establish that a gigalitre is 1,000,000,000 litres. The Murray-Darling River Authority website, Water volumes: How much water? www.mdba.gov.au/services/education-resources/water-volumes , provides a useful visual method of describing litres, kilolitres, megalitres and gigalitres.
- Explain that one method of looking at water consumed through irrigation farming involves calculating water use per hectare to grow that product. Relate the size of a hectare to something with which students are familiar, for example, 25 basketball courts. Alternatively, if you have access to a grassed area that is 100 metres wide and 100 metres long you could take your students out to measure it and experience for themselves how large a hectare is. Remind students that a megalitre is one million litres. So, using wheat as an example from Table 1.1 below – in rough terms – it takes a volume of water equivalent to 1.3 filled Olympic swimming pools to grow a field of wheat the size of 25 basketball courts.
- Discuss the information in Table 1.1. Relate the water used in irrigated farming and the high consumption of water in certain sections of the Murray-Darling Basin to the rest of Australia. Students can refer to Maps 1.5–1.8, used in Lesson 1.2 that display the crops or livestock grown or raised in that area. Look for connections between water consumption and the types of crops grown in particular areas of the Basin.

Table 1.1 Estimated water use in megalitres per hectare for selected crops

Crop	Water use (megalitres per hectare)
wine grapes	5.0
citrus	8.1
stone fruit	6.8
vegetables	4.7
wheat	2.3
barley	2.0
rice	12.3
cotton	5.8
hay	4.0

Courtesy Australian Bureau of Agricultural and Resource Economics and Sciences

- Explain that another method of considering water consumption is to look at the virtual water content of particular products. Virtual water relates to the total amount of water used to produce the product. Show students Table 1.2.



Map 1.9 Water consumption in gigalitres across Australia

Table 1.2 Global average virtual water content of selected products

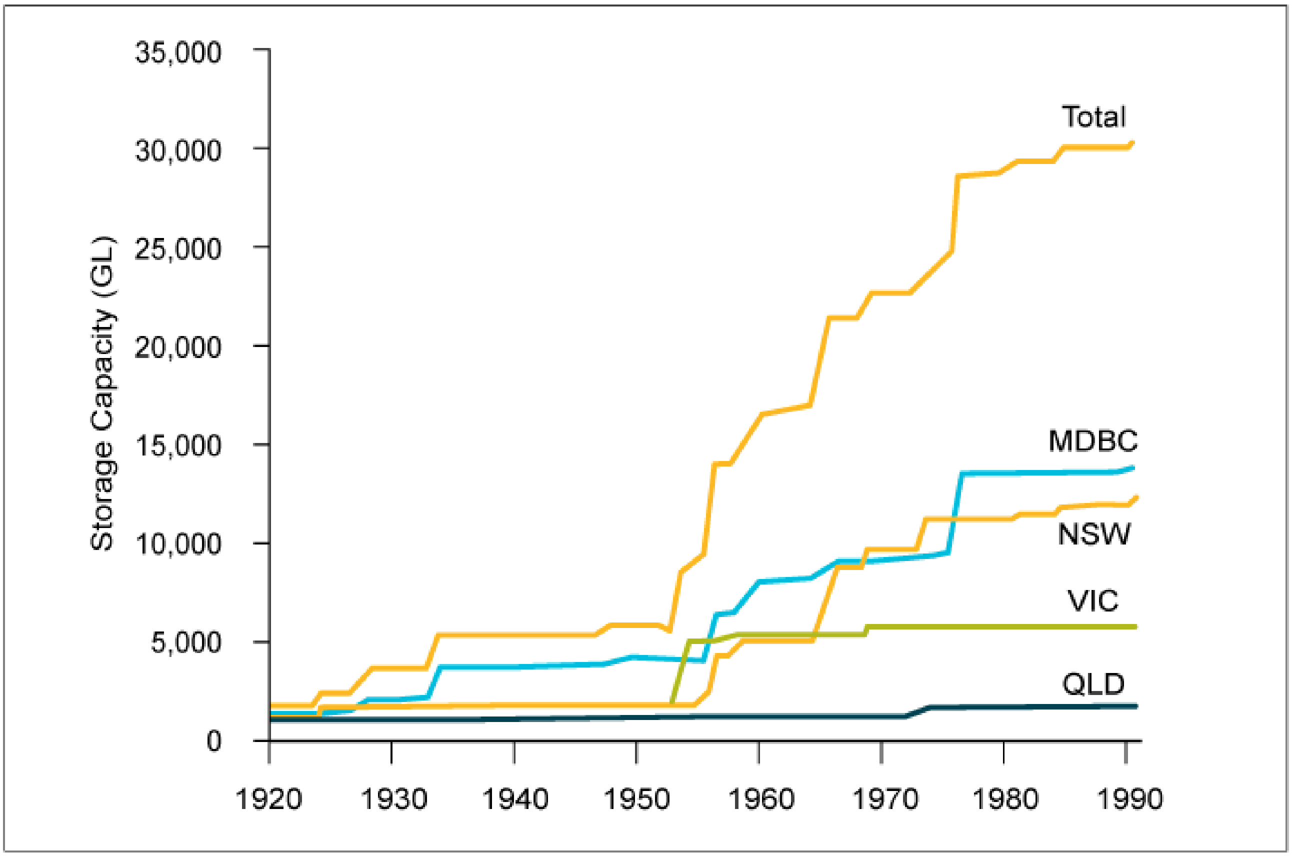
Product	Virtual water content (litres)
1 glass of milk (200 ml)	200
1 glass of apple juice (200 ml)	190
1 glass of orange juice (200 ml)	170
1 bag of potato crisps (200 g)	185
1 slice of bread (30 g)	40
1 potato (100 g)	25
1 apple (100 g)	70
1 orange (100 g)	50
1 hamburger (150 g)	2,400
1 cotton T-shirt (medium sized, 500 g)	4,100
1 sheet of A4 paper (80 g/m^2)	10

- Students analyse the data and give reasons for the suggested number of litres used to produce each product.

Part B: Diverting water in the Murray-Darling Basin

- View Map 1.1 from Lesson 1.1 (page 16) and identify townships that are part of rural communities. Make generalisations about the location of towns relative to sources of water.
- Explain that water for crops and livestock is often diverted from rivers and lakes or from constructed dams that store water. Provide Graph 1.2 (on page 36) which displays information about water diversions for the four states that the Murray-Darling Basin covers. Interpret the patterns of use by each state, and trends over time.
- Ask: Why, in 1995, did the Australian Government put a cap on how much water each state was able to divert from the Murray-Darling Basin?
- Consider and discuss the potential for any possible conflict that may arise due to water use by different states.
- Discuss the importance of water to rural communities and the need for them to have sufficient access to water to carry on their lives and businesses. Discuss how Australians benefit from food and fibre production, and other industries, such as mining, that consume water in their production of resources. Using a series of concentric circles as shown in Figure 1.1, students represent the benefits of these businesses to their family, the local community, the Murray-Darling Basin, and the nation and globe.

Figure 1.1 Benefits of the Murray-Darling Basin



Courtesy Murray-Darling Basin Authority

Graph 1.2 Growth in Murray-Darling Basin storages since 1920

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

INVESTIGATION 2

How important is the Murray-Darling Basin as a food-producing region and what are the consequences for managing its water resources?

Introduction

The Murray-Darling Basin is commonly referred to as Australia's food bowl since the region produces a significant amount of the nation's food. The Basin also contributes to the world's food supply through exports. The Murray-Darling Basin's primary industries support related industries and services, communities and townships within and beyond the region. Managing the water of the Basin involves considering the social and economic factors as well as the environmental needs of the system.

Many communities in the Basin have had to endure the continued cycle of long dry periods of drought followed by periods of flooding rains. These climatic variations affect agricultural production which, in turn, impacts on community resilience. The security of having access to water to continue agricultural production is vital for the wellbeing of the Basin communities.

In 2006, 10 per cent of all people employed in the Basin worked in agriculture. The value to the Australian economy for agricultural production in the Basin was $15 billion, which equates to 39 per cent of the total Australian value of agricultural commodities. The continued food production in the Basin is important to Australia's food availability. The reduced availability of food can lead to higher food prices.

Agriculture in the Murray-Darling Basin, 2005–06
www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/94F2007584736094CA2574A50014B1B6?opendocument

The agricultural and irrigation industries directly and indirectly support communities through job creation in related and supporting industries and services. A relationship exists between these industries and the wellbeing of the community.

Australian Curriculum links

Science – Year 7		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Biological sciences • Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions **Chemical sciences** • Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques **Earth and space sciences** • Some of Earth's resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Nature and development of science** • Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world • Science knowledge can develop through collaboration and connecting ideas across the disciplines of science **Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations • Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management	**Questioning and predicting** • Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge **Planning and conducting** • Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed • In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions **Evaluating** • Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • the hydrologic cycle describes the movement of water between the atmosphere, land and oceans • weather can be a hazard, but the risks can be reduced through human adjustment to the conditions presented • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed • census data can be used to describe the growth, movement and characteristics of the populations of places • information collected in a survey should be evaluated for reliability **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships **Communicating** • each type of communication has conventions that should usually be followed for communication to be effective • the climate of place can be represented by a graph of average monthly temperature and precipitation **Planning and implementing actions** • finding a way of resolving a problem depends on an understanding of the causes of that problem **Reflecting on the investigation** • each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

Lessons

Lesson 2.1
Why is the management of the Murray-Darling Basin's water resources such a complex issue?

Outcome

Students identify the importance of the Murray-Darling Basin to Australia's food and fibre production and exports, the trend of world population growth and the implications for managing the Murray-Darling Basin's water resources. Students begin to understand the complexity of the issues surrounding water use and the health of the Murray-Darling river system.

Background

In the previous lessons students established that the climate of the Basin is highly variable and that this affects the environment and the people that live there. This series of lessons introduces students to the social and economic value of the Murray-Darling Basin. Understanding the different perspectives of the people involved and how they may be affected will help students recognise the complexity of the issue.

According to the Australian Bureau of Statistics (ABS), during 2005–06 food production industries in the Basin:

> collectively generated a gross value of $15 billion, or 39% of Australia's total value of agricultural production. For example, livestock (excluding dairy) contributed $4 billion, cereals for grain (excluding rice) $3 billion, and fruit and nuts $1 billion. Although representing just 14% of Australia's total land area, the Basin contains 20% of Australia's agricultural land.

Agriculture in the Murray-Darling Basin, 2005–06, www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/94F2007584736094CA2574A50014B1B6?opendocument

Australia is one of the world's major agricultural producers of grain, beef and dairy, and has large export markets for a range of other commodities including cotton, wool, wine and other horticulture. Agriculture for food and fibre production is an important issue globally.

On the other hand, the Australian population that we need to feed is growing rapidly. In 2011 Australia's population was approximately 22.5 million. According to the ABS data projections, by 2050 Australia's population could reach 34 million.

Population clock, www.abs.gov.au/ausstats/abs@.nsf/94713a445ff1425ca25682000192af2/1647509ef7e25faaca2568a900154b63?opendocument

Similarly, the world's population is growing rapidly. It will reach an estimate of nearly 10 billion people by 2050 (see www.census.gov/population/international/data/idb/worldpopinfo.php).

The Murray-Darling Basin already exports a great deal of food and fibre to meet the needs of other countries. The Basin's exports earn $9 billion a year and the Basin produces sufficient food to feed around 20 million people. In the long term, the Murray-Darling Basin has the potential to make a major contribution to addressing the world's food and fibre needs.

Resources and preparation

Figure, graphs, maps and tables

Figure 2.1 Agriculture in the Murray-Darling Basin

Student worksheet

Student worksheet 2.1 Food production in Australia compared with the Murray-Darling Basin

References

Agriculture in the Murray-Darling Basin, 2005–06 ABS, www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/94F2007584736094CA2574A50014B1B6?opendocument

World Population Clock – Worldometer, www.worldometers.info/population

Lesson outline

- Present the following information about food production in the Murray-Darling Basin. Explain that the years 2005–06 were chosen as this was the latest information available from the Australian Bureau of Statistics. According to the ABS in 2005–06:
  - 7,720 gigalitres of water was consumed for agricultural production in the Murray-Darling Basin, 66 per cent of Australia's agricultural water consumption.
  - The Gross Value of Agricultural Production (GVAP) in the Murray-Darling-Basin was worth $15 billion, or 39 per cent of the total Australian value of agricultural commodities.
  - A significant proportion of Australia's food production was grown in the Murray-Darling Basin (refer to Table 2.1).
  - The Murray-Daring Basin's exports earn $9 billion a year and produce sufficient food to feed around 20 million people.
- Overall, the Murray-Darling Basin dominates irrigation farming in Australia. The total area of crops and pastures irrigated in the Basin is 1,472,241 hectares. This is 71.1 per cent of the total area of irrigated crops and pastures in Australia (2,069,344 hectares), 18.7 per cent of the total area of crops, pastures and grasses, and 1.7 per cent of the total area in farms (see Figure 2.1).

- Students work in pairs to predict the likely impacts if the amount of water available to agriculture was reduced by 20 per cent. The class then discusses the reasoning behind these predictions.

  In pairs, students study the table on Student worksheet 2.1 and calculate the percentage of a food grown in the Murray-Darling Basin compared with that food grown across Australia. Discuss the high percentages of food types grown in the Murray-Darling Basin. Ask students to give reasons why so much of Australia's food is grown in this area.

- In a general class discussion, explore how the data in this chart affects the predictions they proposed in the previous exercise.
- Explore with students what they know about the size of Australia's population and the predictions for the future. Have students jot down what they think Australia's population was in the years 1975, 2000, and now. Then ask them to write down their predictions for the size of our population in 2025 and 2050. Discuss the trends they expect. Use the following resource to compare their predictions with the estimated

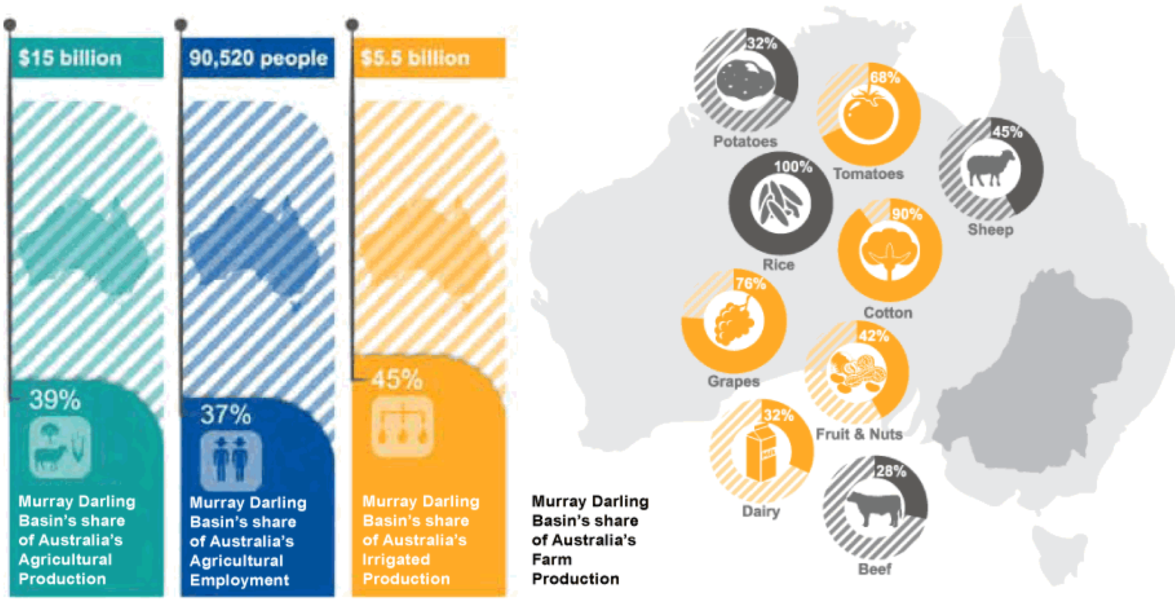


Figure 2.1 Agriculture in the Murray-Darling Basin

Sources: 1. ABS, Water and the Murray-Darling Basin – A Statistical Profile, 2000–01 to 2005–06, 2008. 2. ABS, Water Account, Australia, 2008–09, 2011.

Note: Unless otherwise stated, farm production figures are based on volume. The 2005–06 profile is still considered broadly consistent with the status quo in the Basin. The ABS is currently conducting its 2011 Agricultural Census and known population: www.abs.gov.au/websitedbs/d3310114.nsf/home/Population%20%20Pyramid%20-%20Australia%20.

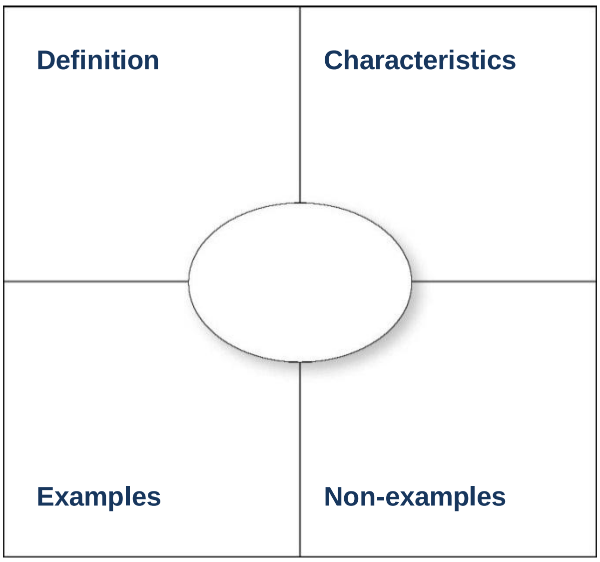
- Then have students consider the growth of the world's population. What is that population now? What are the estimates for the world's population for 2025 and 2050? See World Population Clock – Worldometer, www.worldometers.info/population .
- Ask students to consider the impact of a growing population as shown by the population pyramid and the Worldometer. Students work in pairs and list factors that might limit the increase in food production from the Murray-Darling Basin that is required to meet the demands of this increasing population. Ask students to incorporate their reasoning into the list. Ideas to explore might include:
  - Access to sufficient water; the Murray-Darling Basin supply is already stretched.
  - Access to suitable land to grow food or raise livestock. Some areas of land are affected by salinity.
  - A decrease in the number of farmers or farms due to financial hardship during times of extended drought.
  - According to CSIRO's The Murray-Darling Basin Sustainable Yields Study (2008) the Murray-Darling Basin experiences natural climate variability and highly variable rainfall.
  - Also, according to this study, climate change has the potential to lead to less water due to decreased rainfall and higher average temperatures.
- Discuss possible impacts of increased population on food production for example:
  - increased demand for more food production from the Murray-Darling Basin
  - increased food imports from other countries
  - reduced food types being available (food production is based on efficiencies of space and water use).
- As a summary exercise, conduct a Q&A conversation using 'inside-outside circles':
  - Step 1: Divide the class into two groups of equal size. Group A forms an inner circle and Group B forms another, outer circle around them. Each student in Group A faces his or her direct opposite in Group B.
  - Step 2: Each Group A person asks their opposite in Group B to respond, in his or her own words, for two minutes, to the question: 'Why do you think water use in the Murray-Darling Basin is a complex issue?'
  - Step 3: The Group A student asks the Group B student to clarify or add further information for another minute.
  - Step 4: When the three minutes is up, students in the inside circle move to their left so they are opposite another Group B student.
  - Step 5: Students run through Steps 2–4 twice more.
  - Step 6: When the Group A students have heard three different views, reconvene as a whole-class group and have volunteers from Group A form a panel of 'experts'.
- Teachers then facilitate a Q&A where the class explore the issues raised in the key question.
- Once this activity is complete, help the students to summarise the issues surrounding the use of water for agriculture in the Murray-Darling Basin and the importance of the area as a food and fibre producer.

Developing vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as 'irrigation', and on the back of the card its meaning – 'diverting water for farming'. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

Unfamiliar terms may include underlined glossary items.



Student Worksheet 2.1

Food production in Australia compared with the Murray-Darling Basin

	In Australia '000 tonnes	In the Murray-Darling Basin '000 tonnes	Percentage of food grown in the Murray-Darling Basin
Cereal for grain			
wheat	25,150	12,110	
barley	9,482	4,635	
grain sorghum	1,932	1,717	
rice	1,003	1,003	
all other cereals	2,880	1,847	
Crops for livestock feed			
pasture and crops cut for hay	8,065	3,531	
Fruit, nuts and grapes			
oranges	507	482	
apples	276	148	
pears (inc nashi)	142	124	
peaches	91	83	
apricots	17	16	
almonds	12	12	
nectarines	49	42	
plums and prunes	26	22	
lemons and limes	33	15	
cherries	10	7	
grapes	143	188	
grapes for winemaking	1,782	1,320	
Vegetables			
tomatoes	450	306	
potatoes	1,250	397	
onions	196	66	
Livestock			
cattle	28,393	7,972	
sheep and lambs	91,028	40,609	
pigs	2,733	1,707	

Agriculture in the Murray-Darling Basin, 2005–06, ABS,
www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/94F2007584736094 CA2574A50014B1B6?opendocument

Lesson 2.2
What is the value to our society of agriculture in the Murray-Darling Basin?

Outcome

Students identify their connections to the Murray-Darling Basin and explore the socio-economic impacts of agricultural activity in the Basin for the broad community.

Background

Farmers who grow or raise produce in the Murray-Darling Basin are directly involved in the issues around water consumption and the health of the river system. However, it is important for students to recognise their own connection to the issues, both as consumers of this produce and as citizens who care about their communities and environment. The local and national economies are strongly tied to agricultural production in the Murray-Darling Basin. Both directly and indirectly, a significant number of people in our communities work in industries that are related to agriculture including farm machinery and servicing, irrigation supplies, transportation of the produce and often some form of processing.

Resources and preparation

Figures, maps, graphs and tables

Map 2.1 Production of wheat in the Murray-Darling Basin

Student worksheets

Student worksheet 2.1 Food production in Australia compared with Murray-Darling Basin (review)

Student worksheet 2.2 The value of agriculture in the Murray-Darling Basin

References

Australian Wheat Board, Australian wheat, www.awb.com.au/customers/australianwheat

Better Health Channel, Foods and plants from animals, www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Foods_from_plants_and_animals?open

Better Health Channel, Gluten free diet, www.betterhealth.vic.gov.au/bhcv2/bhcarticlesnsf/pages/Gluten-free_diet

Dairy Australia, Dairy products,

www.dairyaustralia.com.au/Dairy-food-and-recipes/Dairy-Products.aspx

Murray-Darling Basin Commission, Agricultural crops, www.mdba.gov.au/services/education-resources

Paradise, How biscuits are made, http://esvc000267.wic050u.server-web.com/aboutus_schoolinfo2.php

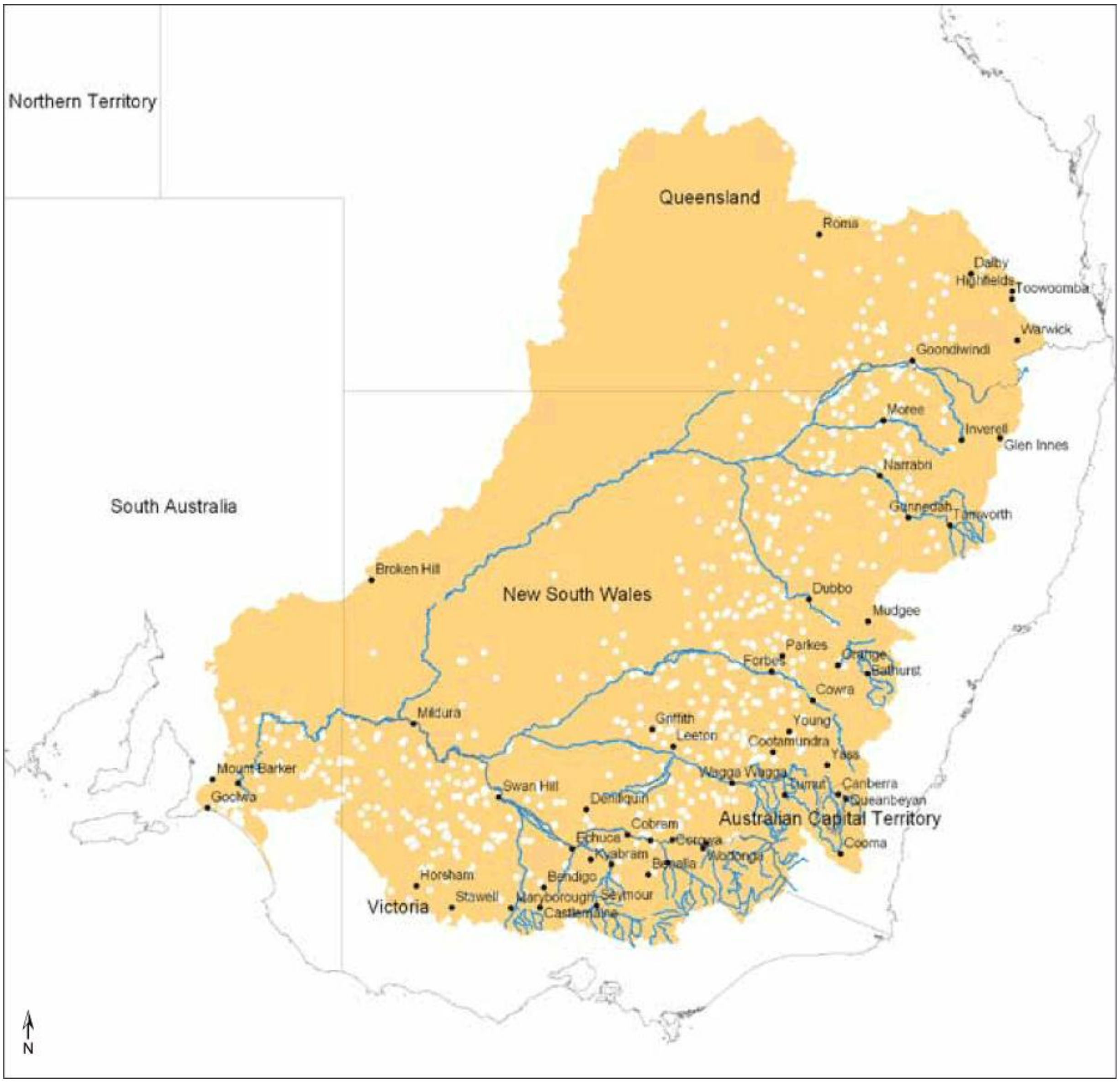
Quality tools, Learning about flow charts, http://asq.org/learn-about-quality/process-analysis-tools/overview/flowchart.html

SPC Ardmona, Fresh from our orchards, www.spcardmona.com.au/index.php

Sunrice, Growing rice, from paddock to plate, www.sunrice.com.au/?nodeId=295

Lesson outline

- Students identify their connections to the Murray-Darling Basin and explore the socioeconomic impacts of agricultural activity in the Basin for the broad community.
- Ask: What is your own connection to the Murray-Darling Basin? Discuss the students' ideas. Some students may find it difficult to make a connection to this area. They may think of only personal or social connections (family or friends who live there or tourism experiences). Help shape their ideas by establishing our reliance on this area for some of the foods and products we buy and use:
- Establish our connection as consumers of food and other products to the Murray-Darling Basin. Relate this reliance on food to our connection to the water used in the Basin and in turn the health of the river system. Students review Student worksheet 2.1 from Lesson 2.1.
- Ask: Which of the products listed have you eaten over the past two days? What is the likelihood that some of these have come from the Murray-Darling Basin?
- Ask: What common ingredient is used in the production of bread, pasta and biscuits? Establish that flour is the common ingredient, which is processed by crushing and milling wheat.
- Refer back to the table on Student worksheet 2.1 and highlight that wheat is the major crop grown in the Murray-Darling Basin, accounting for 48 per cent of wheat produced in Australia. Refer also to Map 2.1, which shows the production of wheat in relation to other cereal crops within the Murray-Darling Basin.
- Use the wheat example to explore the connection to us and others in society. Brainstorm all the steps involved in producing wheat. These may include preparing the soil, fertilising, sowing seed, controlling weeds, harvesting, storing, transporting, processing, packaging for wholesalers, packaging for sale, advertising and marketing, retail outlets, purchasing by the consumer, banking and insurance throughout. Discuss the use of a flow chart to visually describe these processes.
- Provide students working in pairs with Student worksheet 2.2. Students select a food and research the steps involved in its production. The end result for students will be the creation of a flow chart describing the process used to develop that product.
- Discuss:
  - farming inputs (such as finance, water, seeds, machinery, fertiliser, pesticides, fodder for livestock, veterinary services, fuel, labour) and outputs (crops/livestock, waste)
  - the difference between whole foods such as fruits and vegetables that are unrefined and consumed virtually as they were picked, compared with processed foods, which have been altered from their natural state.
- Students access the Murray-Darling Basin Commission web page, Agricultural crops, at www.mdba.gov.au/services/education-resources



Courtesy Murray-Darling Basin Authority

Map 2.1 Production of wheat in the Murray-Darling Basin

Note: The white dots represent the wheat-growing districts.

- Alternatively, students use the internet and a keyword search to find out about their selected food and its production.
- After students have developed their flow chart they can add occupations/employment that could support production. From this task students should be able to respond with two short articles to the following questions:

  7. What is the value to the broader community of the agricultural industry in the Murray-Darling Basin?
  8. What would be the possible effects of reduced water availability (caused by drought or reduced water allocations allowed from the system) on Murray-Darling Basin farmers and the potential flow-on effects to other related industries?

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Student worksheet 2.2

The value of agriculture in the Murray-Darling Basin

Today, most Australians rely on others to grow their food and other produce. By the time we buy them many people have been involved in the process.

Consider a food you regularly eat. The food I choose is ……………………………………………..

9. Is it a whole food or has it been processed?
10. If it has been processed, what has it been made from? Research your food product. Identify the core ingredients. Find out about those ingredients. If it is packaged, read the list of ingredients.

Consider these questions to help you work out the relevant steps in the production of your food.

Guiding question	My first thoughts	What I found after further research
Is it made up of one main ingredient or a number of ingredients?		
Does it come from an animal or plant?		
What type of field preparation is required to grow or raise the food or ingredient(s)?		
Does it need irrigated water?		
How long does it take		
to grow or be raised?		
What type of care is required?		
What happens to it after harvesting or collecting for processing?		

Student worksheet 2.2 cont.

The value of agriculture in the Murray-Darling Basin

Guiding question	My first thoughts	What I found after further research
How is it processed? Is it processed several times to make the product you eat?		
From what type of outlet is it purchased?		

11. What steps are involved, from the time it is grown or raised to when you purchase the product? Create a flow chart to show these steps.

12. Look at all the steps involved. Now think about all the related jobs that could support the creation of this product. Add these to your flow chart.

13. Write a response to this question: What is the value of agriculture to our society? Refer back to your flow chart for evidence to support your ideas.

Lesson 2.3
What is the value of primary industry to communities within the Murray-Darling Basin?

Outcome

Students relate water consumption levels to the significant output of produce across the Murray-Darling Basin. Students compare two irrigation regions, Mildura and Coleambally, to describe the importance of water to the regions and their communities by exploring one town from each region.

Background

In 1883 the Victorian politician (and later prime minister) Alfred Deakin went to California to investigate irrigation and conservation schemes. There he met the Chaffey brothers, George and William Benjamin, and inspected their irrigation experiments. The Chaffeys came to Victoria in 1886 and demonstrated their methods at Mildura. The Victorian government supported the new farming technique and soon passed laws that provided for the construction of state-aided irrigation works. In 1887 the irrigation colony in the Mildura region was born. The region's first horticultural industry was dried raisins and sultanas followed by citrus. More recently it has been dominated by wine grapes, table grapes and large-scale wine production.

Coleambally, in the Murrumbidgee region, is the newest town in New South Wales.

> Planned to service the surrounding Coleambally Irrigation Area, it was established in 1968. Since that time, surrounding irrigated farmland has diversified into a vast array of agricultural industries including rice, maize, soybeans, wheat, canola, oats, grapes, prunes, almonds, cattle, sheep and organic horticulture.
>
> Coleambally Community and Economic Action Plan, www.bankofideas.com.au/Newsletter/May10/downloads/Coleambally.pdf

Both the Mildura and Coleambally regions are based on irrigated water, with communities relying heavily on water availability.

Resources and preparation

Student handout

Student handout 2.3 Key aspects of the Murrumbidgee and Mildura regions

References

Bank of Ideas, Coleambally Community and Economic Action Plan, www.bankofideas.com.au/Newsletter/May10/downloads/Coleambally.pdf

Grow Mildura Region, Agriculture, http://growmilduraregion.com.au/html/agriculture/mildura_region_grains.html

Mildura Development Corporation, Creating our regions future, www.aph.gov.au/house/committee/ra/murraydarling/subs/sub237.pdf

Murrumbidgee Catchment Authority,

Our catchment, www.murrumbidgee.cma.nsw.gov.au/about/catchment.aspx

Lesson outline

- View maps of the Murrumbidgee and Mildura regions. Provide students with Student handout 2.3. Discuss the similarities and differences between the two regions.
- Divide the class into two groups. One is to research Mildura and the other, Coleambally. The focus for the research is to provide an informative overview of each town and its community and to demonstrate that community's connections and level of reliance on primary industry activity and ecological values within the region.
  - Students research a range of data sources to develop a socio-economic profile of the two townships of Mildura and Coleambally.
  - Assist students to define the elements of a common profile template and the data they will require (for example, location map, town map, population statistics, population growth trends, major industries and economic activity, occupations, cultural and sporting activities, health and education services).
  - Students then explore the local news media to develop a sense of the issues and concerns that were important in a particular period of time (for example, one week).
  - Have each group develop a presentation for the rest of the class on the township's social, economic and cultural connections to both the ecological and primary industry values of the region.

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Student handout 2.3

Key aspects of the Murrumbidgee and Mildura regions

Key aspects	Murrumbidgee region	Mildura region
Area	84,000 square kilometres	48,355 square kilometres
Population	More than 500,000 people	Approximately 60,000 people
Town in focus	Coleambally, the newest town in NSW, was established as an irrigation town in the 1960s.	Mildura was established as an irrigation district in 1886 under guidance from the Chaffey brothers.
Main water supply	More than 10,000 kilometres of irrigation channels deliver water supplied by Burrinjuck Dam near Yass and Blowering Dam near Tumut.	Water supplied by Murray River and the irrigation system. There is a strong reliance on permanent plantings (such as fruit trees and grape vines) as opposed to annual crops and therefore a reliance on a continuous water supply
Produce	The irrigation industry produces 25 per cent of NSW's fruit and vegetables, 42 per cent of its grapes and 50 per cent of Australia's rice.	The region produces a significant amount of Australia's horticulture: • 98 per cent of dried fruit • 75 per cent of table grapes • 65 per cent of almonds • 24 per cent of citrus • 41 per cent of pistachios • 20 per cent of overall wine grape crush.
Other major industries	Beef production, intensive poultry production, sheep and wool, cropping and softwood plantations.	Fishery and forestry, sheep and lambs, grain industry, food processing industries and manufacturing
Economy	Agricultural production is worth in excess of $1.9 billion annually. Irrigated agriculture across the catchment produces approximately $200 million worth of rice annually, $60 million worth of vegetables, $80 million worth of grapes, $150 million worth of fruit and $10 million worth of dairy products.	The Gross Regional Product (GRP) of the region is $2.788 billion

Student handout 2.3

Key aspects of the Murrumbidgee and Mildura regions

Key aspects	Murrumbidgee region	Mildura region
Water efficiencies	Water recycling systems on broadacre irrigation properties and water-efficient drip-irrigation systems on smaller horticulture farms.	Over 70 per cent of irrigators across the Mildura region have adapted water-efficient technology, using drippers or low-level sprinklers.
Sites of international ecological significance	Lowbidgee Wetlands and the Ramsar-listed Fivebough and Tuckerbil Swamps	Ramsar-listed Hattah Lakes as well as Lindsay Island and Mulcra Island

Sources: www.murrumbidgee.cma.nsw.gov.au/about/catchment.aspx, www.aph.gov.au/house/committee/ra/murraydarling/subs/sub237.pdf, http://growmilduraregion.com.au/html/agriculture/mildura_region_grains.html

Lesson 2.4
Long-term investigation (growing small crops using dry-farming and irrigation-farming methods)

Outcome

As an extension activity, students plan, implement and report on a small comparative crop-growing experiment to understand more about water management in farming.

Lesson outline

- With the students, plan and conduct a long-term investigation to grow a crop suitable for the season and climate of your area. Have four small groups of students work in teams. Two groups grow crops that are based on dry-farming techniques and the other two groups grow crops based on irrigation techniques. Carefully consider the growing season and the expected growing time before selecting a suitable crop.
- Ideas for investigation:
  - Grow each crop and record the amount of water used for the plot of one square metre over time.
  - Measure the yield of the crop compared to the water used in litres. It may be possible to estimate the water use after taking careful measurements in the first month. Discuss organic fertilisers such as compost.
  - Have students compare the yields and inputs for each crop and see which crops were best suited to the different farming techniques.
  - A comparison could be made between specific amounts of water given to each plot per day/week. An investigation question could be: Can crops be grown with limited water?
- Each student team develops an ICT-based presentation that includes data sheets, digital photography, a description of methods, water management activity, problems encountered and solutions trialled. Students should report on the effect of pest and disease; water usage; yield; germination; the conditions tested; the problems encountered and the solutions trialled.

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

INVESTIGATION 3

How does the Murray-Darling Basin work as a system?

Introduction

The Murray-Darling Basin is an example of a basin where waterflows out to sea. In contrast the Lake Eyre Basin is an internal drainage system where waterflows terminate at a shallow salt lake.

The Murray-Darling Basin is one of Australia’s largest drainage areas, capturing rainfall in the catchment areas of Australia’s three longest rivers (the Murray, the Darling and the Murrumbidgee). The drainage basin functions as an open system: precipitation is the input, the water may evaporate back into the atmosphere (output), seep into the ground and add to groundwater or flow across the surface as run-off into streams and waterways. The waterflows out of the system via rivers and streams that flow out to sea (output). Vegetation that draws up the water via roots in the soil transpires and contributes to evapotranspiration.

Several factors influence the movement of water in the drainage system such as topography, soil and bedrock types, climate and vegetation cover.

Australian Curriculum links

<table>
<tr><th colspan="3">Science – Year 7</th></tr>
<tr><td>Science Understanding

Biological sciences
Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions
Earth and space sciences
Some of Earth’s resources are renewable, but others are non-renewable
Water is an important resource that cycles through the environment</td><td>Science as a Human Endeavour

Use and influence of science
Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations
Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management</td><td>Science Inquiry Skills

Questioning and predicting
Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge
Planning and conducting
In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task
Processing and analysing data and information
Summarise data, from students’ own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions
Evaluating
Use scientific knowledge and findings from investigations to evaluate claims
Communicating
Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate</td></tr>
</table>

Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • the hydrologic cycle describes the movement of water between the atmosphere, land and oceans • weather can be a hazard, but the risks can be reduced through human adjustment to the conditions presented • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships

Lessons

Lesson 3.1
What are the natural components of the Murray-Darling Basin system?

Outcome

Students describe the natural components of the Murray-Darling Basin river system and explore their role and function.

Background

In the previous lessons students established the social and economic importance of the Basin. This series of lessons introduces the environmental importance of the Murray-Darling Basin and how it functions as a system. It sets the scene to demonstrate how a healthy system operates. Understanding how the natural system functions provides a useful background when students consider ways in which human actions have affected the system and explore the consequences of these actions.

Most of the water available in the southern Murray-Darling Basin comes from rainfall (and snowfall) in catchment areas on the Great Dividing Range along the southern and south-eastern margins of the Basin. At the river basin level, more run-off, occurs in the Upper Murray (4,472 GL), Murrumbidgee (3,831 GL) and Goulburn (2,686 GL) river basins than in others.

Water and the Murray-Darling Basin – A Statistical Profile, 2000–01 to 2005–06, Australian Bureau of Statistics released August, 2008

The hydrological cycle is an important concept to understand when relating how water moves within a river basin. Water in the form of precipitation falls in the Basin's catchment and flows across the surface as run-off or infiltrates the soil. Waterflows into river channels via surface runoff or by under-surface movement. Water that seeps deep into the ground through soil and rock recharges groundwater resources.

Periodic flooding of rivers in the Murray-Darling Basin is important for river health. Over-bank flows connect the river to floodplains and wetlands. Plants and algae in the floodplains and wetlands transfer energy, carbon and nutrients into the river channel.

Floodplains and wetlands also recharge many groundwater aquifers. The river channels, floodplains and groundwater systems are often interconnected. Water flows from flooding rivers into the underground water and then back into the river during dry times. Weirs and levees used to regulate flows have cut these vital connections.

Resources and preparation

Part A

Figures, graphs, maps and tables

Map 1.3 Twenty-year average annual rainfall in the Murray-Darling Basin (review)

Map 3.1 Murray-Darling Basin topography

Resources

An atlas

Materials

- Modelling clay
- Toothpicks
- A sink or tub of water

Part B

Figures, graphs, maps and tables

Figure 3.1 The hydrological cycle

Figure 3.2 Model of capillary action

Figure 3.3. Model of soil permeability and infiltration

Materials

- large, clear plastic bag
- access to a growing tree or large shrub
- sticky tape
- 2 x plastic lemonade bottle (one with the base cut off and one cut in half)
- samples of sand
- samples of three soil types: clay, loam and soil with high organic content
- a selection of large beakers or containers
- 1 litre of water

Technology

Waterflows (PowerPoint resource)

Part C

Figures, graphs, maps and tables

Figure 3.4 Cross-section of a river

Figure 3.5 The connection between overbank-flows and floodplains and wetlands

Technology

Access to Google Maps

References

ABC Online, Easy solutions for Murray-Darling have run dry, www.abc.net.au/science/articles/2010/10/14/3038385.htm?site=rural

BBC, Drainage basin, Intermediate geography Rivers, www.bbc.co.uk/scotland/education/int/geog/rivers/drainage/index.shtml

CSIRO, Water for a healthy country: National research flag ship, www.clw.csiro.au/publications/waterforahealthycountry/cllamm/CLLAMM-CoorongKnowledgeGaps.pdf

Department of Environment and Water Resources, Irrigation areas, www.environment.gov.au/water/publications/mdb/pubs/dry-inflow-planning-may07-map.pdf

The Encyclopaedia of Earth, Evapotranspiration, www.eoearth.org/article/Evapotranspiration

Google, Google Maps, http://maps.google.com.au/

Hankinson, A and Soutar, L, The biodiversity and values of the Darling Basin a valuable and iconic Australian asset, Amy Inland Rivers Network, www.irnnsw.org.au/pdf/IRNDarlingValuesReport.pdf

Inland Rivers Network, Water extraction, www.edo.org.au/edonsw/site/pdf/presentations/floodplain.pdf

Lamontagne S, McEwan, K Webster I, Ford, P, Leaney, F and Walker, G 2004, Coorong, Lower Lakes and Murray Mouth. Knowledge gaps and knowledge needs for delivering better ecological outcomes. Water for a Healthy Country National Research, Flagship CSIRO, Canberra, www.csiro.au/resources/WaterAvailabilityInMurray-DarlingBasinMDBSY.html

The Living Murray, Foundation Report on the significant ecological assets targeted in the First Step Decision, www.mdba.gov.au/services/publications/more-information?publicationid=108

Murray-Darling Basin Commission, Murray-Darling Basin e-Resources 2005, www.mdba.gov.au/services/education-resources

National Water Commission, Ground water recharge, www.water.gov.au/WaterAvailability/Whatisourtotalwaterresource/GroundwaterRecharge/index.aspx?Menu=Level1_3_1_6 ,

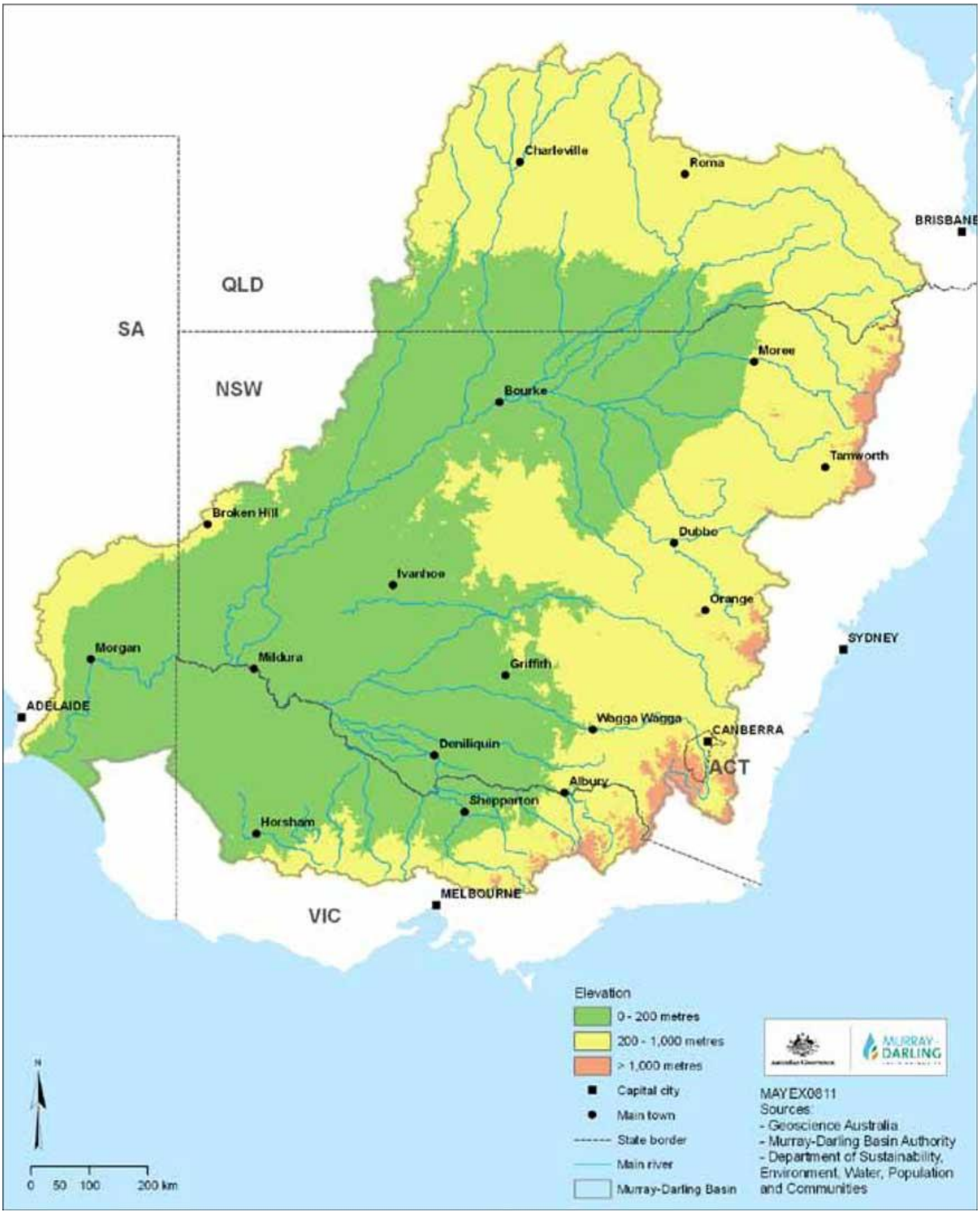
Parks Victoria, What is a wetland, www.enviroactiv.com.au/wetlands_types.html

South Australian Water Corporation, Murray Mouth sand pumping: Keeping the tides flowing, Adelaide, Australia, www.riversymposium.com/index.php?element=CAMPBELL_Tom_FullPaper

Lesson outline

Part A: Exploring the Murray-Darling Basin catchment

- Display Map 3.1. It is shaded to show ranges in height above sea level in metres. Identify the areas of highest elevation, and those of lowest elevation, which includes the floodplains along the major rivers, the Darling and Murray. Discuss the range of elevation – for example, 200 metres to 1,000 metres. Use an atlas to identify the Great Dividing Range that runs along the east coast of Australia.
- Provide students with modelling clay so they can create a 3-D representation of the topography of the Basin. Discuss the range of elevation – for example, 200 metres to 1,000 metres. Ask what scale students will use to create their elevation. Students demonstrate the areas of highest elevation, particularly along the eastern section of the Basin. They use a toothpick to mark in the major rivers of the Basin.
- Use the representation to model waterflows by placing their model in a tub. Students pour a small amount of water over the eastern section to represent rainfall. They observe how the water flows. The water should flow out of the Basin to reflect how water flows out to sea.
- Explain that the model shows how the Basin is a catchment that funnels water from rainfall (and snowmelts from the Snowy Mountains) down the sloping valleys into the river systems.
- Students compare Map 3.1 with Map 1.3 from Part B of Lesson 1.2. This provides a useful opportunity to identify patterns of rainfall and height above sea level.



Courtesy Murray-Darling Basin Authority

Map 3.1 Murray-Darling Basin topography

Part B: Exploring the hydrological cycle

- Explain the hydrological cycle and its relevance to a river system. Model waterflows through the river system and drainage basin where the river flows to the ocean, as this is a similar process to what occurs in the Murray-Darling Basin.

Investigate the hydrological cycle

- Use the PowerPoint resource Waterflows to discuss the inflows, movements and outflows of a river system and drainage basin.
- Use Figure 3.1 and the PowerPoint resource to explain terms such as precipitation, evaporation, transpiration, evapotranspiration, infiltration, percolation and groundwater.

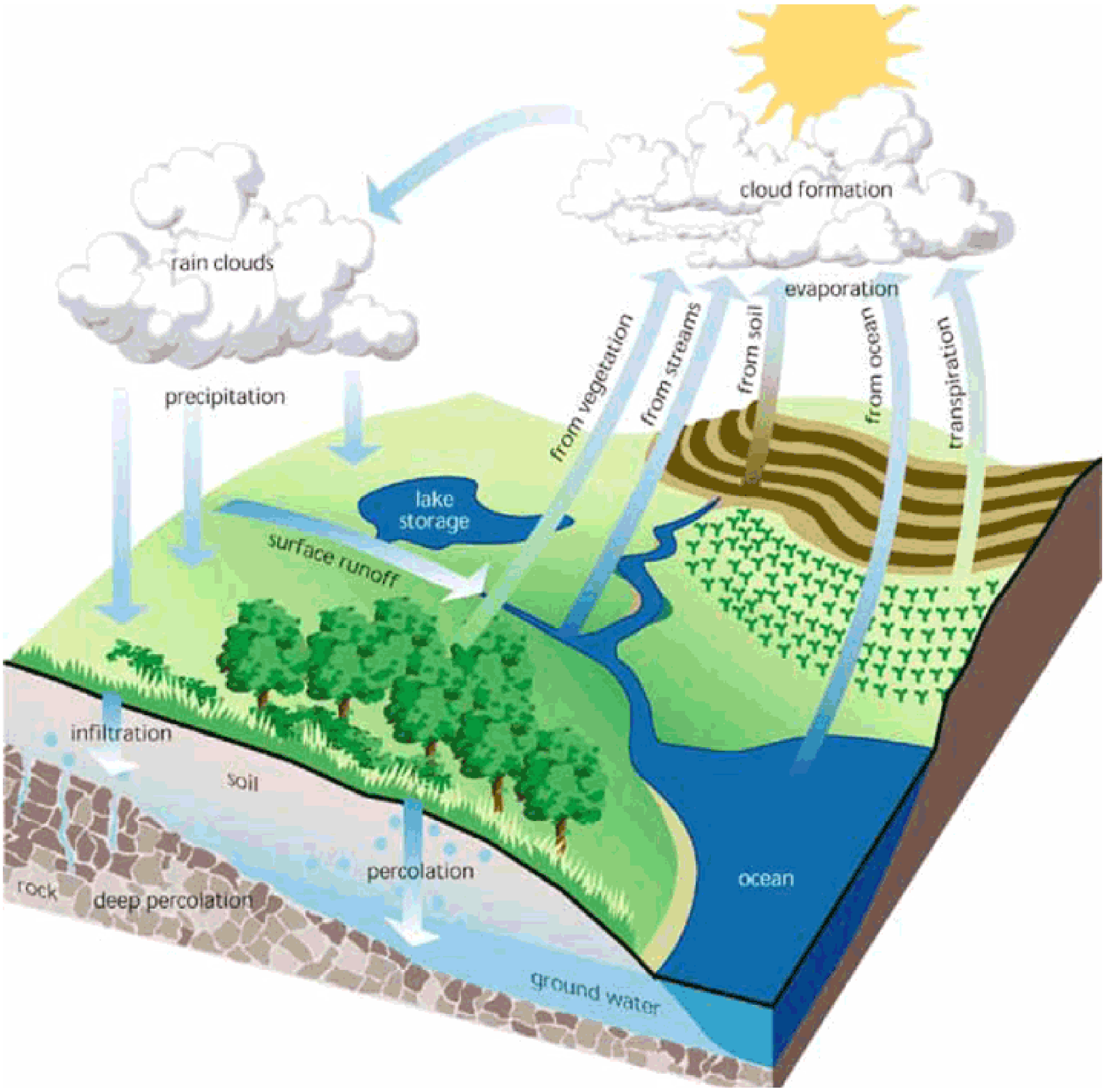


Figure 3.1 The hydrological cycle

US Department of Agriculture

Describe the following process to explain waterflows:

– Inputs: precipitation
– Transfer: Surface flow (run-off) and flow-through; soil infiltration, percolation
– Storage: surface storage and groundwater
– Outputs: to the ocean and losses through evapotranspiration.

Investigate transpiration

- As a follow-up to the discussion of the hydrological cycle, investigate transpiration by having students place a large clear plastic bag around the branch and leaves of a tree or large shrub. Tape up the bag and check after several hours. Students should observe condensation and a small amount of water collecting in the bag.
- Ask students to explain where the water has come from. Discuss the structure of a plant leaf, which has small holes called stomata that open and close as the plant respires. As these small holes open, water vapour moves out of the leaves: the higher the surrounding temperature, the higher the rate of transpiration. Discuss the transport of water from the roots that absorb water from the soil through the stem to the branches and leaves. Use this investigation to link other aspects of the water cycle, such as water that seeps into the soil, evaporation, transpiration, condensation and precipitation. Students create a labelled diagram of transpiration.

Investigate capillary action flow

- Infiltration is the movement of water into the soil layer. After rain, water in the soil drains deeper into the soil layer as a result of the force exerted by gravity. Capillary action is responsible for moving groundwater from wet areas of the soil to dry areas. It also moves water from one area in the soil to replace losses in another – for example, at the surface to replace the water consumed by plants through transpiration.
- Model the capillary action flow of water (see Figure 3.2). To model the water table (saturated soil), fill a beaker with sand and saturate it with water. Cut the base off a plastic one litre lemonade bottle and remove the lid. Place the inverted lemonade bottle into the saturated sand. Pour dry sand into the lemonade bottle. The dry sand will be in contact with the saturated wet sand. Predict what will happen and observe. Relate this to groundwater flows and the water table.

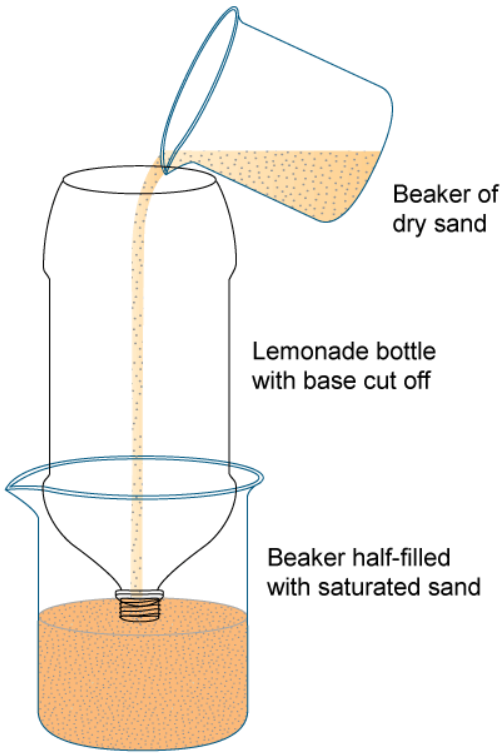


Figure 3.2 Model of capillary action

Investigate infiltration

- Water moving below ground depends on permeability and porosity.
- Examine three soil types: clay, loam and soil with high organic content; and the time taken for 250 millilitres of water to seep through to the collecting container (see Figure 3.3). Measure the initial amount of water and the differences in the amounts of water collected from each sample. Interpret the results and relate them to surface run-off and infiltration.
- Students could use a plastic lemonade bottle, cut in half. Invert the top half of the lemonade bottle and half fill it with the first soil type. Place it in the bottom half of the bottle. Gradually pour water through the soil and allow it to collect in the bottom half of the bottle. Record your results.

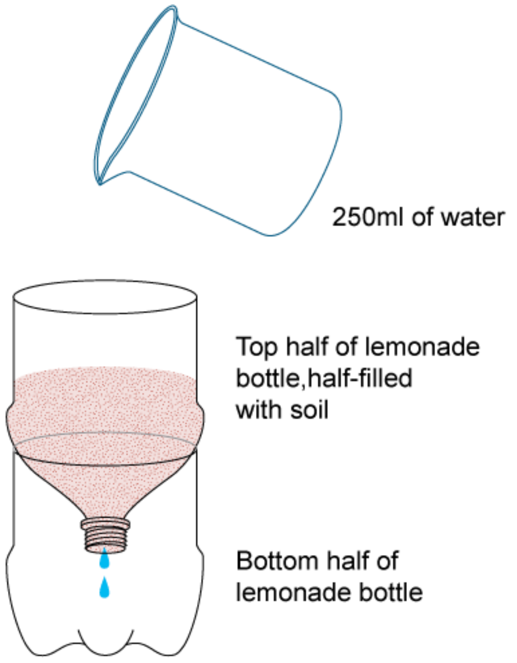


Figure 3.3 Model of soil permeability and infiltration

Part C: Floodplains and wetlands of the Murray-Darling Basin

- Use Google Maps to locate a section of river in the Murray-Darling Basin – for example, the Darling, Murray, Murrumbidgee, Paroo or Macquarie. Refer to the scale used at the bottom left-hand corner of the Google map. Facilitate discussion:
  - What is the scale of the Google map? Explain why that scale was selected or useful.
  - Explain the reasons for the differences in colour on the map.
  - What would occur in this section of the river after a significant rain event?
  - Describe the shape of the river and how this relates to its flow.
- Identify waterflows that go to the wetlands. Wetlands act as a filter and further slow waterflow.
- Discuss the importance of vegetation on the banks of the river and surrounding channel. Introduce the term riparian vegetation; the natural plants that cover the riverbanks. Riparian vegetation holds the soil intact, helping to reduce erosion. It also acts as a filter by capturing sediment carried by run-off, thereby limiting soil particles reaching the river. Contrast the existence of riparian vegetation with an area affected by clearing or trampling by livestock.
- Use Figure 3.2 to show what occurs when the river channel receives increased flows above its base flow, such as during small to medium flood events. Explain that large flood events where the river flows over the banks and into the floodplain result in the interconnection between wetlands and the river channel. The water that

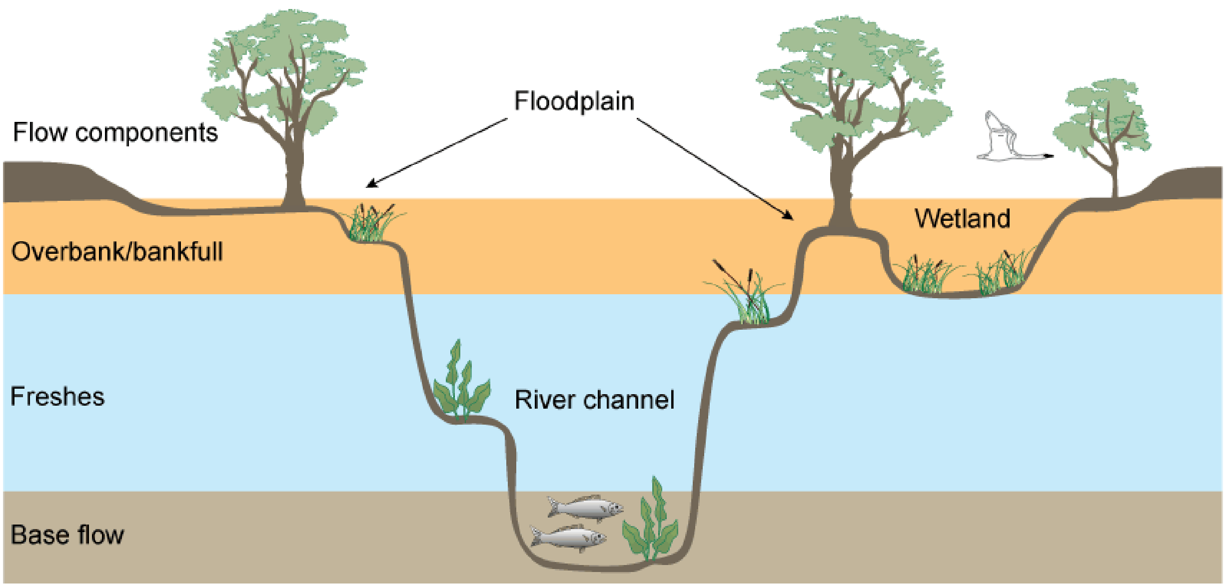
replenishes the wetlands on either side of the riverbank recedes after the flood to supplement the base flows via below-surface movement. The wetlands act as a large sponge and hold water for extended periods and, over time, water flows through to replenish groundwater.

- Use Figure 3.4 to describe how rich organic matter (on which a healthy aquatic ecosystem depends) flows into the river when flooding connects the river channel to the surrounding floodplain and wetlands. Use the analogy that the floodplains are like a supermarket for the river. When sufficient water results in over-bank flows, the water picks up organic matter. As the water recedes, rich with this organic matter, it 'feeds' the river. Invertebrates break down the organic matter into nutrients, which are used by other organisms. High water levels enable the transfer of small fish, aquatic insects (macro-invertebrates), micro-organisms and nutrients into the river. This in turn provides food for larger aquatic animals such as fish, turtles and

Figure 3.5 The connection between over-bank flows and floodplains and wetlands

platypus. The health of the river is dependent on these flood events. Have the students create food chains or more complex food webs to show energy flows in an aquatic ecosystem.

- View images of wetlands and identify organisms that inhabit them at the Murray-Darling Basin Authority's website at http://images.mdba.gov.au/thumbnails.php?album=80 .
- Students create a diagram to visually represent what occurs when the floodplains and wetlands are connected through times of over-bank flows, which should look something like Figure 3.5. Students explain the benefits of periodic over-bank flows.



Courtesy Murray-Darling Basin Authority

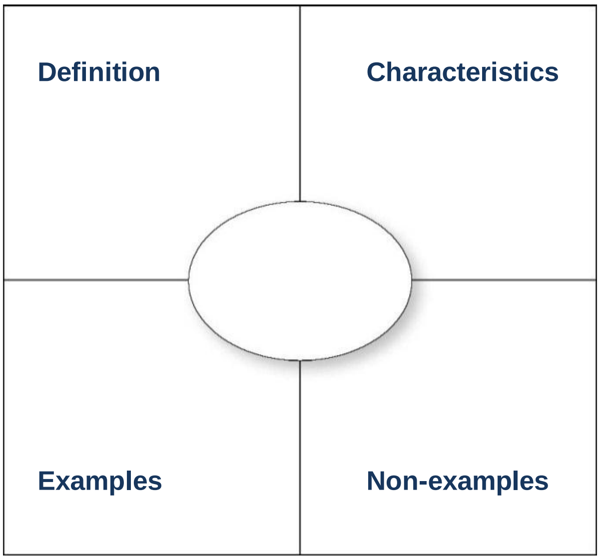
Figure 3.4 Cross-section of a river

Developing vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as 'irrigation', and on the back of the card its meaning – 'diverting water for farming'. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

Unfamiliar terms may include underlined glossary items.



Lesson 3.2
How are parts of the Murray-Darling Basin river system connected?

Outcome

Students describe the interrelationships among parts of the natural system.

Background

The Murray-Darling Basin is a natural system that is made up of a large catchment area that captures and funnels water from precipitation (input) into two major rivers and their tributaries. From time to time waterflows over riverbanks through to floodplains and wetlands where the water is enriched with nutrients. Throughout the system, water can be lost back into the atmosphere through evapotranspiration and water seeps into the ground to recharge underground water stores housed in porous rock (aquifers). The remaining water from the system flows out to sea (output).

Resources and preparation

Student worksheet

Student worksheet 3.1 The Murray-Darling Basin as a system

Reference

eWater CRC, Where did all the water go?, 2010, www.ewater.com.au/h2othinking/?q=2010/08/where-did-all-water-go

Lesson outline

- Once students have an understanding of the water cycle and the role of the catchment, wetlands and floodplains in the Basin they can represent how they are interrelated and connected to other parts of the system.
- Ask: What are the important natural parts of the Murray-Darling River system?
- At this stage don't include discussion of human modifications such as dams, weirs and agricultural developments. This can be more effectively covered once students complete their mind maps of the natural system and then focus on how changes affect it.
- As a class, develop a list of the key components of a system that represent how the Murray-Darling Basin works. The list would include catchment, vegetation, soil and subsoil (porous rock), groundwater, rivers and tributaries, lakes, wetlands, floodplains and ocean.
- Provide Student worksheet 3.1 to students who require support to create their own mind map.
- Once the mind maps are completed, discuss:
  - the input (precipitation) and the outputs (water flowing out to the ocean) and evaporation/ evapotranspiration
  - the flow of water and the roles that the catchment, wetlands, floodplains and vegetation all play
  - the role of water and nutrient flows in maintaining healthy ecosystems. (It is important that these are considered productive parts of the system, particularly when students come to compare them to human land modifications, such as agricultural developments that have a productive element.)

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Student worksheet 3.1

The Murray-Darling Basin as a system

Use interconnecting lines and the terms provided to create your own visual representation of a functioning river system such as a mind map or a concept map. Use additional terms if required.

- catchment
- rivers
- tributaries
- oceans
- vegetation
- soil
- wetlands
- floodplains
- groundwater
- ecosystems
- infiltration

INVESTIGATION 4

What effects have humans had on the Murray-Darling Basin river system?

Introduction

In previous lessons students developed their understanding of the Murray-Darling Basin as a natural system. In this series of lessons students explore ways in which humans have changed components of the natural system and investigate the consequences of those changes.

Due to the variable rainfall across the Basin, water has been diverted from the river system and controlled for various uses. Significant areas of natural vegetation have been replaced with short-rooted crops or grasses. Extraction of water, changes to the natural floodplain by land clearing and development and modifying flows all impact on the productivity of the Murray-Darling Basin and its sustainable use.

Wetlands play an important role in supporting the ecological health of the river system. In the Basin almost 50 per cent of the wetland area has been lost since European settlement. Most of the remaining wetlands have been altered or degraded by changes to rivers flows, reduced flows to floodplains by levee banks and causeways, pollution and excessive grazing.

Native fish populations in the Basin's rivers have declined under threats from flow regulation, habitat degradation, lowered water quality, manmade barriers to fish movement, introduction of alien fish species, fisheries exploitation, the spread of diseases and the translocation and stocking of fish.

Native fish strategy for Murray-Darling Basin 2003–2013, www.mdba.gov.au/programs/nativefishstrategy

Australian Curriculum links

Science – Year 7		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Biological sciences • Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions **Earth and space sciences** • Some of Earth's resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations • Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management	**Questioning and predicting** • Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge **Planning and conducting** • In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions **Evaluating** • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • the hydrologic cycle describes the movement of water between the atmosphere, land and oceans • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed • Census data can be used to describe the growth, movement and characteristics of the populations of places • information collected in a survey should be evaluated for reliability **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships **Communicating** • each type of communication has conventions that should usually be followed for communication to be effective • the climate of a place can be represented by a graph of average monthly temperature and precipitation **Planning and implementing actions** • finding a way of resolving a problem depends on an understanding of the causes of that problem **Reflecting on the investigation** • each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

Lesson plans

Lesson 4.1
Altering the flow of rivers: extraction, diversion and storage

Outcome

Students describe ways in which humans alter the patterns of waterflows in rivers in the Murray-Darling Basin.

Background

Water resource management techniques such as weirs, levees, spillways, locks, floodgates, irrigation and drainage canals and large dams are used to store and divert water. Such modifications can prevent or at least greatly reduce flooding across the Basin, which means the loss of an important natural process.

To calculate waterflows in the Murray-Darling Basin under natural conditions (without human influences) CSIRO Land and Water scientists used computer models. They estimated that under natural conditions almost 11,000 gigalitres of water per year is consumed in wetlands, on the floodplains, or by evaporation from the river surface, and that 12,890 gigalitres per year or 54 per cent of the run-off reaches the sea.

Under current conditions, some of the water that would have been consumed by wetlands and the floodplain is now used for irrigation or evaporated from reservoirs. CSIRO Land and Water scientists believe that, in a typical year, about 21 per cent of run-off reaches the Murray mouth and flows out to sea.

Interpolated from Table 6 Average Annual Flows at Selected Sites in the Murray-Darling Basin www.mdba.gov.au/services/education-resources

Resources and preparation

Part A

Figures, graphs, maps and tables

Map 4.1 Rivers and tributaries of the Murray-Darling Basin

Publication

Discover Murray, Murray River Locks, Weirs, Dams and Barrages, www.murrayriver.com.au/about-the-murray/locks-weirs-dams-barrages

Student handout

Student handout 4.1 Murray-Darling Basin water works

Part B

Figures, graphs, maps and tables

Graph 4.1 Median monthly flows – River Murray downstream of the Yarrawonga Weir

Part C

Figures, graphs, maps and tables

Table 4.1 Average annual flows in the Murray-Darling Basin

References

ABC Science, Coorong, www.abc.net.au/science/features/coorong

Discover Murray, Murray River locks, weirs, dams & barrages, www.murrayriver.com.au/about-the-murray/locks-weirs-dams-barrages

Flagship CSIRO, Lamontagne S, McEwan, K Webster I, Ford, P, Leaney, F and Walker, G 2004, Coorong, Lower Lakes and Murray Mouth. Knowledge gaps and knowledge needs for delivering better ecological outcomes. Water for a Healthy Country National

Research, Canberra, www.csiro.au/resources/WaterAvailabilityInMurray-DarlingBasinMDBSY.html

Save the Murray, Coorong/Lower Lakes/Murray Mouth fact sheet, www.savethemurray.com/media/fact_sheet_4_coorong_llmm.pdf

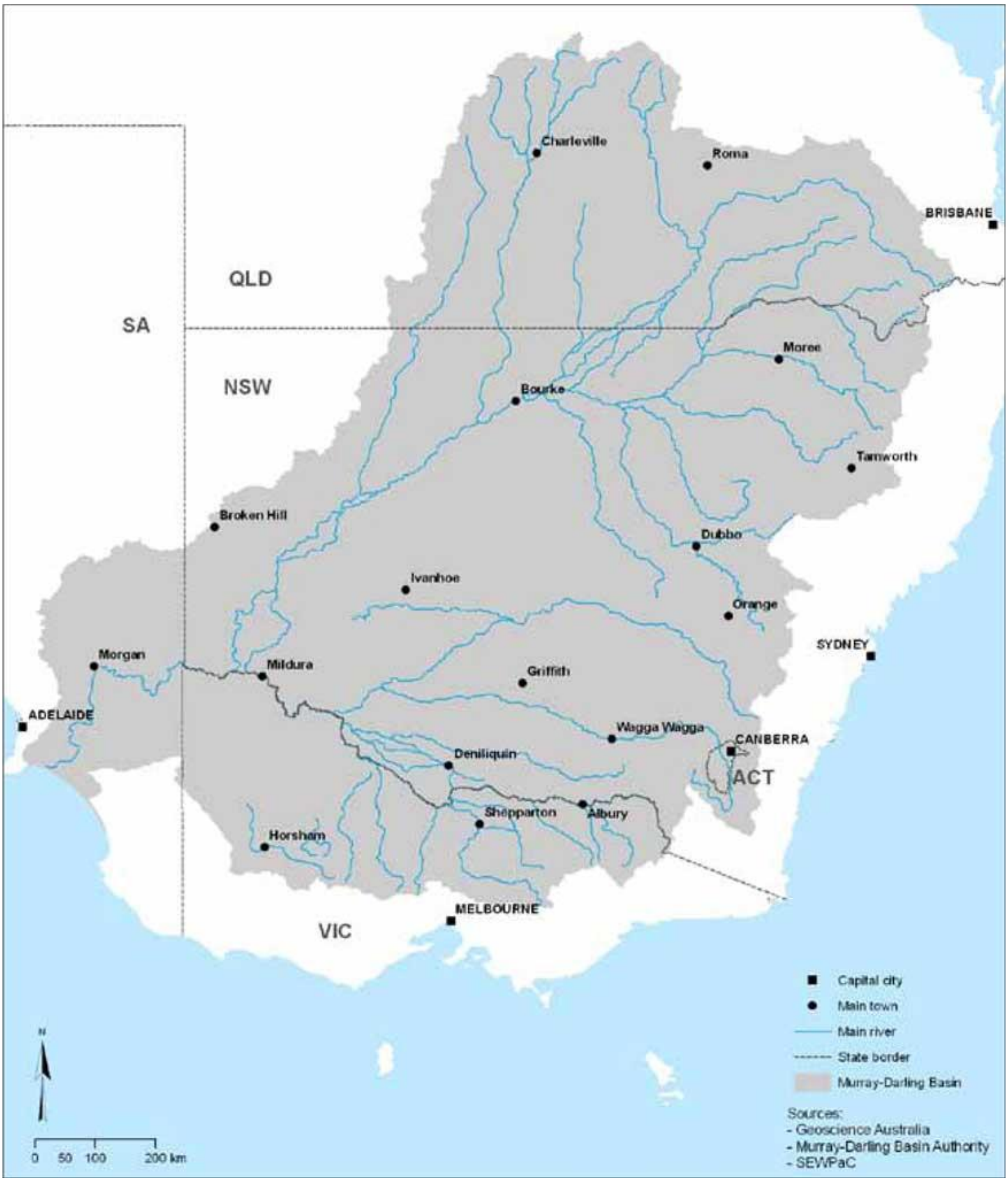
Sea Water Now, Coorong, www.seawaternow.com/lakes/v2/LowerLakesMap.html

State Library Government of South Australia, Images of the River Murray mouth, 1949–2003, http://samemory.sa.gov.au/site/page.cfm?u=463&c=3588

Lesson outline

Part A: How is water in the Basin controlled and regulated?

- Show Map 4.1. Identify the main rivers, the Darling, Murrumbidgee and Murray, and their tributaries. Consider the water levels required to sustain the level of food production across the Murray-Darling Basin.
- Ask: How would people get water to their properties to support large-scale production? What are the benefits of these developments? How has the environment been modified to create them? What effect would taking water out of these rivers have on downstream rivers, their tributaries and other users downstream? What are the consequences? List these questions to focus the inquiry and to refer to as students undertake further research about how water is regulated in the Murray-Darling Basin.
- Provide Student handout 4.1 to view a range of images highlighting the works completed on the rivers of the Murray-Darling Basin, their tributaries and surrounds. Discuss the reasons for the works. Students group images of the works according to their use – for example, ensuring water extraction, diversion and storage of water from the river system. Students could research in more detail the different types of water work developments.
- Provide a brief history of the development of locks, weirs, dams and barrages built along the Murray River to regulate the flow of water. An excellent online reference is 'Murray River locks, weirs, dams and barrages'. Organise students into groups to read sections of the online resource with the task of creating a class timeline demonstrating the major changes to the regulation of the Murray River.

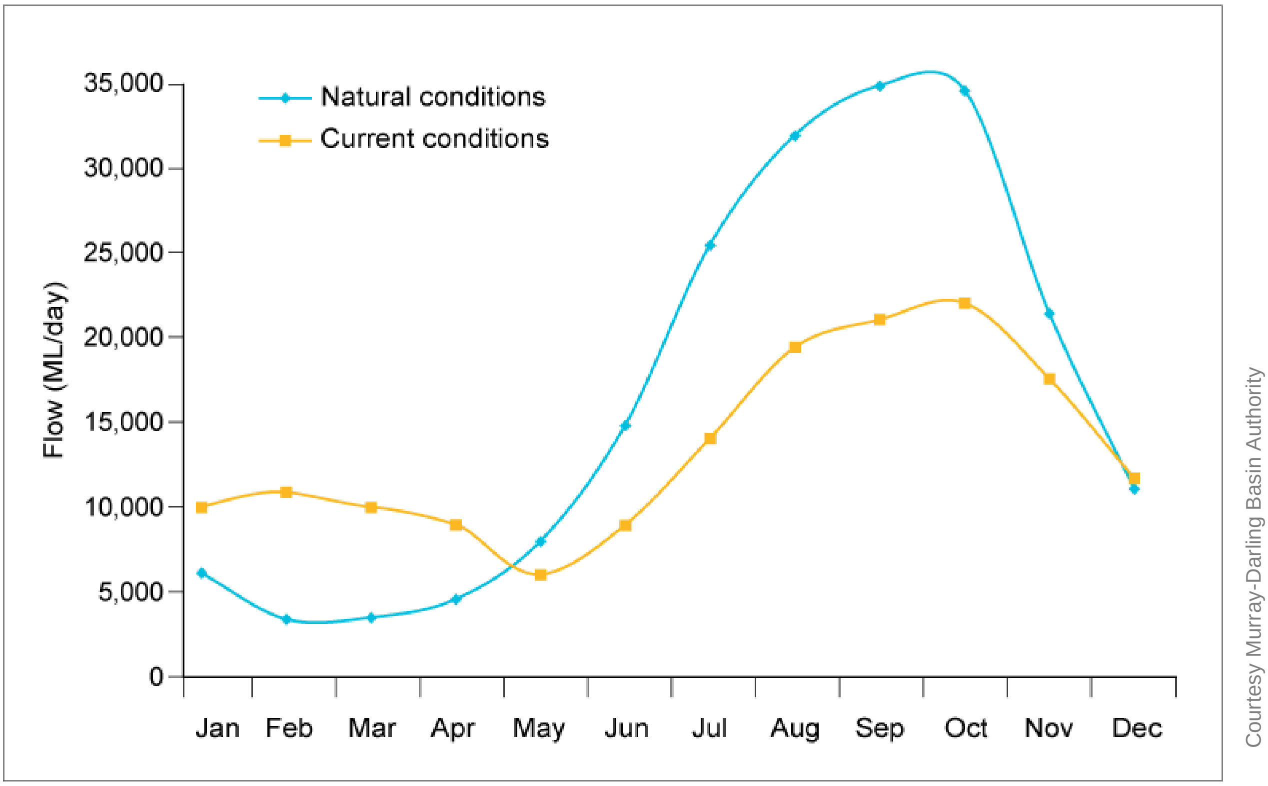


Courtesy Murray-Darling Basin Authority

Map 4.1 Rivers and tributaries of the Murray-Darling Basin

Part B: What effect does regulating the river have on its flow?

- Use Graph 4.1 to highlight the changes to riverflows in a section of the Murray River over a year compared to natural flows. Interpret the graph, and pose questions such as:
  - In what months/season are flows highest under natural conditions? How does that compare with current conditions? Why has this change in flow occurred?
  - In what months/season are flows lowest under natural conditions? How does that compare with current conditions? Why has this change in flow occurred?
- Weirs and dams are used to regulate water.
  - Describe the benefits of these developments to communities that depend on water for their livelihood.
  - Describe potential problems that these developments may cause.



Graph 4.1 Median monthly flows – River Murray downstream of the Yarrawonga Weir

Part C: How much water from the Murray-Darling Basin reaches the sea?

- Table 4.1 indicates the changes in outflows of the Murray-Darling Basin, comparing natural flows to current conditions. What does the data suggest?
- What are the positives and negatives of storing water in reservoirs and dams?
- Water is diverted from the river system for public water use, crop irrigation and livestock. How does this affect the riverflows?
- What possible problems may arise from the fact that water outflow to the sea has dropped from 54 per cent to 21 per cent?
- View the website: http://samemory.sa.gov.au/site/page.cfm?u=463&c=3588 . Discuss their observations of the river mouth and link them to the changes in riverflow over time.
- Discuss reasons why the Murray River mouth would close over. Ask students how the sand would be deposited and built up to stop the riverflow. Have them debate the benefits of closing the mouth of the Murray or leaving it open so water can flow out to sea.
- Students produce a report for the community explaining the benefits and issues of diverting water from the rivers in the Murray-Darling Basin. Students identify issues related to allowing rivers to flood at certain times, however they also point out the benefits of these over-bank flows. Students consider how a healthy wetland, floodplain and connected river may benefit agriculture. Allow students to undertake their own inquiry about changes in waterflows over time. A hot topic of debate is the health of the Coorong, an important wetland area in South Australia at the mouth of the Murray. The Coorong is dependent on sufficient waterflows to function and provides an important habitat for many species of plants and animals including migratory birds.

Table 4.1 Average annual flows in the Murray-Darling Basin

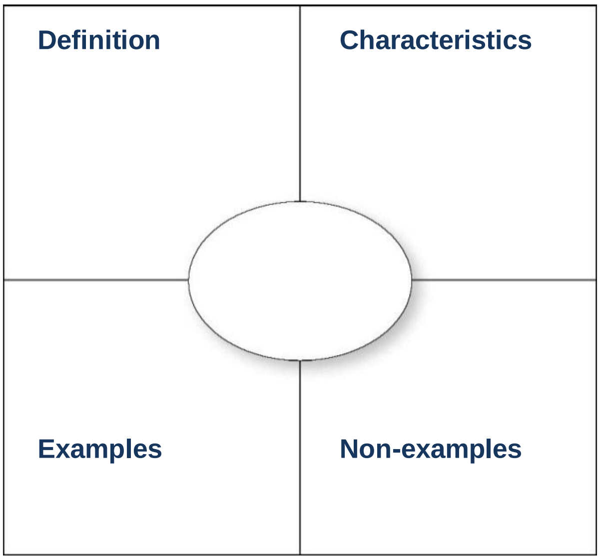
	Natural conditions (gigalitres per year)	**Current conditions (gigalitres per year)**
Run-off	23,850	23,850
Inter-basin transfers (water that comes from outside the Murray-Darling Basin)	0	1,200
Diverted	0	11,580
Evaporated from reservoirs	0	1,430
Consumed by wetlands, floodplains	10,960	6,970
Outflow to sea	12,890	5,070
Outflow to sea as a percentage of run-off	54%	21%

Developing vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as ‘irrigation’, and on the back of the card its meaning – ‘diverting water for farming’. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

Unfamiliar terms may include underlined glossary items.

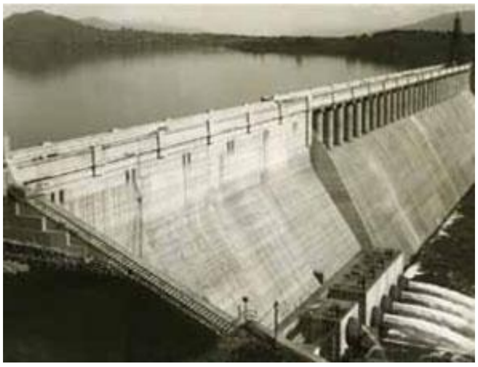


Student handout 4.1

Murray-Darling Basin water works

Courtesy Murray-Darling Basin Authority

Weir infrastructure at Yarrawonga on the Murray River



Hume Dam

Torrumbarry Weir facing downstream

Courtesy Murray-Darling Basin Authority. Photograph by Arthur Mostead

The riverboat Canberra on the Murray River

Courtesy Murray-Darling Basin Authority

Lock 4 on the River Murray, Bookpurnong South

Goolwa Barrage

Student handout 4.1 cont.

Murray-Darling Basin water works

Farm irrigation

Irrigation canal supplying water to furrows near Griffith,

Buckinbah Weir near St George, Queensland

Lock 5 on the Murray River

Example of an ancient Aboriginal fish trap, Macquarie

Irrigated crops

Student handout 4.1cont.

Murray-Darling Basin water works

© CSIRO. Photograph by Willem van Aken

Dethridge wheel measuring irrigation

Courtesy Murray-Darling Basin Authority. Photograph by Arthur Mostead

Groundwater bore being used for irrigation

© CSIRO. Photograph by Gregory Heath

Irrigation canal supplying water to a maize crop near Hay, NSW,1993

© CSIRO. Photograph by Willem van Aken

Pumping equipment used to pick up channel supply water

Lesson 4.2
How does regulating a river affect fish populations?

Outcome

Students describe the impact of developments that regulate waterflow on fish populations. They research the distribution and abundance of fish species over time. Scientific data is used to draw conclusions about how regulating waterflow affects fish populations.

Background

Fish are near the top of the aquatic food chain, and are sensitive to both short- and long-term environmental change. Consequently, the health of native fish communities can serve as an indicator of the overall health of Murray-Darling Basin's water resources.

Over the past 100 years, populations of native fish species in the Basin have suffered serious declines in both distribution and abundance. The population of native fish is currently estimated to be about 10 per cent of what it was before European settlement.

> Over the past century, river regulation to provide water on demand through dams, weirs and diversions has changed the natural flooding and drying cycles of the river systems. This has affected the health of river habitats and native fish populations. Across the Basin, changed riverflows continue to exacerbate the problems of salinity, alien fish species and blue-green algal blooms as well as declining native fish populations.
>
> Native Fish Strategy for the Murray-Darling Basin 2003–2013, www.mdba.gov.au/programs/nativefishstrategy

Natural seasonal flows have been altered due to water being stored and released when irrigators require it. As a result, floods have decreased in size and the number of them, and even their timing, has changed. In particular, the occurrence of small and medium floods has reduced, effecting fish population and ecology.

Another outcome of releasing water from deep storage dams is the potential for much colder water to be released into the river system. This is known as cold-water pollution, which is an artificial decrease in the temperature of river water in a natural ecosystem.

> The life cycles of fish and other aquatic creatures are finely tuned to the natural daily and seasonal variations in temperature. Large volumes of cold water, lowering the overall temperature of water downstream from a dam, disturb the delicate ecological balance by creating an unseasonal environment that ecologists have compared to an 'eternal winter'. In spring and summer the rising temperature of the water becomes an important environmental cue, triggering spawning of native fish. A release of cold water from a major dam can suppress spawning for up to 300 km downstream. The ability of native fish to reproduce, grow and maintain sustainable numbers is reduced. Introduced species such as carp flourish, competing with native fish for food and habitat. Some species of native fish can disappear from large sections of the river.
>
> NSW Office of Water www.water.nsw.gov.au/ Water-management/Water-quality/Temperature/ Temperature/default.aspx

Barriers to fish passage are regarded as a key threat to native fish communities in the Murray-Darling Basin (Native Fish Strategy for the Murray-Darling Basin 2003–2013, www.mdba.gov.au/programs/nativefishstrategy). To inform management of native fish species, scientists have studied the ecology of downstream fish movement, the extent of downstream fish movement past weirs and the impact of weirs on downstream fish movement.

Fish movements may be localised where they access food, shelter or avoid predators. At certain times during the year, usually aligned to rising water levels or temperature, fish species cover significant distances moving downstream and often returning within one or two days. This migration is thought to coincide with their breeding cycle.

Native Fish Strategy for the Murray-Darling Basin 2003–2013, www.mdba.gov.au/programs/nativefishstrategy

Resources and preparation

Part A

Figures, graphs, maps and tables

Map 4.2 Fish species range across the Murray-Darling Basin

Table 4.2 Threats to native fish species Part B

Figures, graphs, maps and tables

Figure 4.1 Hume Dam

Map 4.3 Barriers to fish movement in the Murray-Darling Basin

Student worksheet

Student worksheet 4.2 Fish movements study: Murray River

References

Department of Sustainability and Environment, Victoria, VicFishInfo: Biological Information for Management of Native Freshwater Fish in Victoria, www.dse.vic.gov.au/plants-and-animals/native-plants-and-animals/freshwater-ecosystems/vicfishinfo-biological-information-for-management-of-native-freshwater-fish-in-victoria-opening-page-and-index

Department of Sustainability and Environment, Victoria, Riverine ecology, www.dse.vic.gov.au/arthur-rylah-institute/research-themes/riverine-ecology

Department of Sustainability and Environment, Victoria, Watering floodplain wetlands in the Murray–Darling Basin to benefit native fish, www.dse.vic.gov.au/__data/assets/pdf_file/0009/105669/ARI_Technical_Report_189_Watering_Floodplain_Wetlands_in_the_Murray-Darling_Basin_to_Benefit_Native_Fish.pdf

Graham, Russell and Harris, John H, 2005, Floodplain inundation and fish dynamics in the Murray-Darling Basin. Current concepts and future research: a scoping study, Cooperative Research Centre for Freshwater Ecology, Canberra, http://freshwater.canberra.edu.au/Publications.nsf/0/1b16a245ba5f9e6aca25702f0019f0a8/$FILE/HarrisFloodplainWebVsn.pdf

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Murray-Darling Basin Commission, Fish fact sheets, www.mdba.gov.au/services/publications/native-fish-fact-sheets

Murray-Darling Basin Commission, Murray-Darling Basin e-resources 2005: Fish, www.mdba.gov.au/services/education-resources

Murray-Darling Basin Ministerial Council, Native Fish Strategy for the Murray-Darling Basin 2003–2013, www.mdba.gov.au/programs/nativefishstrategy

O'Connor, Justin, O'Mahony, Damien, O'Mahony, Justin 2003, Downstream migration of adult Murray-Darling fish species with particular reference to the impact on that movement, Department of Natural Resources and Environment, Arthur Rylah Institute for Environmental Research, Heidelberg, www.dse.vic.gov.au/CA256F310024B628/0/43844F9B7ABD54A2CA25714C00157CE2/$File/Downstream_Movement_of_Adult_Murray_Darling_Fish_Speci es_2003.pdf

Office of Water, NSW, Temperature – Cold water pollution, www.water.nsw.gov.au/Water-management/Water-quality/Temperature/Temperature/default.aspx

World Wildlife Fund, Threat of invasive species in the Murray-Darling, http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/river_decline/10_rivers_risk/murray_darling/murray_threats/

Lesson outline

Part A: How have fish species abundance and distribution changed over time?

- Discuss the range of different fish species across estuarine environments, lowland, slopes and upland mountainous regions. Ask students to research a particular species of interest and describe its natural distribution and how that may have changed over time.
  - Use the website Murray-Darling Basin e_ Resources Chapter 4 Fish, www.mdba.gov.au/services/education-resources
  -
  - Students access distribution and abundance data on a particular native fish species found in the Murray-Darling Basin. Compare data for records before and after 1980. Students access the fish fact sheets from the Murray-Darling Basin Commission website at www.mdba.gov.au/services/publications/native-fish-fact-sheets
- Identify key threats to native fish species and list these in a table based on Table 4.2 below. Provide a second column to describe how each threat affects native fish species. Discuss actions that could be implemented or are being conducted to address the threats.

Table 4.2 Threats to native fish species

Threat	How the threat affects native fish species
Changes to natural riverflows	
Degraded habitat	
Lowered water quality	
Barriers	
Introduced species	

Part B: What do we know about fish movements and the effects of barriers?

- Refer to an image showing water being released from the bottom of a large water storage dam such as Figure 4.1 of the Hume Dam. Consider the temperature of the water compared to the temperature at the surface of the dam. Ask students to predict what impact water temperature might have on fish populations

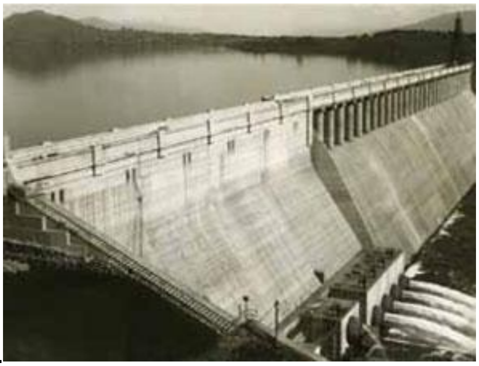
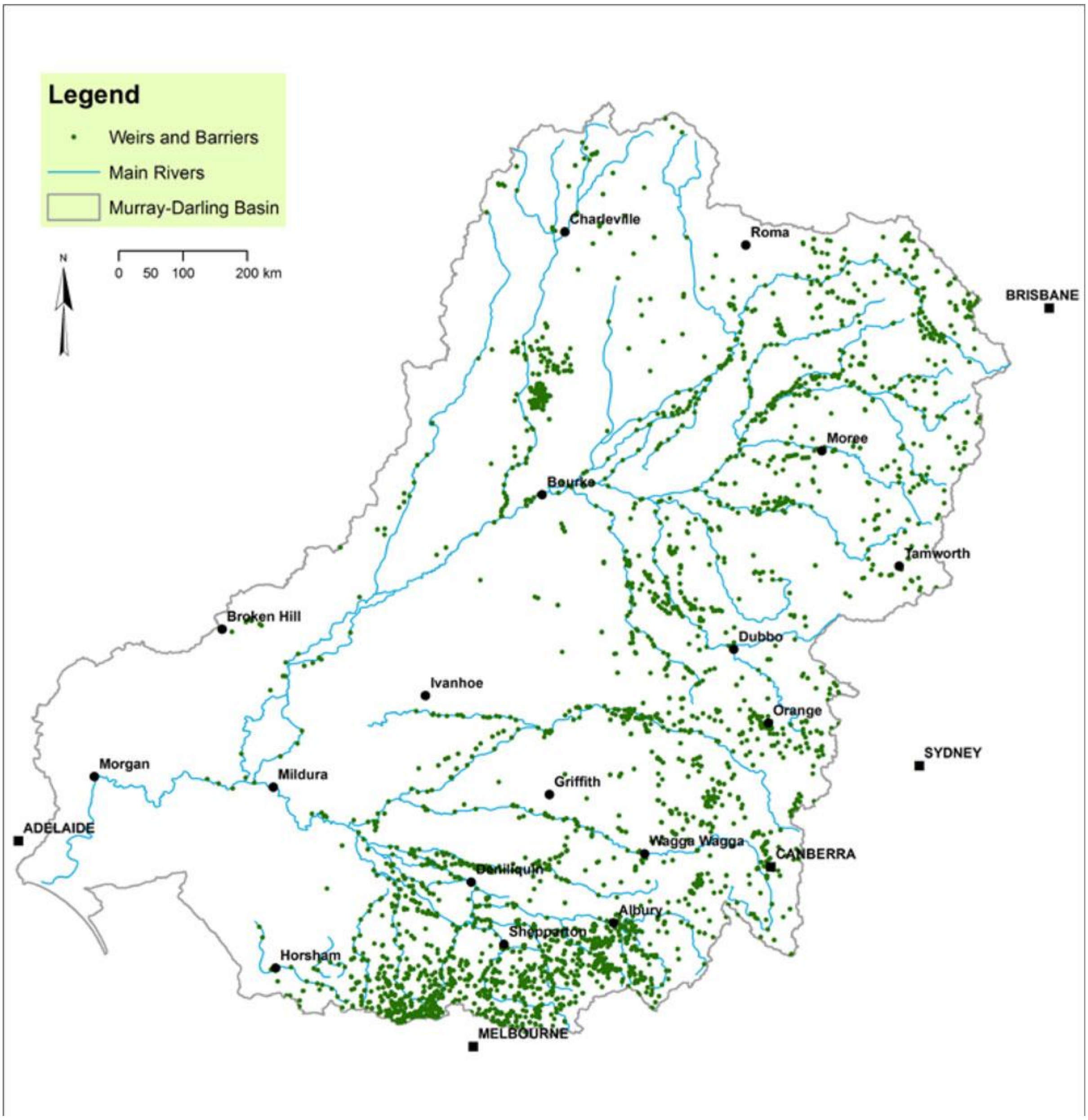


Figure 4.1 Hume Dam

- Discuss the issue of cold water pollution. This occurs when water is released from the bottom of a dam into a river. The water from the dam is significantly colder than the water temperature of the river into which it flows.
- Discuss a study where scientists implanted radio-tracking devices (radio-telemetry) into samples of fish captured along the Murray River and tracked their movements over a period of two years. For further information refer to O'Connor et al (2003).
- Provide Student worksheet 4.2. Students use the graphs and data to find out about fish movements in the Murray River and its tributaries. Graphs relate to fish movement, riverflows and temperature. Students also consider impacts on fish movement by barriers such as weirs, which are used to regulate waterflows. Provide Map 4.3, and prompt students to consider the extent of the distribution of weirs and other barriers and their effects on fish populations. Discuss the importance of increasing riverflows during the year and the optimum times that this should occur – for example, relating it to spawning periods in spring through to early summer.
- Students research the effect of introduced fish species on native fish species within the Murray-Darling Basin. Students make connections between the distribution and abundance of native fish species and that of introduced fish species.
- Research local Aboriginal peoples' histories of fishing along the Murray River. Make a note of different techniques used by different peoples including fish traps.
- Provide data on the reduced frequency of flooding. Relate this to fish moving to floodplains and wetlands that provide feeding, spawning and nursery areas for many species, such as golden perch, Murray cod and silver perch. Most large native river fish spawn in spring, requiring particular water levels and temperature.

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.



Courtesy Murray-Darling Basin Authority

Map 4.3 Barriers to fish movement in the Murray-Darling Basin

Student worksheet 4.2

Fish movements study: Murray River

Scientists studying freshwater fish movements in the Murray River in 2003 found that generally the freshwater fish inhabited a section of river within a range of 2–5 kilometres.

At certain times during the year, however, many fish species such as golden perch, a native fish species, migrate large distances at times more than 60–80 kilometres downstream of their usual range.

1. List three reasons that fish would move upstream or downstream from their usual range.

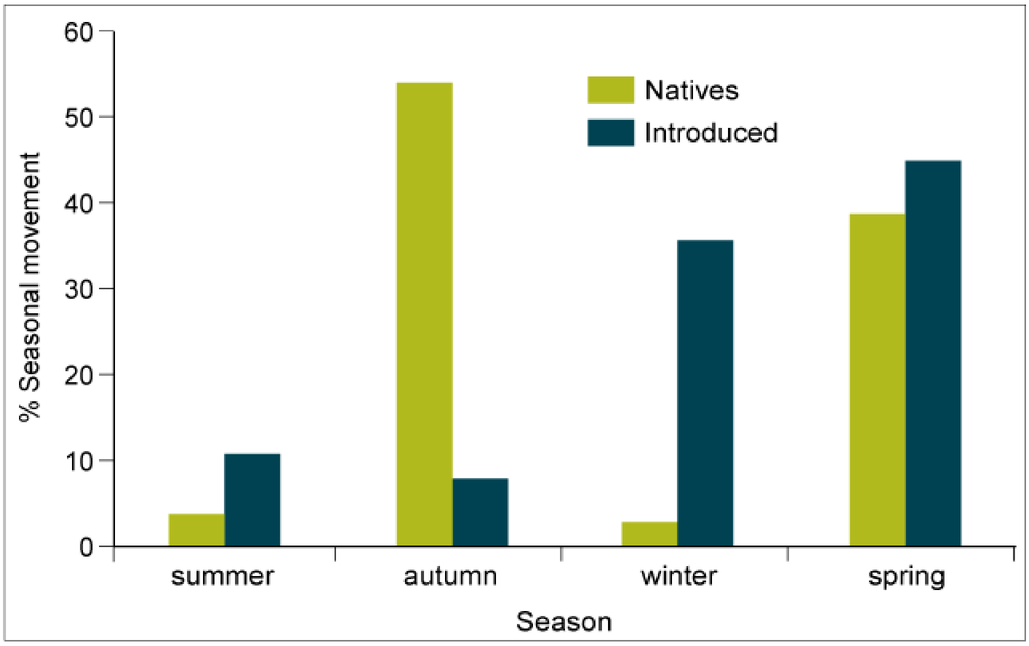
a) --

b) --

c) --

2. Analyse Graph A for native and introduced fish movements at a location on the Murray River. The data shows the movement of fish as a seasonal percentage.

3. Describe differences in fish movements for the four seasons.



Graph A: Standardised, percentage seasonal downstream movement for native and introduced fish at Kennedy's Weir, 2003

O'Connor, Justin, O'Mahony, Damien & O'Mahony, Justin, Downstream Movement of Adult Murray-Darling Fish Species: Final Report to Agriculture Fisheries & Forestry Australia, Arthur Rylah Institute, 2002, page 36

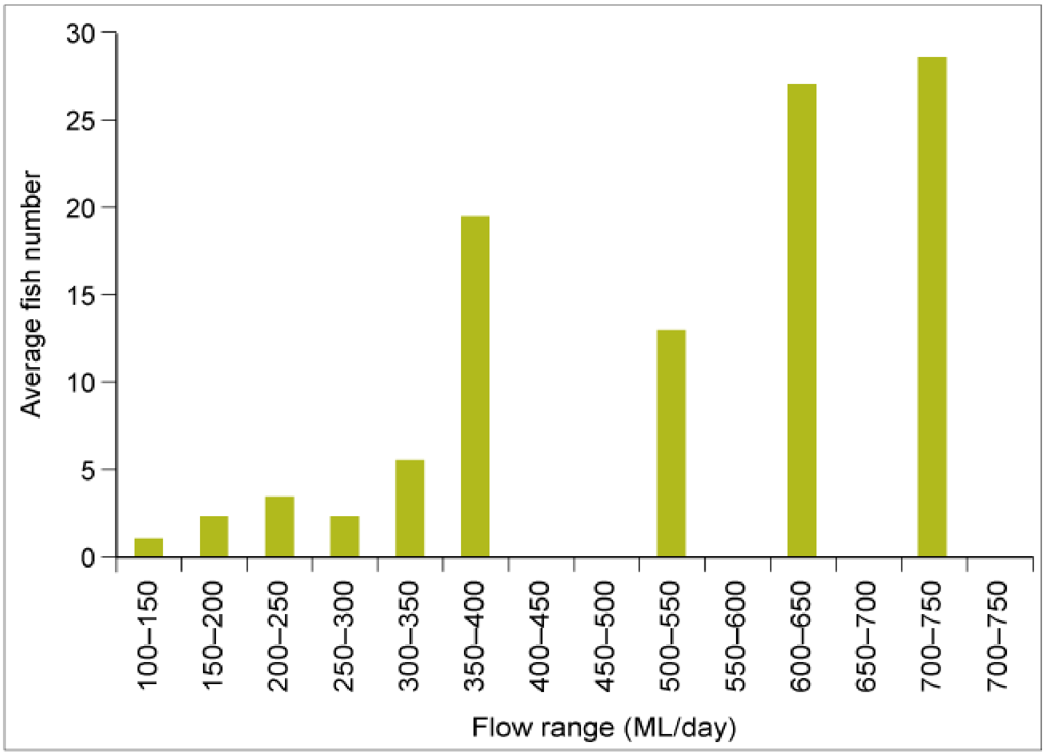
Student worksheet 4.2 cont.

Fish movements study: Murray River

4. Analyse Graph B, which shows the movement of native fish tracked during the study against the average daily number of native fish moving downstream at increasing flow range.

a) What does the data suggest?

b) What might be the possible reasons for increased riverflows? What is the importance of increased riverflows for native fish species?



Graph B: Average daily number of native fish moving downstream at increasing flow range, 2003

O'Connor, Justin, O'Mahony, Damien & O'Mahony, Justin, Downstream Movement of Adult Murray-Darling Fish Species: Final Report to Agriculture Fisheries & Forestry Australia, Arthur Rylah Institute, 2002, page 37

Student worksheet 4.2 cont.

Fish movements study: Murray River

5. Scientists believe that golden perch spawning is associated with increasing water temperature and water level. Graph C shows the weekly movement of fish from their capture location (usual range). Graph D shows the riverflow rate and temperature.

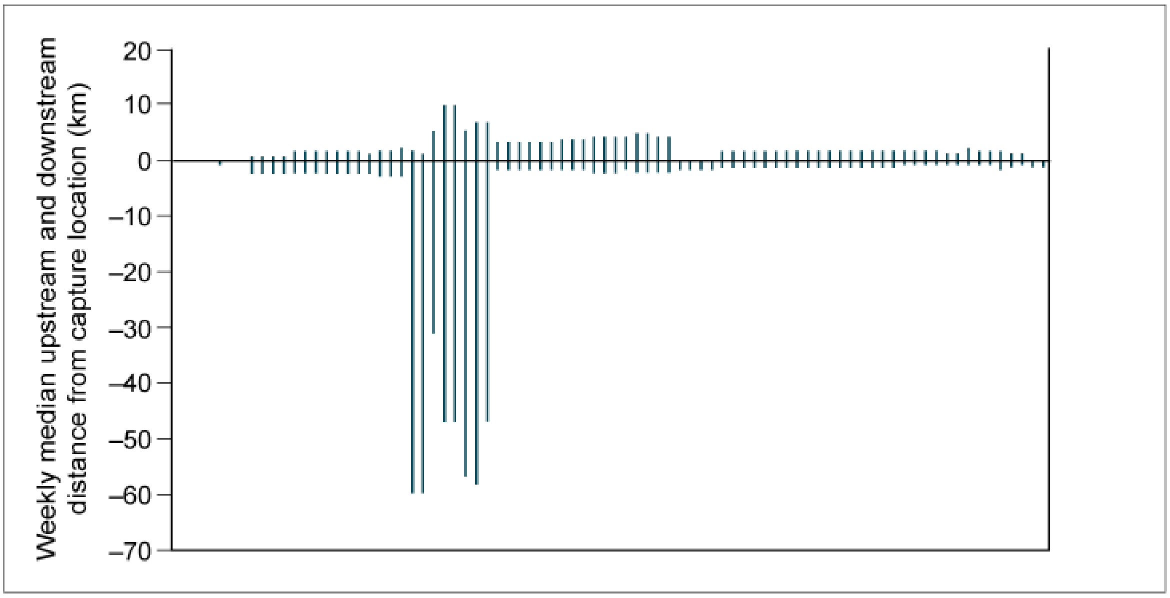
a) During which months were there significant fish movements downstream?

b) How would you describe the riverflow rate and temperature at this time?

c) Does the data in both graphs fit with the scientists' view of when golden perch spawn? Explain your answer.

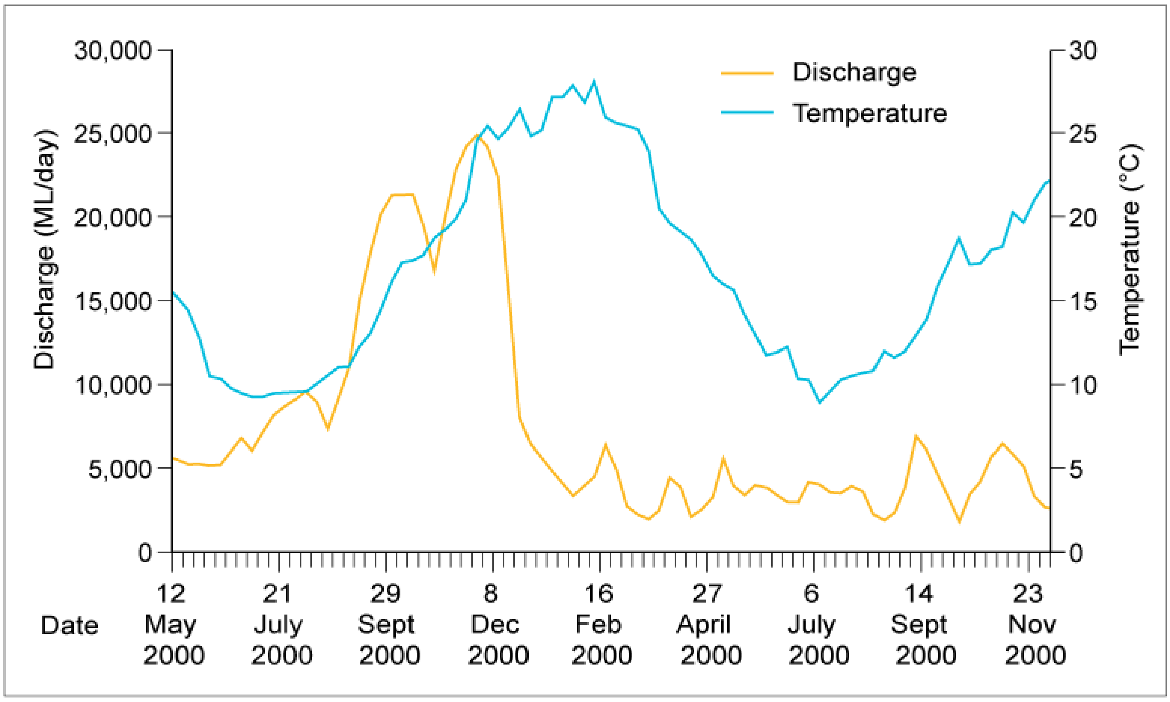
Student worksheet 4.2 cont.

Fish movements study: Murray River



© O'Connor et al

Graph C: Weekly movement of fish from their capture location (usual range)



© O'Connor et al

Graph D Riverflow rate and temperature

O'Connor, Justin, O'Mahony, Damien & O'Mahony, Justin, Downstream Movement of Adult Murray-Darling Fish Species: Final Report to Agriculture Fisheries & Forestry Australia, Arthur Rylah Institute, 2002, page 30

Student worksheet 4.2 cont.

Fish movements study: Murray River

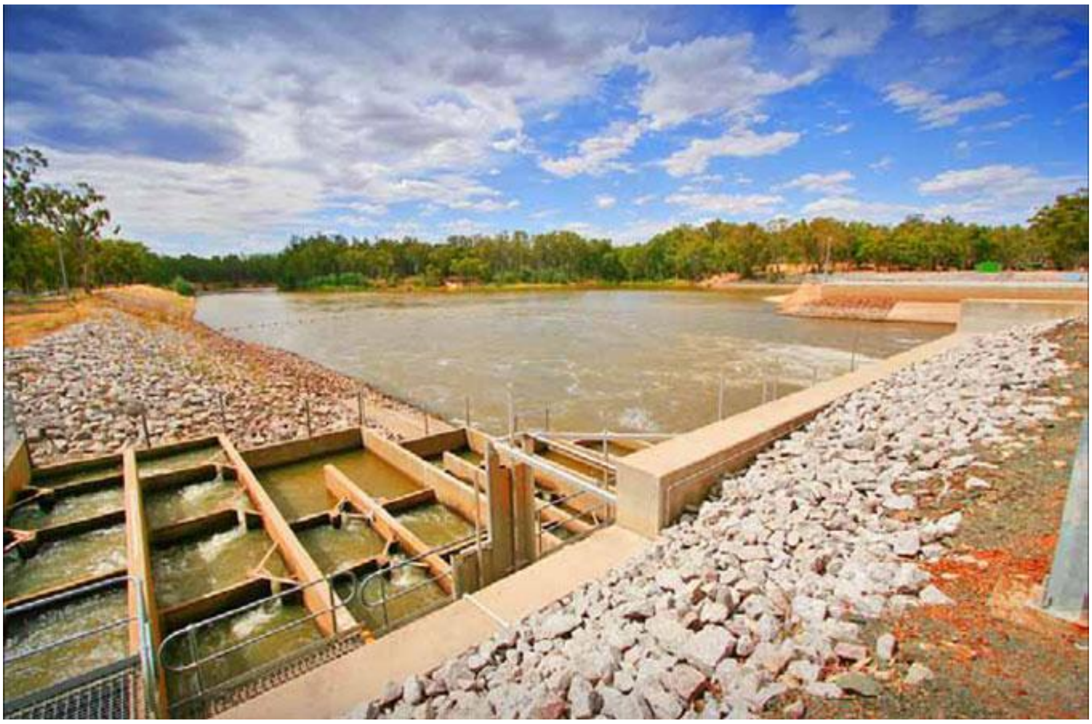
6. Scientists believe that floods are important for native fish species. When flooding occurs fish are able to move between the river channel and the floodplain. The floodplains and the connected wetlands provide a nursery for fish hatchlings.

   What is the effect on fish populations if flows are controlled and flooding is prevented? Explain your answer.

7. Scientists made an interesting observation at weirs such as the one at Torrumbarry:

   That when confronted by a downstream barrier more than 80 per cent of the fish were reluctant to pass downstream over or through barriers.

Describe the implications for populations of fish species of weirs in the Murray-Darling Basin such as the Torrumbarry Weir shown in this photograph.



Torrumbarry Weir facing downstream

Lesson 4.3
What is the effect of removing natural vegetation?

Outcome

Students relate increased salinity to clearance of natural vegetation and planting with shallower rooted plants such as crops and grasses. They explore impacts of changes to riparian vegetation.

Background

Salt is a naturally occurring substance found deep in the soils. The existence of salt deep in soil layers is thought to be a result of the weathering of rocks and the area being covered by an inland sea millions of years ago. Under normal conditions this salt is so far down the soil layers it does not affect plant growth. However many areas of farmland are showing evidence of increased salt at the surface (dryland salinity). This salt is carried upwards by groundwater. The water table rises when water from the surface that is not used by plants leaks into the soil. In natural conditions native plants with long roots and year-round demand for water maintain the water table at a safe level. However when the native vegetation is replaced with short-rooted crops that are grown and harvested seasonally the excess water seeps into the soil and raises the water table bringing up the salts with it. In areas of irrigated farming, salinity is exacerbated by the large amounts of excess water that leak into the soil causing the water table to rise.

Salt at the surface then finds its way into neighbouring streams and rivers via surface run-off. The salt in the ground can also move sideways in the soil layers and leach into streams. The result of both these actions is increased salinity in our waterways (in-stream salinity).

Salinity is the total concentration of salts in water or soil. Salts can be in the form of sodium chloride, magnesium, potassium and bicarbonate. Fertilisers, herbicides and pesticides all contain salts.

Salinity can be measured using a salinity meter, which measures the electrical conductivity (EC) . EC is measured in units called microsiemens per centimetre. A measure of 650 units can damage irrigated crops.

Riparian vegetation (the native vegetation along streams and rivers) filters nutrients, salts, and soil particles that contain salts. Therefore, the removal of riparian vegetation impacts on salt and sediment loads in waterways.

Livestock trample vegetation adjoining waterways and contribute to increased sediment load in the waterways due to increased erosion. They also increase nutrient levels through their wastes.

Resources and preparation

Part A

Figures, graphs, maps and tables

Map 4.4 Tree loss in the Murray-Darling Basin

Materials

- a plastic cup with holes in the bottom
- 3/4 cup of soil
- 1 x cup of water
- 1 x tablespoon of salt

Digital curriculum resource

R8938 Causes of soil salinity. (Information about how to access this resource can be found at www.ndlrn.edu.au/using_the_resources/access/access_information.html .)

Part B

Figures, graphs, maps and tables

Figure 4.2 Removal of riparian vegetation

Materials

- a plastic cup with holes in the bottom
- a margarine container of soil
- a container of water with a tablespoon of salt in it

Part C

Student worksheet

Student worksheet 3.1 Mind map: The Murray-Darling Basin (completed, from Lesson 3.2)

References

ABC, Hazardous soils identified across Basin, www.abc.net.au/local/audio/2011/08/25/3301682.htm

ABC, Salinity fact sheet, www.abc.net.au/learn/silentflood/factsheet.htm

Australian Academy of Science, Monitoring the white death – soil salinity, NOVA, www.science.org.au/nova/032/032box01.htm

Land, Water & Wool Program and the Future Farm Industries Cooperative Research Centre, Saltland Genie, www.saltlandgenie.org.au/index.htm

Managed Water Resources, The Murray-Darling Basin groundwater depletion story, www.anra.gov.au/topics/salinity/pubs/summary_reports/dryland_salinity/pubs/salinity-summary.pdf

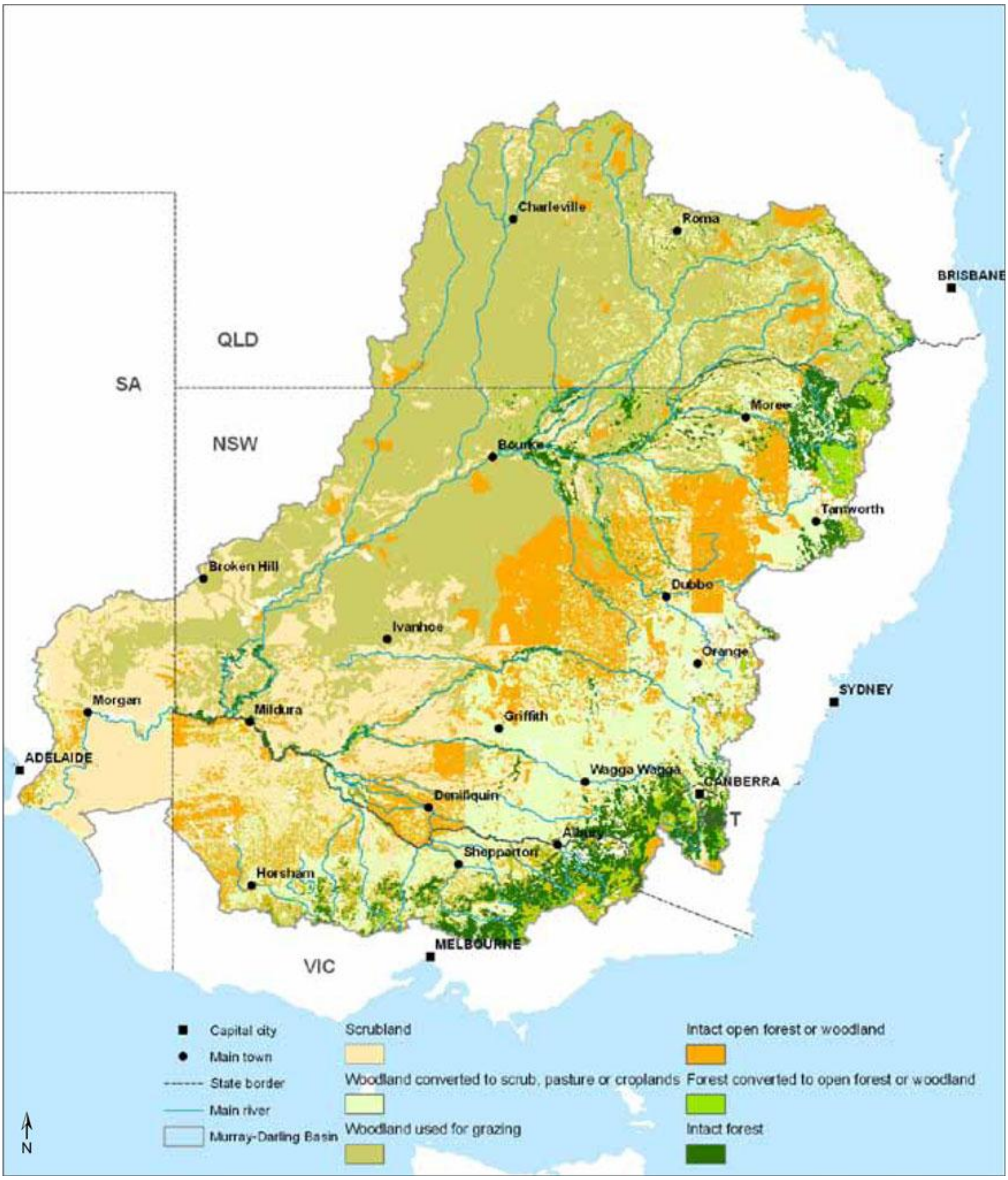
National Heritage Trust, Dryland salinity in Australia, http://managedwater.com/node/23?PHPSESSID=236bec7e6a0f1641fb469540b27341b7

Primary Industries and Resources, SA, Causes of dryland salinity, www.pir.sa.gov.au/__data/assets/pdf_file/0006/49785/saltcaus.pdf

Lesson outline

Part A: Impacts of removing natural vegetation

- Use Map 4.4 to establish the heavy levels of vegetation clearing across the Basin. Discuss reasons for this. In pairs, students make a list of issues that could occur as a result of land clearing.
- Ask students what they know about salinity. What causes it? Find out what students know about groundwater, rising water table, loss of vegetation, capillary action, flooding, measuring/units of salinity.
- Use interactive models and fact sheets to review the concept of salinity. Use a search engine with a key terms such as ‘salinity explained’. View the digital curriculum resource, R8938 Causes of soil salinity (Information about how to access this resource can be found at www.ndlrn.edu.au/using_the_resources/access/schools_landing.html .) Discuss how irrigation contributes to salinity.
- Students investigate salinity by observing salt water rising in a sample of soil. They use the ‘predict, explore, explain’ strategy.
    1. Prior to starting the experiment students predict what they expect to happen.
    2. Students add a sample of soil so as to three quarters fill the plastic cup.
    3. Students place the cup in the container of salty water.
    4. Over a week to ten days students observe and record the effect.
    5. Students explain their observations.
    6. Students’ explanation should include the fact that the salt water is drawn up through the soil by capillary action; water at the surface of the soil evaporates, leaving behind salt crystals. Students relate this to groundwater levels rising and bringing salt with it into the soil layers and reaching the surface.
- Students may ask how plants cope with water that contains salts. Support students to investigate the effect of different amounts of salt in a solution and to observe the effects on seedlings. Where possible, students could measure and record temperature and electrical conductivity (EC) with data-logging equipment and probes.
- Students create a poster demonstrating how salinity occurs, its affect on the land and strategies to address the issue.



Courtesy Murray-Darling Basin Authority

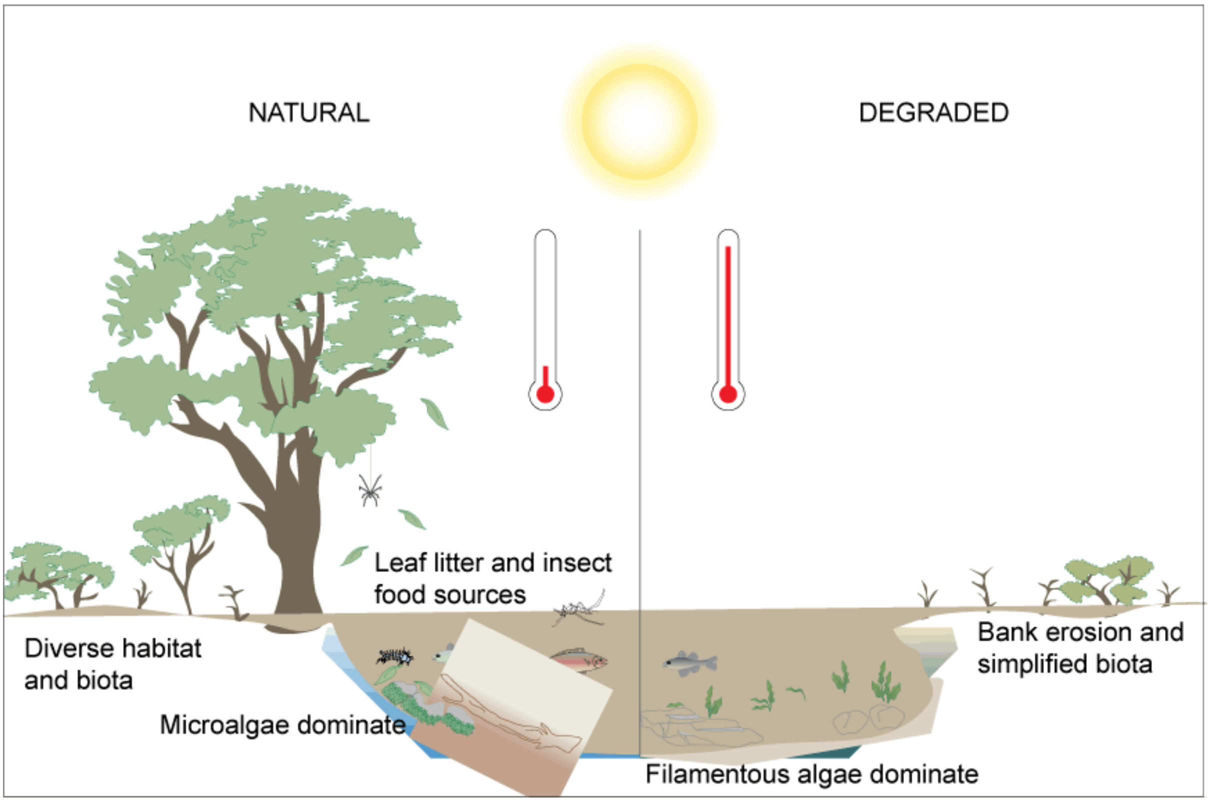
Map 4.4 Tree loss in the Murray-Darling Basin

Part B: Removal of riparian vegetation

- Explain that riparian vegetation is the natural streamside vegetation. Use Figure 4.2 to discuss the impacts of its removal on a river system.
- Healthy rivers generally have significant areas of riparian vegetation intact. Discuss bank erosion, livestock access to water and the effect that increased sediments have on water clarity and turbidity. (Damage to vegetation by livestock leads to increased erosion, which in turn – due to increased particles and suspended solids in the river – affects water clarity.)

Part C: Review and update mind map

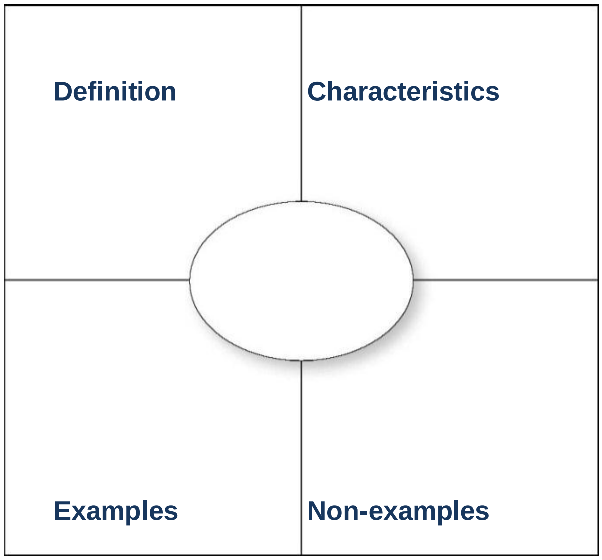
- On Student worksheet 3.1, Lesson 3.2, students created a mind map to show the natural elements of the Murray-Darling River system and how those elements are interconnected. Invite students to add a new section ‘human influences’ to their mind map. Students then describe human activity that affects biodiversity or water quality such as food and fibre production or irrigation and water -diversions.



Courtesy Australian Natural Resources Atlas

Figure 4.2 Removal of riparian vegetation

- Use the mind map to discuss the natural system and describe the result or consequences of a human-induced change to a part of that system. Make a list of these changes and the result or consequences. Note: Ensure students remain balanced and objective in their discussions. Changes may have both positive and negative outcomes.
- Students review a strategy such as revegetating a riverbank or an area of land that has been cleared, or replanting sections of farmland with strips or blocks of deeper-rooted plants. They create a poster or information brochure to promote community action to revegetate a local waterway or area of land.



Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms

INVESTIGATION 5

What is, and can be done, to address the current issues?

Introduction

The complex issues surrounding the health of the Murray-Darling river system need to be addressed to ensure that the Basin continues to be productive and its use is sustainable. History demonstrates that the Basin goes through periods of drought followed by heavy rains therefore, even if the flows return, it is likely that the issues will remain into the future. Irrigation efficiencies and using new technologies have been a focus of new approaches to using water in a more sustainable way. Environmental flows have been released to support important environmental assets. There are however various uses of water which can lead to conflict. The discussion of issues around water availability and water quality involves a range of views of people from different backgrounds, and perspectives including those of an environmental, social, economic, cultural or political nature. These differing perspectives can be the source of conflict if not managed appropriately.

The key issues around water use and land degradation in the Basin include:

- rising groundwater where the water tables have risen, resulting in less productive, waterlogged soils
- reduced water quality though increased salts, sediments and nutrients
- deteriorating river health as a result of reduced flows, changes to natural flow patterns and the river's disconnection to adjoining floodplains and wetlands.
- increased dryland salinity.

It's highly likely that, in the future, there will be an increasing demand for water, which may result in less becoming available for irrigation. The irrigation industry has already responded to reduced water availability and implemented improvements in water-use efficiency. These efficiencies include reducing storage and distribution losses (both on- and off-farm); and reducing application losses (including deep drainage and surface run-off).

Australian Curriculum links

Science – Year 7		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Biological sciences • Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions **Earth and space sciences** • Some of Earth's resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Nature and development of science** • Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world **Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations • Science understanding influences the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management	**Planning and conducting** • Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed • In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions **Evaluating** • Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • the hydrologic cycle describes the movement of water between the atmosphere, land and oceans • weather can be a hazard, but the risks can be reduced through human adjustment to the conditions presented • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed • Census data can be used to describe the growth, movement and characteristics of the populations of places • information collected in a survey should be evaluated for reliability **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships **Communicating** • each type of communication has conventions that should usually be followed for communication to be effective • the climate of a place can be represented by a graph of average monthly temperature and precipitation **Planning and implementing actions** • finding a way of resolving a problem depends on an understanding of the causes of that problem **Reflecting on the investigation** • each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

Lessons

Lesson 5.1
How do we make better use of the water we have?

Outcome

Students describe ways that people have come to use water more efficiently.

Background

In previous lessons it was established that the Murray-Darling Basin has interrelated components that, when in balance, maintain high biodiversity and promote a healthy river system. As a result of human influences these interconnected components are not functioning effectively, the health of the system is compromised and the productivity of the Basin is affected. In this series of lessons, current ways of addressing the issues are explored.

The Murray-Darling Basin is a semi-arid environment with highly variable rainfall that has seen agricultural activity and other industries flourish as a result of irrigation and access to water. The decline of the health of the Basin's rivers is due to an unsustainable level of extraction. Water users have recognised this issue and, over time, many have implemented strategies to use the water more effectively.

According to the Australian Bureau of Statistics:

> surface irrigation was the most common method of irrigation in the Murray-Darling Basin in 2008–09, utilised by 5,296 agricultural businesses. These businesses accounted for 69% of all agricultural businesses in Australia using surface irrigation. Above-ground drip or trickle irrigation was the next most common method (3,688), followed by micro-spray sprinklers (1,891).
>
> Water use on Australian farms, 2008–09 Irrigation methods, ABS,www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/4618.0Main%20Features 52008-09?opendocument&tabname=Summary&prodno=4618.0&issue=2008-09&num=&view
>
> In 2008–09, cotton accounted for the highest proportion of irrigation water used in the Murray-Darling Basin (23%), followed by cereal crops for grain or seed (20%) and pasture for grazing (15%).
>
> Water use on Australian farms, 2008– 09, Pastures and crops irrigated, ABS,www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/4618.0Main%20Features32008-09?opendocument&tabname=Summary&prodno=4618.0&issue=2008-09&num=&view=

Irrigation scheduling is the most efficient way that farmers can deliver the right amount of water at the right time. The main methods of delivery include furrow irrigation, overhead irrigation, drip and trickle systems and low-pressure under-tree systems. Flood or furrow irrigation and high-pressure, high-volume sprinkler systems are generally the least efficient. The most efficient are micro-sprinklers or dripper systems, which target the root zone of the crop.

Resources and preparation

Materials

- sensors and probes and data-logging equipment
- 1 x punnet of seedlings
- 1 x sufficient quantity of potting mix to fill a plant pot
- 1 x sufficient quantity (to fill a plant pot) of different types of soil such as a clay-based soil and sandy loam soil
- 1 x margarine-sized container of compost
- water

Student handout

Student handout 5.1 Irrigated farming

References

Baillie, J, Baillie, C & Murray, A 2007, On-farm water use efficiency in the Northern Murray-Darling Basin, Murray-Darling Basin Commission, ACT, www.mdba.gov.au/services/education-resources

Department of Primary Industry, NSW, Irrigators caring for rivers, Farmers stories, www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/195706/Irrigators-caring-for-the-rivers.pdf

Lesson outline

- Provide Student handout 5.1 that gives some strategies farmers have used to reduce water usage and make irrigation more efficient. Have students use the P, M or Δ (Plus, Minus or Δ Delta – a thing you would change) strategy to evaluate each example.
- Students use sensors and probes, and data-logging equipment to investigate and measure differences in soil moisture among different soil types under various test conditions.
- Support students to conduct an investigation where they collect data over time. Students use sensors and probes, and data-logging equipment to monitor soil moisture in growing seedlings using minimal water use. Students design an investigation to compare a seedling that is given a constant amount of water regardless of soil moisture levels to another seedling which is watered a set amount until an identified soil moisture level is reached. Discuss the importance of changing only one variable.

  Note: students use potting mix to grow the seedlings.
- Students:
  - collect data and interpret their results
  - report on water use and the limitations of the investigation
  - discuss their findings as a class and refer to evidence gathered during their investigations to support their conclusions.

- Students could investigate the soil moisture of:
  - different types of soil such as a clay-based soil and sandy loam soil
  - sandy loam soil with and without a layer of compost added to surface
  - the same soil with a different amount of water added
  - the same soil type, same quantity of water, same duration, but one has a seedling and the other does not.

Developing vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as ‘irrigation’, and on the back of the card its meaning – ‘diverting water for farming’. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

Unfamiliar terms may include underlined glossary items.

Student handout 5.1

Irrigated farming

Review the following strategies used by two farmers using irrigated water for farming.

Conduct a PMΔ on both approaches. This is where you list the Pluses, Minuses and Δ Delta (things you would change).

Farmer 1

Our farm grows forage crops of sorghum, wheat, and maize for livestock feed. We use mostly surface irrigation, which is the flood and furrow method. We have on-farm water storage of 4000 megalitres. In previous years water was delivered to our farm via an open channel. This has now been replaced by underground pipes.

When our water supplies are limited we reduce the area of land that we crop. This however reduces our income and profit.

We improved our water efficiency by using laser levelling. This is where our tractor uses GPS technology to ensure the correct level or slope is created. It results in better irrigation and reduced water use. Before this we lost a significant amount of water to deep drainage. When water was plentiful this wastage was not considered an issue.

We also use sensor technology to monitor water use and help schedule irrigation. We used to determine when to water by feeling the soil moisture: now we have reliable data. So when the moisture level drops to a certain point we irrigate that field. We still also use our observations and common sense.

Our evidence shows that our yield improved from about 50 to 75 tonnes per hectare using the same amount of water.

Our future plans are to reduce evaporation and leakage of our water storages. We are looking into covering one of our water storages with a synthetic material that reduces evaporation losses

Student handout 5.1 cont.

Irrigated farming

Farmer 2

We produce pecan nuts on a farm of 750 hectares. We draw water directly from the river and have no on-farm water storage. We can tap into groundwater if the river supply is limited.

We annually apply compost to our crop to retain soil moisture. Composting also reduces soil erosion.

Even though our trees have replaced natural vegetation we have not suffered from the salinity problems of our neighbours who grow shallow-rooted crops.

We monitor soil moisture and evapotranspiration to manage scheduling of all 50 fields.

We mostly rely on surface irrigation, which has concrete-lined ditches to reduce seepage. We have also replaced one field with sub-surface irrigation. Using our water savings we have decided to change to drip irrigation systems in some of our other fields.

As a result of our changes in water use we have found an increased production with a better yield of crop in terms of both quantity and quality.

Through better scheduling, switching to drip irrigation and other approaches we estimate we have reduced water usage by at least 10 per cent.

Lesson 5.2
How are environmental flows impacting on the health of the Murray and Darling rivers, and wetlands of environmental and cultural significance?

Outcome

Students describe local Aboriginal peoples' connections to the Murray-Darling Basin, its environmentally and culturally significant assets, and the benefits of environmental flows to river health.

Background

Environmental flows are used to improve the health of key wetlands of international significance where water cannot be supplied by existing flows. The water for these environmental flows was sourced by purchasing water entitlements from farmers willing to sell their water allocation.

Evidence of the benefits of the significant rains of February–March 2010 and the water buyback for environmental flows became evident in several targeted environmental assets such as Lowbidgee wetland and the iconic wetlands on the Murray River.

The return of environmental flows to wetlands has significant implications for local Aboriginal communities. Local Aboriginal peoples have long histories and deep connections with the Murray-Darling Basin. Their rights and interests need to be respected in decisions that affect the health of the Basin and the use of its resources. Local Aboriginal peoples have cultural knowledge about the Basin that can be shared and incorporated into existing management practices.

Particular sites that have cultural significance require protection, access and management by local Aboriginal peoples. Local Aboriginal peoples need to be able to carry on aspects of their traditional cultures including hunting, fishing and foraging.

Resources and preparation

Part A

Audio

What about the cultural flows?, www.abc.net.au/local/audio/2010/10/21/3044691.htm?site=newengland

Publications

The Barwon-Darling River: Aboriginal life along the River (fact sheet)

People of the Murray River – Aboriginal communities (fact sheet)

Part B

Figures, graphs, maps and tables

Table 5.1 Threats to wetlands

Videos

Murray, Life + Death (purchase DVD of a particular episode or view transcript), www.abc.net.au/tv/messagestick/stories/s1694560.htm

Part C

Videos

ABC, Behind the News program on the Murray-Darling, www.abc.net.au/btn/v4/story/s2214520.htm

ABC, *How green was my valley?*, Landline, www.abc.net.au/landline/content/2010/s3276553.htm .

ABC, Lowbidgee wetlands nourished, www.abc.net.au/news/2010-09-02/lowbidgee-wetlands-nourished/2247212

ABC Shepparton, Exploring the new Murray River, www.abc.net.au/local/videos/2010/09/30/3026081.htm?site=shepparton

Commonwealth Environmental Water Holder, update 10 June 2011, www.environment.gov.au/water/policy-programs/cewh/index.html

References

Indigenous connections to the rivers of the Murray-Darling Basin

Discover Murray River, People of the Murray River – Aboriginal communities, www.murrayriver.com.au/about-the-murray/murray-river-aboriginals

Western Catchment Management Authority, The Barwon-Darling River: Indigenous life along the River, www.western.cma.nsw.gov.au/Publications/2010_River2_AboriginalLife_FactSheet_lr.pdf

Environmental significance

Australian Conservation Foundation and Inland Rivers Network, Wetlands for our future, www.irnnsw.org.au/pdf/WetlandsForOurFuture.pdf

Department of Sustainability, Environment, Water, Population and Communities, The living Murray initiative, www.environment.gov.au/water/policy-programs/lmi/index.html

Department of Sustainability, Victoria, Wetland ecology, www.dse.vic.gov.au/arthur-rylah-institute/research-themes/wetland-ecology

Hankinson, Amy and Soutar, Lindsay, The biodiversity and values of the Darling Basin – a valuable and iconic Australian asset, Inland Rivers Network, www.irnnsw.org.au/pdf/BiodiversityDarling.pdf

Murray-Darling Basin Commission, Wetlands, www.mdba.gov.au/services/education-resources

Environmental flows

ABC, *How green was my Valley?,* Landline (video), www.abc.net.au/landline/content/2008/s2684347.htm

ABC news, Water release revives Lowbidgee wetlands, www.abc.net.au/news/stories/2010/09/01/3000070.htm ,

Australian Government, Restoring the Balance in the Murray-Darling Basin (fact sheet), www.environment.gov.au/water/publications/mdb/pubs/restoring-balance.pdf

Cullen, Peter 2007, Facing up to the water crisis, www.wentworthgroup.org/docs/Facing_up_to_the_Water_Crisis1.pdf

Lesson outline

Part A: Cultural heritage

- Use the following activities to establish local Aboriginal peoples' connections to the Murray-Darling Basin. The Basin forms part of Aboriginal peoples' cultural heritage.
- Listen to the audio file of Fred Hooper, a Murrawarri man, speaking about the significance of the Basin: 'Where do the nation's traditional owners fit into the current conversation about the Murray-Darling Basin?', www.abc.net.au/local/audio/2010/10/21/3044691.htm?site=newengland .
- Provide the fact sheet, The Barwon-Darling River: Aboriginal life along the River, produced by the Western Catchment Management Authority, www.western.cma.nsw.gov.au/Publications/2010_River2_AboriginalLife_FactSheet_lr.pdf :
  - Refer to the painting Kuya created by Tanya Martin. The picture portrays the significance of the Darling River to the Ngemba people.
  - Discuss evidence that suggests local Aboriginal peoples used the river in sustainable ways.
- Organise students into pairs or small groups. Print out sections of the website or the fact sheets.
  - Discover Murray River, People of the Murray River – Aboriginal communities, www.murrayriver.com.au/about-the-murray/murray-river-aboriginals
  - – Murray River Urban Users Committee, Aboriginal connection to the Murray, www.murrayusers.sa.gov.au/PDFs/aboriginal_connection.pdf
- Students recount ways in which the Murray River is and was important to local Aboriginal peoples' ways of life.
- View the ABC video, Murray, Life + Death, or read the transcript at www.abc.net.au/tv/messagestick/stories/s1694560.htm . In groups, students identify the issues surrounding the Coorong and develop a poster to describe how environmental flows and increasing water levels will benefit the Coorong. Students describe why the Coorong is important to local Aboriginal peoples.

Part B: Important environmental assets of the Basin

- In groups, students research internationally recognised wetland sites within the Basin. They include Currawinya Lakes, Paroo River Wetlands, Narran Lakes, Gwydir Wetlands, Macquarie Marshes, Lowbidgee Floodplain, Barmah-Millewa Forest, Coorong and lower lakes. If possible, provide access to the Murray, Life + Death video. Students complete a table of information that can be shared to create a class list. Students could also locate and label the wetland site that they researched in Lesson 1.1 (Student worksheet 1.2). The table could be set up like Table 5.1.

Table 5.1 Threats to wetlands

Wetland	General description of its value	Waterbirds	Disturbances or threats

Part C: Increasing the flows to environmental assets

- To provide an overview of issues to do with Murray-Darling Basin, view ABC's Behind the News program on the Murray-Darling, www.abc.net.au/btn/v4/story/s2214520.htm .
- In pairs, students recount the issues described in the program and use these to develop a class list.
- View the first five minutes of the ABC's Landline program entitled How green was my valley? to discover the positive impacts of increased flow from rain and the Australian Government's environmental waterflows. This is available at www.abc.net.au/landline/content/2010/s3276553.htm .
- View the rest of the online videos listed in the Resources and preparation section, which cover the impacts on the floodplains and wetlands from recent rains and the Australian Government's environmental waterflows.

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Lesson 5.3
How do we balance environmental, economic and social demands on the Murray-Darling Basin?

Outcome

Students describe the importance of the Murray-Darling Basin and the wide-ranging points of view in regard to its use.

Background

Managing the Murray-Darling Basin requires balancing values and assets that are potentially in competition. Through sustainable management, and understanding, acknowledging and responding to different points of view on water use, we can reduce the tensions among environmental and cultural needs and production-orientated activities. There may also be competition between different economic interests, which needs careful management.

In terms of environmental needs, the Basin is ecologically diverse and supports a variety of ecosystems. Many species of waterbirds breed in large numbers only during the flooding of wetlands and lakes. The large wetlands on the lower reaches of the Condamine-Balonne, Gwydir, Macquarie, Lachlan and Murrumbidgee rivers are among the most important sites of this type in Australia.

In terms of cultural significances, the Basin has been home to Aboriginal peoples for at least 50,000 years, sustaining cultural, social, economic and spiritual life. Trade routes, major gathering places and sacred sites exist across the length and breadth of the Basin. People belonging to local Aboriginal groups all along the Murray and Darling rivers and throughout the Basin talk of their deep relationship to the rivers.

Adapted from Murray-Darling Basin Authority (MDBA) 2010, Guide to the proposed Basin Plan. Volume 1: Overview, Murray–Darling Basin Authority, Canberra

Economically:

> The agricultural industry in the Murray-Darling Basin provides an annual average of $15 billion worth of produce to the national economy ... Indirectly, agricultural activity is also a key economic driver of local industries and regional activities that support small and medium enterprises and employment across the Basin. For example, around one-third of people employed in manufacturing are employed in food products industries.
>
> Murray-Darling Basin Authority (MDBA) 2010, Guide to the proposed Basin Plan. Volume 1: Overview, Murray–Darling Basin Authority, Canberra, page 21
>
> www.mdba.gov.au/proposed-basin-plan

Resources and preparation

Part A

Figures, graphs, maps and tables

Table 5.2 The significance of the Murray-Darling Basin

Part B

Figures, graphs, maps and tables

Table 5.3 Conflict matrix

Student worksheet

Student worksheet 5.2 Potential sources of conflict among people in the Murray-Darling Basin

Part D

Materials

Assessment rubric

Technology

www.wikispaces.com

References

Murray-Darling Basin Authority, Draft Basin Plan, www.mdba.gov.au/proposed-basin-plan

Murray-Darling Basin Authority, Guide to the Proposed Basin plan, http://thebasinplan.mdba.gov.au/guide/guide.php?document=the-murray-darling-basin

Wentworth Group of Concerned Scientists, Australian agriculture: Redesigning for resilience, www.wentworthgroup.org/docs/Australian_Agriculture_Redesigning_for_Resilience.pdf

Lesson outline

Part A: Importance of the Murray-Darling Basin

- Lead discussion about the different ways the Murray-Darling Basin is significant. Ask students to elaborate on their ideas. Through discussion highlight the varying type of significance:
  - Cultural significance is a concept which helps in estimating the value of places. The places that are likely to be of significance are those which help an understanding of the past or enrich the present, and which will be of value to future generations.
  - Social significance is about the importance of the area to society. It is related to the wellbeing of people.
  - Environmental significance relates to areas that contain listed threatened species and ecological communities, habitat where internationally protected migratory species visit and Ramsar wetlands of international importance, for example.
  - Economic significance relates to the income derived from industries. It deals with the immediate production of goods such as food and resources as well as services provided to communities. This production can also have flow-on effects to industries that process the foods and resources, creating jobs and securing the livelihood of many people. Foods, products and other resources can be exported overseas to generate income. Tourism is another Basin industry that generates valuable income.

- Create a class chart displaying students' thoughts about the significance of the Basin. These could be categorised as shown in Table 5.2.
- In creating the chart above students may decide that some aspects cover more than one type of significance; therefore multiple columns may be checked.

Table 5.2 The significance of the Murray-Darling Basin

Students' ideas about the significance of the Murray-Darling Basin	Social significance	Economic significance	Environmental significance	Cultural significance
Rivers are a source of water for people. Without clean water you would not survive.	✓			✓
The Murray-Darling Basin has important wetlands.			✓	✓
The Murray-Darling Basin has a large agricultural industry.	✓	✓		✓
The Murray and Darling rivers are spiritually and culturally significant places for people belonging to local Aboriginal groups.	✓			✓
Many people take part in recreational fishing in the Murray-Darling Basin.	✓	✓		✓

Part B: Is there a possible conflict?

- Provide the Student worksheet 5.2, which outlines the needs of different people of the Basin who provide a range of different perspectives on the use and management of water.
- Using the conflict matrix on the last page of the worksheet, select 1, 2 or 3 to represent the level of conflict you believe might exist among community members:

  1 = minimal conflict,

  2 = moderate conflict,

  3 = strong conflict.
- Propose questions to consider any possible conflict between members of the Basin community:
  - Which people would have similar or common goals? Explain your answer.
  - Which people would have different or conflicting goals? Explain your answer.
  - How might taking water from the Murray River or the Darling River affect other people who need access to water in the Mvurray¬Darling Basin?
- Use the roles of the community members as the basis for a debate. Students could formulate arguments to support their perspective about their needs for water. The focus of the debate could be themed 'How do we use and manage water from the Murray-Darling Basin fairly and sustainably?'
- A proposal was submitted to allocate water to several wetlands that are internationally recognised as Ramsar sites. The water allocation is termed 'environmental flows' and is designed to improve wetland health and, ultimately, the health of the river system. Write a letter taking on a particular role from those listed. Put forward your arguments for or against the proposal.

Part C: Balancing a productive farm and a healthy ecosystem

- Discuss the dilemma for farmers who have a business to run with the goals of ensuring profitability; maximising their land use; keeping their farms productive; managing their water use and purchasing it when required; and maintaining soil quality.
- Discuss the farm as a subsystem of the Murray-Darling river system. Support and guide discussion around:
  - inputs (water from rainfall, groundwater or irrigation, seeds/seedlings, animals for livestock, income from selling produce)
  - processes (adding chemical fertilisers, tillage, cycles of growing and cropping, breeding livestock, disease/weed/pest control, irrigating fields using surface and sub-surface irrigation, maintaining natural areas)
  - outputs (produce, run-off, evapotranspiration, nutrients and sediments into waterways, biodiversity, rising salinity)
  - farm benefits (food production, local jobs and community involvement).

- Draw a diagram of a typical farm that includes a river frontage. Add features such as:
  - areas of the floodplain that have been cleared and replanted for crops or pasture grass to graze livestock
  - a wetland that has been cleared and drained and used for crops
  - streamside vegetation that has been removed to increase the cropping area
  - irrigation for crops or livestock – on-farm water storage – remnant vegetation.
- Offer the view that part of the farmer's role is to maintain the essential ecological functions of the landscape as a service to the wider community. Discuss what value we should put on the care and maintenance of natural ecosystems such as wetlands, floodplains and riparian vegetation. How can the farmer be compensated for maintaining the landscape? Can the farm income include credits for managing healthy landscapes, rivers and wetlands, contributing to a healthier river system?
- Follow-up tasks could include:
  1. You are a scientist who has been asked to develop a proposal to more sustainably manage the ecological functions of a farm and its surrounding landscape. Describe what evidence you would collect to work out if the improvements had the predicted effect.
  2. You are a farmer who has chosen to take part in a government pilot project that offers credits to farmers who seek to maintain the health of the river that abuts their farm. Write a proposal to the government to take part in this project and include a list of the changes you will make and the reasons you should be compensated.
  3. Draw a plan of a farm showing improvements you have made to preserve the ecological functions of your farm and its surrounds including waterways. In an accompanying brief report, describe the changes you have made and the expected effects on your profitability over time and the benefits/costs to the broader community.

Part D: Bringing it all together

- Students create an information product that summarises what they have found out through their inquiry. It could be a brochure, an oral or electronic presentation, a poster, a report, or a newsletter article.
- Possible themes include:
  - Is it possible to manage the Murray-Darling Basin sustainably?
  - How do we improve the health of the Murray-Darling Basin river system?
  - What will the Murray-Darling Basin be like in 2030?
  - How do we ensure the Murray-Darling Basin remains productive?
  - How might climate change affect the Murray-Darling Basin?
- Provide the opportunity for students to share their information product with the wider school community.

Alternative approach

Provide students as a class the opportunity to share their ideas about the complex issues and possible ways to address them using a wiki.

Getting started

Set up a wiki home page for the group and post the question to which students will respond. The question will depend on the types of responses you want your students to focus on.

Suggested questions include:

- Why is the Murray-Darling Basin a concern for all Australians? What are the issues?
- How healthy is the Murray-Darling Basin and what has influenced its health?
- What needs to be done for the Murray-Darling Basin to remain productive?

Student ideas

Direct students to the wiki page that sets up the research question and ask them to respond by sourcing their own information and adding text, images, audio and/or video links that support their ideas. Encourage students to consider the lessons covered in this Investigation and include any information that is relevant.

Responding to other students' ideas

Once all students have uploaded their responses to the initial question, they respond to at least two students. It's important that the feedback is in a form that is useful to the original author i.e. that validates certain points or challenges others based on evidence that the responder has identified using other sources. (The teacher can view the history to monitor the responses of students.)

Using the feedback

As a result of feedback from students, the author of the wiki reviews and updates his or her ideas.

Summary

A possible follow-up to the wiki is to look at common ideas developed by students. Organise these under particular sub-headings, and share in a discussion that teases out related issues and complexities. The wikis could be further added to and/or reviewed and modified to address issues that may not have been articulated in the response to the initial question.

Developing vocabulary

Add any unfamiliar terms to the word hanging, word wall or graphic organiser. Ensure students have a good understanding of the underlined glossary terms.

Student worksheet 5.2

Potential sources of conflict among people in the Murray-Darling Basin

Person	Background
National Park ranger	My role is to conserve the wetlands, which have a strong connection to the health of the river. When the wetlands are operating as they should under natural water levels there is abundant birdlife that comes to feed on the small fish and insects. There is an amazing web of life that depends upon getting the suitable levels of water that normally happen in spring when the river floods its banks. The recent flood is the first we have had in nearly ten years.
Murrawarri traditional owner from western Basin area	We have a very strong continued connection to the land. We have taken care of the country since time immemorial. One particular interest right down the Murray-Darling Basin is our Rainbow Serpent; we call it the Mundaguddah. He keeps the rivers healthy. Another part of the land, the red river gum, is our link to our ancestors. Our old people would talk to the ancestors through the leaves of the red river gums growing along the river. If the red river gum dies, our spiritual connection to our ancestors and our Dreaming is lost. That's our strong cultural connection to the river.
Grape grower	Our family has been in the grape-growing industry for nearly 50 years. We own a vineyard in Mildura, Victoria. We used to use flood irrigation but realised we could irrigate in a more efficient way so we moved to drip irrigation, which was very costly to set up. We need a secure water supply to ensure our vines grow and stay alive year after year. Our town relies on the income of the farming community. I, and other farmers, put money into the community.
Dairy cattle farmer	I appreciate that the environment is important so the critical thing for me is to balance the amount of water I use and be able to supply people the milk they need. Our dairy-farming community supplies milk to the local area as well as the cities. Many businesses rely on our milk for their income – for example, processing, transport, packaging and retail.
Grain grower	Irrigating our farmland increases our productivity. On our farm we grow wheat. It could be wheat from my farm that is turned into flour which is used to make the bread, pasta and biscuits that you eat. New technologies help me reduce my water use. It ensures that I water only when the soil moisture is at a certain level.

Student worksheet 5.2 cont.

Potential sources of conflict among people in the Murray-Darling Basin

Person	Background
Orchardist	I grow apples, pears and peaches. I have taken out a large bank loan to run my orchard. It’s been difficult with the recent drought. I’ve removed a levee bank that stopped my back paddock from flooding so now the wetland is reconnected to the river. This seems to have benefited my overall crop production, but I don’t have any hard evidence. It seems in dry times that the surrounding area benefits from the wetland. It’s possible that the wetland provides a flow of water to these areas through the soil profile, which is accessed by deep-rooted plants such as my apple, pear and peach trees. Most of my produce goes to the markets in the big cities. I rely on water from the local river to run my irrigation lines to the fruit trees. The drip system is much more efficient than the flood irrigation we used in the past.
Local recreational fisherman	I’ve lived on the Murray for 50 years and have observed the decline in fish numbers over that time. The Murray is now full of carp and catching any decent fish is a rare event. I think the fish are a good indicator of river health. I’d say at the moment the Murray and other rivers of the Basin are pretty sick and need some attention.
Tourism: Paddle- steamer operator	I look forward to better flows for the Murray. Tourists come to see a healthy river not one where the flows are so low that you can only travel at certain times. When the river is healthy, the trees are healthy and people are interested in travelling along the Murray to see this mighty river.
Community member in South Australia	Our community relies on the Murray for its water supply. When water is extracted by users upriver, less water flows down the Murray to us. With the rain we have had in 2010–11, it looks like the riverflows are finally reaching South Australia and the Coorong might improve in health. But what is going to happen when the next drought comes?
Tractor salesperson	I rely on the farming community for my livelihood. Farmers in turn rely on water. Our whole community is built around the irrigation industry and without it my town will die.

Student worksheet 5.2 cont.

Potential sources of conflict among people in the Murray-Darling Basin

Conflict matrix

	National Park ranger	Murrawarri traditional owner from western Basin area	Grape grower	Dairy cattle farmer	Grain grower	Orchardist	Local recreational fisherman	Tourism: Paddle steamer operator	Community member in South Australia	Tractor salesperson
National Park ranger	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Murrawarri traditional owner from western Basin area	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grape grower	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Dairy cattle farmer	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grain grower	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Orchardist	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Local recreational fisherman	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tourism: Paddle steamer operator	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Community member in South Australia	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tractor salesperson	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

INVESTIGATION 6

How do we take responsibility for sustainable water use?

Introduction

It is important for students to recognise that their actions and those of their family can contribute to a sustainable water supply in for future generations of Australians. The combined efforts of householders to reduce water consumption can reduce the level of waterflows required to maintain sufficient water levels in water storages. Many innovative products are available for consumers to increase their home's water efficiency.

As students have seen in the Investigations about the Murray-Darling Basin, maintaining the health of local rivers and waterways is a concern for all Australians. Understanding our impact on waterways and addressing these environmental impacts will help restore and maintain river health.

Community action groups provide an avenue for interested people to improve the health of wetlands and connected waterways through projects such as revegetation, water quality testing and species monitoring.

Australian Curriculum links

Science – Year 7		
Science Understanding	**Science as a Human Endeavour**	**Science Inquiry Skills**
Earth and space sciences • Some of Earth's resources are renewable, but others are non-renewable • Water is an important resource that cycles through the environment	**Use and influence of science** • Science and technology contribute to finding solutions to a range of contemporary issues; these solutions may impact on other areas of society and involve ethical considerations	**Planning and conducting** • Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed **Processing and analysing data and information** • Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate • Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions **Evaluating** • Use scientific knowledge and findings from investigations to evaluate claims **Communicating** • Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate

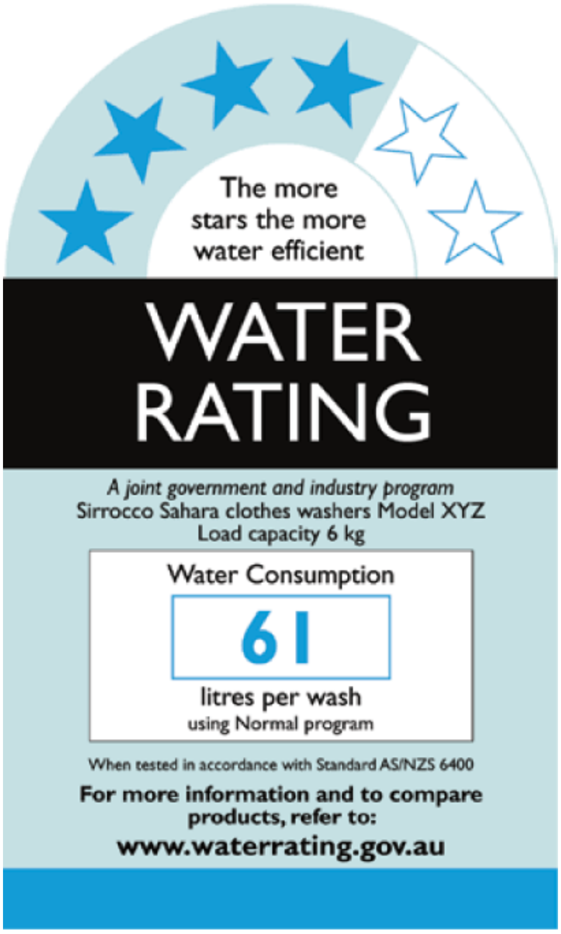
Geography (from Shape of the Australian Curriculum: Geography)	
Geographical knowledge and understanding **Year 7** **Weather and water** • water is a difficult resource to manage because it is integrated into environmental systems in complex ways, can be highly variable over time and across space, and has many competing uses	**Geographical inquiry and skills** **Developing a geographical question** • observation can lead to questions for investigation **Planning a geographical inquiry** • some geographical features can be explained by cause and effect relationships with other places **Collecting, evaluating and managing information** • primary and secondary data must be evaluated for accuracy and bias before being analysed • Census data can be used to describe the growth, movement and characteristics of the populations of places • information collected in a survey should be evaluated for reliability **Making sense of the information** • mapping the spatial distribution of a characteristic such as rainfall, can be a first step in developing an understanding of that characteristic and suggesting possible causal relationships **Communicating** • each type of communication has conventions that should usually be followed for communication to be effective **Planning and implementing actions** • finding a way of resolving a problem depends on an understanding of the causes of that problem **Reflecting on the investigation** • each investigation should be evaluated for what has been learned about the topic investigated and what has been learned about the process of investigation

Lessons

Lesson 6.1
What can I do to ensure our water is secured for the future?

Outcome

Students describe ways they can use water more efficiently. They explore the Water Efficiency Labelling and Standards (WELS), a labelling system that reflects water use in some household items. Students apply their understandings and take action in their local environment.



Background

Many households have purchased items such as water-efficient showerheads and low-flow taps to reduce their water use. The WELS Scheme labels a range of products for water efficiency, helping Australian households save water and money.

Students conduct a home audit and identify products that are WELS compliant such as dual-flushing toilets, water-efficient clothes washers and dishwashers, and low-flow taps and showerheads. As a class, the information is collated and used to create a graph to visually represent and analyse it. Students make claims about their classes' water consumption and areas that water efficiencies can be increased.

Resources and preparation

Part A

Technology

interactive whiteboard

Part B

Field trip

Research a local waterway to visit. It should have sections that are relatively untouched and sections that have been visibly affected by human intervention.

References

SA Water, Interactive house, www.sawater.com.au/interactivehouse

Save Water Alliance, Mission H20, www.savewater.com.au/mission-h2o-game

Water Efficiency Labelling and Standards Scheme, www.waterrating.gov.au

Lesson outline

Part A: Using water efficiently in the home

- Ask: What does your family do to reduce its water use?
- Discuss saving water as a household and why this is important. List the approaches used by students' families. Discuss what has motivated the family to change their behaviours.
- Use the resource Mission H20 (ideally on an interactive whiteboard) to discuss home water-saving strategies. See www.savewater.com.au/mission-h2o-game . Provide resources such as Mission H20 and Interactive house, www.sawater.com.au/interactivehouse , to enable students to explore water reduction strategies in their homes and the effect on the amount of water used.
- Discuss behaviours for using less water such as turning the tap off while brushing your teeth.
- Students promote community water-saving strategies, providing rationale, scientific background and making claims based on evidence. For example, how much water does your family save annually by swapping to a low-flow showerhead? Make the link back to the benefits to the environment if the whole community uses less water.

Part B: A local study – How have our waterways been modified?

- Students conduct their own geographical inquiry into local waterways and how they have been regulated and modified:
  - identify relevant questions to help guide their inquiry
  - as part of a field trip, visit local waterways and discuss what they would have looked like before being altered
  - as a comparison, look for remaining areas that have not been altered
  - take photographs of the areas
  - guide students to identify cause and effect relationships
  - if possible organise relevant community members with local knowledge to offer reasons for the modifications
  - source other secondary data that provides evidence about the local waterway
  - create a map of the location using BOLTS (Border, Orientation, Legend, Title, Scale) mapping conventions and make sense of the information gathered
  - seek out possible actions to improve the health of local waterways: for example, revegetation of riparian areas
  - communicate findings to the broad community
  - create a visual display promoting areas that can be revegetated
  - make contact with local council to support and coordinate community efforts.

Developing vocabulary

Create a word wall of terms that students come across in their inquiry which are unfamiliar and require further explanation. One idea could be to have individual words on cards, such as ‘irrigation’, and on the back of the card its meaning – ‘diverting water for farming’. These could hang from string. Alternatively a word wall could be set up with the words on cards with the description beside it.

Another option is to provide students in pairs with an unfamiliar word and using a graphic organiser with the word written in the centre, establish a definition, characteristics and a relevant example and non-example. See the model below.

Unfamiliar terms may include underlined glossary items.

Definition	Characteristics
Examples	Non-examples

GLOSSARY

abundance

The amount of a species in a particular ecosystem.

agriculture

The production of food and goods through farming.

annual

Yearly.

arid

A region lacking sufficient water or rainfall.

average

Around the middle of a scale.

barrage

An artificial barrier at the mouth of a tidal river to control flows.

biodiversity

A measure of the variety of living things in a particular region.

breeding cycle

The continual process of producing offspring.

capillary action

The flow of liquid along the surface of a solid, which is due to the attraction of the liquid's molecules to those of the solid.

catchment

The geographical area that collects and funnels water to its connected waterway such as a river and its tributaries, lakes, or other water sources. The water can flow along the surface or seep into groundwater.

community

A group of people living in a particular local area or, in biological terms, a group of organisms that interrelate within an ecosystem.

compromise

To make a deal where one party gives up part of, or all of its demand.

condensation

The process of changing from a gas to a liquid, for example water vapour to water.

conflict

A clash between two opposing groups.

conserve/conservation

The aim of protecting species, their habitats, and ecosystems

consumer

In biological terms, an organism that feeds on another organism. A first order consumer feeds on plants (herbivore). A second order consumer feeds on other animals (carnivore) or plants and animals (omnivore).

cultural heritage

the legacy of physical artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations.

distribution

In a biological sense, the range or geographical area that species can be found in; in a geographical sense, the area that a natural or human-induced feature can be found in, such as rainfall or agricultural crops.

diverting/diversion (water)

Changing the flow of water to suit a particular need, for example, a channel to divert water from a river to a farm.

drainage basin

All the land that serves as a drainage area for a specific stream or river.

dryland salinity

Evidence of increased salts in soils and increased concentration of salts in water resources that occurs in non-irrigated areas.

ecology

The study of interrelationships among living things in an environment.

ecosystem

A system formed through complex relationships among living organisms functioning as a community and interacting with their physical environment.

electrical conductivity (EC)

the characteristic of a substance that allows it to conduct electricity. Salt water conducts electricity more easily than purer water so electrical conductivity is often used to measure salinity.

elevation

A geographic location where its height is given above a fixed reference point, such as the height above sea level.

environmental flows

An allocation of water at a particular time of year to sustain the health of freshwater ecosystems through increased waterflow.

erosion

A process that moves solids such as soil or rock particles in the natural environment and deposits them elsewhere.

evaporation

The process of changing from a liquid to a gas, for example, water in its liquid form changing to water vapour.

evapotranspiration

the combined process of evaporation from soil and other parts of the land surface, and plant transpiration to the atmosphere.

floodplain

A flat or quite flat stretch of land next to a stream or river that experiences occasional or periodic flooding.

groundwater

Water that exists beneath the Earth’s surface in underground streams and aquifers.

infiltration

A process by which water on the ground surface enters the soil.

input

Something feeding into a process which has an output.

irrigation

Supplying land with water by some means of control: for example, channels to direct the flow, or storage for use in irrigated pasture

laser levelling

A method used in farming to accurately grade a slope to a certain angle or flat.

levee

A natural or artificial slope or wall to regulate water levels.

livestock

Animals domesticated for cultivation: for example, cattle, sheep and pigs.

lock

A mechanism that controls the height of a river to enable the navigation of vessels along it.

micro-organism

An organism of microscopic size.

migration

A regular seasonal journey undertaken by many species: for example, birds fly long distances to access food in another region.

moisture

Level of wetness, being damp.

output

Something exiting a process which has an input.

over-bank flows

Occurrence of water flowing over a riverbank and into adjoining floodplains.

percolation

Slow movement of water through gaps and spaces between soil and rock particles.

permeability

How easy or difficult it is for water to move through.

population density

The average number of people who live on each square kilometre of land.

porosity

The amount of open space in the material of subsurface rock.

precipitation

In hydrology and meteorology refers to rainfall, hail and snow.

producer

An organism that makes its own food in the form of sugars, such as a plant.

Ramsar

Convention used to indicate wetlands of international importance (otherwise known as the Ramsar Convention). These wetlands are commonly known as Ramsar sites.

remnant vegetation

Remaining pockets of the naturally occurring vegetation that has survived the impacts of human activity.

revegetation

The process of planting an area devoid of, or that has a limited coverage of, vegetation where there was once such coverage.

riparian vegetation

Plants that exist by the side of a river or other waterway

river mouth

The end of a river where it flow out to the sea or a lake.

run-off

Water that flows across the surface of the earth after evaporation and seepage into the ground.

salinity

The degree of saltiness which may relate to rivers or other waterways.

semi-arid

A climactic region of low rainfall that only supports scrubby vegetation and grasses.

settlement

An area where a group of families live together to form a community.

spawning

The fertilising of fish eggs.

species

Members of the same taxonomic group that can interbreed.

spillway

A channel for the overflow of water from a water storage area such as a reservoir or dam.

stomata

A pore in the leaf and stem epidermis that is used for gas exchange.

sub-surface irrigation

Below-surface method of watering crops.

surface irrigation

Watering land at the surface, usually by filling ditches (furrows).

sustainable

The use of natural resources in a way that does not risk their use over future generations.

system

A group of independent but interrelated elements that work together to perform some function.

temperate

A region that experiences mild changes in temperature between summer and winter, rather than extremes.

tillage

The cultivation of land where the top layer of the soil is ploughed or worked in some way to sow and raise crops.

topography

The arrangement of hills and valleys in a geographic area.

transpiration

The loss of water to the air from leaves of plants, most of it through the stomata.

tributaries

Small streams that feed into a main river that are part of a catchment.

turbidity

Cloudiness in a liquid caused by the presence of tiny suspended particles.

unsustainable

The use of natural resources in a way that risks their use over future generations.

vegetation

The plant life in a particular geographical area.

virtual water

Relates to the total amount of water used to produce something.

water (hydrological) cycle

The continuous movement of water from the oceans and other water sources to the air and land and then back to the oceans and other water sources.

water table

The level below the land surface at which the soil and rock is fully saturated with water.

weir

A barrier built across a stream to raise its level or divert its flow.

wetland

An area that is inundated by water for all or some period of time or that has water-saturated soil during an extended period, supports wildlife and has a role in flood protection and water quality.

wiki

An online environment that allows students to collaborate and share ideas around a central