Australian Science
Teachers Association

OUR DRY CONTINENT

A resource book of ideas for teachers
for National Science Week 2006

MINISTER'S FOREWORD

National Science Week is Australia's pre-eminent celebration of science. Now in its ninth year, it comprises over 700 events celebrating Australia's scientific abilities and achievements. It showcases science, its impact on everyday life and its potential to transform our future.

The event is a wonderful example of knowledge transfer throughout the community. Large organisations join with community groups and schools to bring National Science Week into classrooms and communities across the country - from city centres to remote rural regions.

The National Science Week Resource Book, which is produced each year by the Australian Science Teachers Association (ASTA), provides teachers with a valuable teaching resource. I am pleased on behalf of the Australian Government to be able to support the production and distribution of the Resource Book to every school in Australia. As a result, every school student will have a means to actively participate in National Science Week.

With 2006 being the International Year of Desertification, ASTA has taken the opportunity to make ***"Our Dry Continent"*** *the theme for this year's Resource Book. Our deserts provide an abundance of fascinating material for the case studies, experiments and activities that explore the question "Why is Australia so dry?". This year's theme will enable the majority of students living in metropolitan areas to think beyond their urban surroundings and discover how plants, animals and humans have adapted to life in dry areas.*

I commend ASTA for its excellent effort in producing ***"Our Dry Continent"****. I'm sure teachers Australia-wide will find it a valuable tool in helping them to plan and run activities during National Science Week and enthuse their students about the wonders of science and nurture Australia's scientists of tomorrow.*

The Hon Julie Bishop MP
Minister for Education, Science and Training
February 2006

OUR DRY CONTINENT

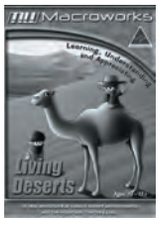
Teacher Feedback Questionnaire

FAX THIS EVALUATION FORM TO ASTA

02 6282 9477

BY 22 SEPTEMBER 2006 TO WIN

PRIZE 1: 1 x Living Deserts (unlimited site licence) valued at $195.00
PRIZES: 6 x Living Deserts (school edition) CD-ROM valued at $69.95 each



Macroworks Premier Education Software

www.macroworks.com.au

"Living Deserts" is a timeless resource that takes students on a journey of discovery as they learn about life in some of the world's hottest deserts. From Australia to Morocco, animals to desertification, the program has 3 self-contained modules with enough curriculum material to support any classroom activity, learning objective or project for upper primary to senior secondary students.

Our Dry Continent is an ASTA resource book of ideas for teachers for National Science Week 2006. The information you provide will help ASTA make improvements to future publications.

YOUR NAME:	YEAR LEVEL YOU TEACH:
YOUR SCHOOL NAME:	YEAR LEVELS CATERED FOR AT YOUR SCHOOL:
SCHOOL ADDRESS:	
SCHOOL PHONE NUMBER:	SCHOOL FAX NUMBER:
SCHOOL EMAIL ADDRESS:	ASTA MEMBER: YES/NO *(If yes which science teachers association)*

PLEASE INDICATE YOUR RATINGS

FEEDBACK CRITERIA: ***Our Dry Continent***

1. Overall response to the book	**1**	**2**	**3**	**4**	**5**	
A valuable resource						Of little value
Well presented						Poorly presented
Information sections were helpful						Not helpful
Supports an inquiry approach to student learning						Does not support an inquiry approach
Applicable beyond National Science Week 2006						Not applicable
2. Resource Book Content	**1**	**2**	**3**	**4**	**5**	
Too complex						Too simple
Includes activities relevant to the class level I teach						Irrelevant to my students
Created student interest						Little interest created
Provided a springboard to other ideas and activities						No scope for creativity
Additional resource links were useful						Not useful
Appropriate methodology						Inappropriate methodology

3. What did you find most valuable about the book? _____

Why? _____

4. What did you find least valuable about the book? _____

Why? _____

CONTENTS AND ACKNOWLEDGEMENTS

Australian Science
Teachers Association

An Australian Government Initiative

To help celebrate National Science Week 2006 in schools, and to recognise the United Nations International Year of Deserts and Desertification, the Australian Science Teachers Association (ASTA) is proud to present *Our Dry Continent*, the 22nd edition of the ASTA National Science Week Teacher Resource Book. It provides a comprehensive profile of land and resource management in dry Australia, examining related environmental issues and drawing on the latest research and findings from the Australian scientific community. Teachers will find an abundance of information, websites, classroom activities and experiments, photographs, diagrams, projects and challenges to support their science programs in National Science Week 2006 and beyond.

On behalf of ASTA I would like to acknowledge the funds received from the Australian Government through the Department of Education, Science and Training and sponsors Sydney Catchment Authority, Murray Darling Basin Commission, Screenrights, Centre for Groundwater Studies, Geoscience Australia and Macroworks.

I would also like to acknowledge the many who have contributed to the researching, writing, reviewing, validation and design of *Our Dry Continent*. The writing and review teams have worked with commitment and dedication to providing a valuable, ongoing science resource for Australian teachers and students. I would particularly like to recognise the work and efforts of the ASTA National Science Week Science Teacher Association Representatives who have assisted local school participation.

The interest, dedication and voluntary hours given by school communities in every state and territory of Australia are what make National Science Week a unique celebration. I am sure you will find *Our Dry Continent* a valuable resource for your school's celebration of National Science Week 2006.

Paul Carnemolla
President, Australian Science Teachers Association (ASTA)

ASTA would like to acknowledge the following people for their valuable advice during the development of this book:
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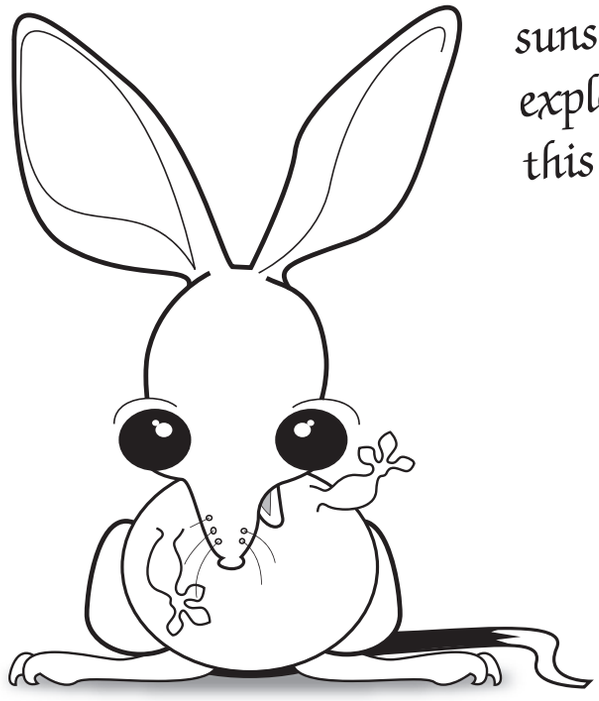
INTRODUCTION



"Hi, I'm Bill the Bilby. Grab your hat, sunnies and sunscreen and jump on in to explore my world. But be warned, this book is way HOT!"

*Our Dry Continen*t is a comprehensive resource book about arid Australia. It applies a scientific approach to the study of the themes of Australia's dry climate, natural resource management, adaptations to aridity, and sustainable water use. All themes are explored with a student-oriented focus and are aimed at developing students' scientific literacy and skills in the fields of biology, environmental science, meteorology, chemistry and agriculture. We have supported all information and activities with case studies from different regions of our dry continent. The purpose of these case studies is to highlight the reality of achieving sustainable natural resource management.

HOW TO USE THIS BOOK

All information has an Australian focus and has been written using the most current sources available. All topics are self-contained, allowing teachers to select at random information and activities about specific topics. Each topic is structured to include scientific information about the topic, activities, experiments and case studies. Web links and other resources are included for each topic to enable teachers and students to conduct further research on any detail addressed in the chapter.

Activities

Activities are included in every topic to engage students in the significant concepts introduced using a student-centred approach. Where relevant, all activities are linked to websites for further information.

Websites/Resources

Where appropriate websites have been suggested to enable readers to access further information and activities. All websites were deemed appropriate at the time of publication. It cannot be guaranteed that all websites will continue to be available after publication.

Did You Know?

Interesting snippets included as a light and easy way to retain students' interest!

Questionnaire

Please complete and return to ASTA to ensure we continue to improve.

Curriculum Guidelines

This resource book is intended to enhance all teaching programs within your school. They are not specifically curriculum linked, although the activities are designed to reflect a broad sweep of nationwide curriculum outcomes. The information and activities are not intended to be prescriptive but able to be incorporated wherever it is deemed appropriate or relevant.

Safety Awareness

All student activities included in Our Dry Continent have been designed to minimise hazards, however, there is no guarantee that a procedure will not cause injury. Teachers should test all activities/experiments before using them in class and consider the OH&S requirements within their state or territory. All necessary safety precautions should be outlined clearly to students. Students must be provided with all safety equipment necessary prior to the commencement of experiments/activities.

Centre for Groundwater Studies

Groundwater Short Courses 2006

CGS is an international cooperative venture that undertakes leading edge groundwater research, education and training in Australia and internationally. Interdisciplinary research conducted by member organisations, agencies and companies include expertise in groundwater recharge, discharge, contamination, remediation and management.

Course	When & Where	Course Fee Please add GST
14th Getting To Know Groundwater and Surfacewater	Wed 10 – Fri 12 May 2006 DPI & F Conference Centre, Rockhampton	AU$800
*31st Australian Groundwater School	Mon 10 – Sat 15 July 2006 Currie Hall, UWA	AU$1500
*5th NAPLs and Groundwater	Tue 18 – Fri 21 July 2006 University of NSW, New College	AU$1800
*2nd Groundwater Model Calibration - Parameter Estimation & Uncertainty Analysis using Modflow & PEST	Wed 30 Aug – Fri 1 Sept 2006 DPI & F Conference Centre, Brisbane	AU$1200
*32nd Australian Groundwater School	Mon 25 – Sat 30 Sept 2006 Yungaba Conference Centre, Kangaroo Point Brisbane	AU$1500
*1st New Zealand Groundwater Modelling School: Concepts; Application Visual MODFLOW;PEST	Tues 14 – Fri 17 Nov 2006 O'Rorke Hall of Residence, Auckland University	AU$1800
1st New Zealand Getting To Know Groundwater & Surfacewater	Wed 15 – Fri 17 Nov 2006 Canterbury University, Christchurch	AU$800
*5th Australian Groundwater Modelling School: Concepts; Application Visual MODFLOW;PEST	Tues 21 – Fri 24 Nov 2006 Barker Lodge Motor Inn, Sydney	AU$1800
*6th Australian Groundwater Modelling School: Concepts; Application Visual MODFLOW;PEST	Tues 28 Nov – Fri 1 Dec 2006 Kings Perth Hotel, Perth	AU$1800
1st Irrigated Soils Management	TBA	TBA

***Denotes courses that attract postgraduate credits at Flinders University** www.scieng.flinders.edu.au/courses/groundwater

Early registration is advised, as places are limited.
For Information & Registration Form see web:http://groundwater.com.au/short-courses.html
Trevor Pillar: Ph: +61 8 8201 5632 Fax: +61 8 8201 5635
Email: cgs@groundwater.com.au

Groundwater will be an enduring gauge of this generation's intelligence in water and Land management

OUR DRY CONTINENT

Australia is the driest inhabited continent in the world. Eighty percent of the continent is semi-arid, having an average rainfall of less than 500mm per year and fifty percent of the continent is arid, having an average annual rainfall of less than 250mm.

The climate in arid Australia is varied with highly erratic rainfall, extremes of long dry periods and flooding deluges. Arid Australia sustains a diverse ecosystem of plants and animals that have adapted to the harsh dry conditions, as well as the human activities of grazing, mining and tourism. It is the challenge for the future to manage human activities carefully so as to ensure protection of this ecosystem and the sustainability of our dry continent.

Our Scarcest Resource

Australia has about five percent of the world's land area yet only one percent of the global river runoff. Human-induced pressures on our inland waters such as pollution, salination, irrigation, urbanisation, agriculture and recreation all affect the long-term sustainability of our continent. To achieve a balance between availability and use we must manage the equitable allocation of our water resources, including improving the water use efficiency of our agricultural enterprises and developing a more efficient water delivery infrastructure whilst maintaining and improving water quality.

Did You Know?

The driest continent in the world is Antarctica? It is a cold desert.[1]

ACTIVITY – WILL IT RAIN?

Describe what a cold front is and find out what causes a cold front. Collect copies of weather maps from the newspaper over a few days. See if you can predict the weather for the next day.

Help with this can be found at www.bom.gov.au or in Kleeman, G, Pask, R, Butler, J (1998), A Geography of Global Environments and Communities, Heinemann, Vic.

Did You Know?

On average, much of inland Australia experiences less than 300mm of rain per year while on the Queensland coast near Cairns and in parts of western Tasmania, annual rainfall averages over 3000 mm.

Printed

White, M. (1997) *Listen...Our Land is Crying.* Kangaroo Press Pty Ltd. NSW

1. Parish, S. (2003) *Discover and Learn about Australian Deserts and Aridlands* p. 4, Steve Parish Publishing Pty Ltd, Qld.

Issues in Society Vol 89: Water Resources (1998), Spinney Press Australia.

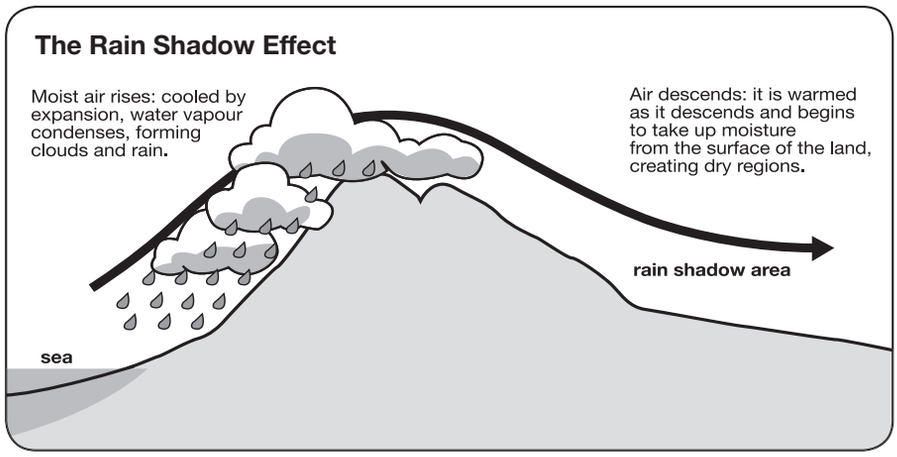
ACTIVITY – THE STATISTICS OF RAIN

Use the rainfall wizard on the www.daff.gov.au website.
This allows students to look at the mean rainfall, reliability of rainfall and seasonal variations in areas all over Australia.
www.affa.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A2200060B0A06272

Why is Australia dry?

A study of Australia's climate requires an understanding of the earth's atmosphere, embracing studies of physics, chemistry and mathematics.

Inland areas of Australia are much drier than coastal regions. Winds blowing off the sea carry moisture which usually falls near the coast. By the time the winds reach the inland areas there is not much moisture left. Mountains act as barriers to the movement of the winds carrying moisture from the sea resulting in arid areas on the other side. This is known as the rain-shadow effect.



Images of arid Australia: left, The Flinders Ranges and right, the Purnululu National Park (aka the Bungle Bungles) in the remote north-east of Western Australia.

ACTIVITY – MAKING A RAIN GAUGE

Have students design and construct a rain gauge.
The gauge must be able to collect and measure the rain.

NB. A simple rain gauge can be made by marking the side of a jar in millimetres up the side.

Set up the rain guage and measure the rain every day for twelve weeks. Graph the results. Analyse the results. What is the average monthly rainfall? What is the average daily rainfall? Which month had the most rainfall? Which month had the least rain? Explain reasons for changes in rainfall. Look up the Bureau of Meteorology website www.bom.gov.au. How do your results compare with the average annual Australian rainfall? Read the definition of arid and semi-arid on page 7 of this book.
Do you live in an arid or semi-arid climate zone? Research the other types of climate zones. Which one do you live in?

Did You Know?

Meteorology means the scientific study of the weather and of atmospheric processes.

www.

Printed

Weather Kit
Order from the Department of Education and Training, GPO Box 4367 Melbourne Vic 3001

Good for developing middle school weather skills:
Jenkins, C., Sweeny, and J. et. al. (1991) *Science Scene 3*, Edward Arnold Pty Ltd. Vic

Websites

Image of map of weather variation in Australia. Learn more about weather
www.bom.gov.au/lam/climate/index.htm

What makes it rain? For information on what makes rain
www.agric.nsw.gov.au/reader/nr-climate

Understanding the weather map
www.agric.nsw.gov.au/reader/climate/et7.htm#PREPARING

Primary Connections - Early Stage1 – Stage 2. A wonderful array of resources and curriculum links for the teaching of Science and Technology.
www.science.org.au/primaryconnections/additional.htm

A EXPERIMENT – MEASURING HUMIDITY

Aim:
To measure the humidity in the classroom.

Materials:
Two alcohol thermometers, cotton wool, rubber band.

Safety:
Handle thermometers carefully. Students shouldn't try to clean up the mess if a thermometer happens to break.

Procedure:
1. Wrap the cotton wool around the bulb of a thermometer. Secure it with a rubber band.
2. Dip the wrapped bulb in water.
3. Gently fan the wet-bulb thermometer until the temperature reaches a minimum.
4. Compare the reading of the wet-bulb thermometer and the dry-bulb thermometer.

Question:
Why does the wet bulb thermometer register a lower temperature than the dry-bulb thermometer?

T_{db} (°C)	Dry Bulb - Wet Bulb Temperatures (°C)														
	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20
2	84	68	52	37	22	8									
4	85	70	56	42	29	26	3								
6	86	73	60	47	34	22	11								
8	87	75	63	51	39	28	18	7							
10	88	76	65	54	44	33	23	14	4						
12	89	78	67	57	47	38	29	20	11	3					
14	89	79	69	60	51	42	33	25	17	9					
15	90	80	71	62	54	45	37	29	22	14					
18	91	81	73	64	56	48	41	33	26	19	6				
20	91	82	74	66	58	51	44	37	30	24	11				
22	91	83	75	68	60	53	46	40	34	27	16	5			
24	92	84	76	69	62	55	49	43	37	31	20	9			
26	92	85	77	70	64	57	51	45	39	34	23	14	4		
28	92	85	78	72	65	59	53	47	42	37	26	17	8		
30	93	86	79	73	67	61	55	49	44	39	29	20	12	4	
32	93	86	80	74	68	62	56	51	46	41	32	23	15	8	1
34	93	87	81	75	69	63	58	53	48	43	34	26	18	11	5
36	93	87	81	75	70	64	59	54	50	45	36	28	21	14	8
38	94	88	82	76	71	65	60	56	51	47	38	31	23	17	11
40	94	88	82	77	72	66	62	57	52	48	40	33	26	19	13
42	94	88	83	77	72	67	63	58	54	50	42	34	28	21	16
44	94	89	82	78	73	68	64	59	55	51	43	36	29	23	18

RELATIVE HUMIDITY TABLE

Instructions:

- Measure the dry bulb temperature (°C) - $\mathbf{T_{db}}$
- Find the difference between $\mathbf{T_{db}}$ and the wet bulb temperature (°C) $\mathbf{T_{wb}}$
- Values where these coordinates intersect give percentage relative humidity **RH**.

NB. Wet-bulb temperature is measured using a standard thermometer, with the thermometer bulb wrapped in wet muslin. The evaporation of water from the thermometer has a cooling effect, so the temperature indicated by the wet bulb thermometer is less than the temperature indicated by a regular thermometer. The rate of evaporation from the wet-bulb thermometer depends on the humidity of the air. For this reason, the difference in the temperatures indicated by the two thermometers gives a measure of atmospheric humidity.

WWW.

The Bureau of Meteorology runs school excursions in some areas.
Visit www.bom.gov.au/lam/Students_Teachers/learnact.htm to find out where these are conducted.

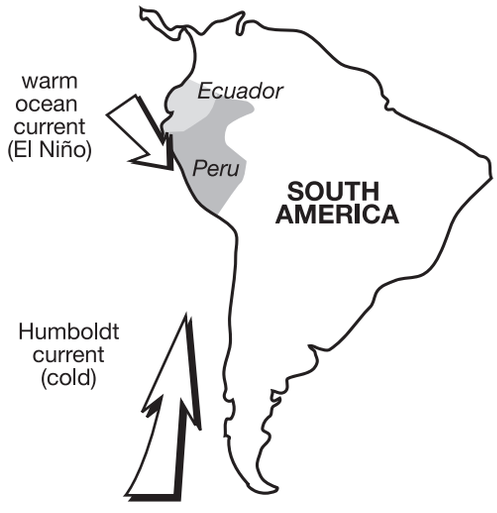
Printed

For a comprehensive outline about the weather for primary students look for
McClish, B (1994), *Weather and Climate*, Macmillan Education Australia Pty Ltd. VIC.

El Niño – What is it?

El Niño is a large scale oceanic warming that affects most of the tropical Pacific Ocean. It is caused when El Niño is normally accompanied by a change in atmospheric circulation called the Southern Oscillation. Together the El Niño Southern Oscillation (ENSO) phenomenon is one of the main sources of variability in weather and climate around the world.

Home of El Niño



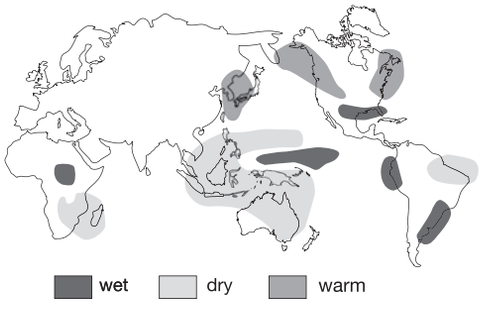
El Niño episodes bring warm ocean current to South America coast

Source: Bureau of Metereology

The Effects of El Niño

Usually hot water gathers in the western tropical Pacific Ocean where the ecosystem has adapted to the heavy rains that result. During El Niño, the hot water gathers in the eastern tropical Pacific Ocean where the climate, geography and people are not prepared for it. The predominant effect of El Niño in Australia is dry conditions, particularly over the south-eastern states. The opposite phase El Niño is La Niña which is characterised by unusually cold ocean temperatures in the eastern tropical Pacific. La Niña events usually lead to greater rainfall in Australia.

Areas most consistently affected by El Niño



Source: Bureau of Metereology

Case Study

The Australian Dust Storm, 23 October 2002

The dust storm was a result of drought conditions in eastern Australia caused by the 2002 El Niño event. The high-density section of this band of dust was approximately 1,500 kilometres long, about 400 kilometres wide and about 2,500 metres high. For more information on the dust storm visit: www.ga.gov.au/education/facts/news/duststorm.htm

ACTIVITY – WHAT ARE THE CHANCES OF RAINFALL?

Aim:
To analyse the effects of El Niño and La Niña on rainfall in Australia.

Background:
During "Normal" climatic conditions there are equal proportions of dry, wet and normal periods. During El Niño conditions the "dry" category is largest, while during La Niña the "wet" category is largest. The proportions in each rainfall category will actually depend on the strength of the El Niño or La Niña event and will also differ from location to location and from season to season.

Materials:
Cardboard, toothpicks, coloured textas.

Procedure:
Cut three circles out of the cardboard, 5cm in diameter. Make them into pie charts with the following proportions:

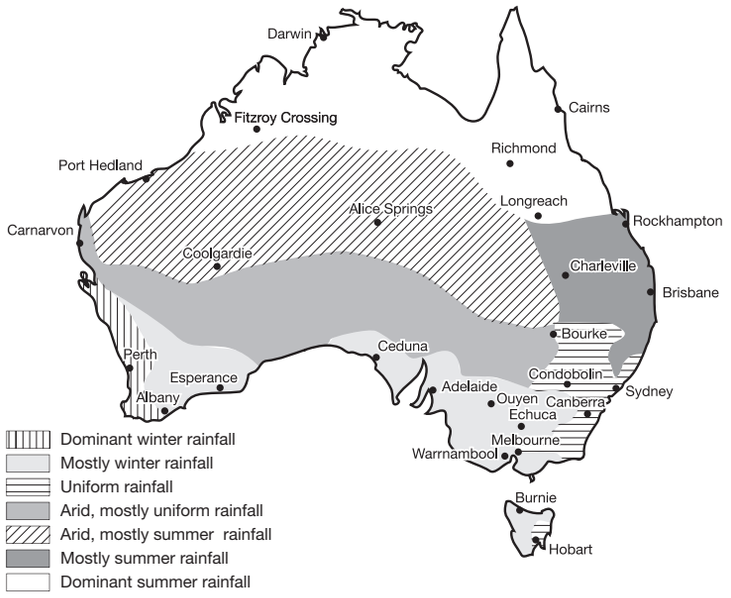
1. **El Niño pie chart** - 50% dry, 17% wet, 33% normal
2. **La Niña pie chart** - 50% wet, 17% dry, 33% normal
3. **Normal pie chart** - 33.3% wet, 33.3% dry, 33% normal

Questions:
Draw up three tables each with three columns headed Normal, Dry, Wet. Spin each of the wheels ten times. For each wheel tally the number of times the wheel lands on each of the climatic conditions.

From these results, calculate the percentage chance of each climatic condition occurring during an El Niño, La Niña and Normal season. Are your results in keeping with the trend?

Results:
What do these results tell us about the effects of changing weather patterns on rainfall? Write a conclusion for the experiment.

Climate zones according to rainfall



Source: www.bom.gov.au/lam/climate/levelthree/ausclim/zones.htm

ACTIVITY – RAINFALL?

Look at the map of Australia. In what rainfall zone is your town located? Use a rain gauge to record the rainfall in your town for one month. Visit the Bureau of Meteorology site at www.bom.gov.au to find out what the annual rainfall in your town is. Calculate your monthly rainfall as a percentage of your towns annual rainfall. Are your calculations accurate in terms of the information recorded on this map?

Has Australia always been dry?

Globally the climate is changing. Evidence suggests that much of Australia is becoming more arid and droughts are likely to be more intense in the future. This climate change is predicted to accelerate throughout the next century.

Did You Know?

The highest temperature ever measured in Australia's arid lands was 53.1 degrees Celcius at Cloncurry, QLD, in 1889 .

Websites

More information about El Niño
www.pmel.noaa.gov/tao/elniño/el-niño-story.html

Climate Variability and El Niño - for a comprehensive look at the impact of El Niño on Australia's climate go to:
www.bom.gov.au/climate/glossary/elniño/elniño.shtml or call the Head Office of the Bureau of Meteorology on 03 9669 4333.

Printed

Parish, S, *Discover and Learn about Australian Deserts and Aridlands*, Steve Parish Publishing Pty Ltd, Qld.

Lye, J, (1996), *Dry Climates*, Wayland Publishers, London.

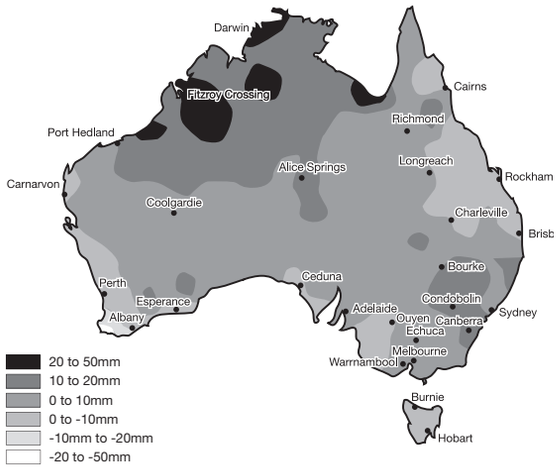
QUESTIONS

Analyse the map below and answer the following question:

1. What has been the general trend in terms of annual rainfall in Australia since 1900?

Research - In groups explore reasons to explain why rainfall is so varied in Australia? Explain your findings in a presentation to your class.

Trend in annual total rainfall 1900-2005 (mm/10years)



Source: www.bom.gov.au/cgi-bin/silo/reg/cli_chg/trendmaps.cgi

OUR FRAGILE LAND

2006 is the International Year of Deserts and Desertification. Desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from factors including changes in climate and the impact of human activities. Desertification refers to land degradation arising from over-exploitation of natural resources through broad scale land clearing, over-grazing and unsustainable farming practices.

Causes of desertification

- Wind and water erosion
- Salinity
- Soil structure decline
- Induced soil acidity
- Weed invasion
- Pest animals
- Human mismanagement

ACTIVITY – THE CAUSES OF DESERTIFICATION

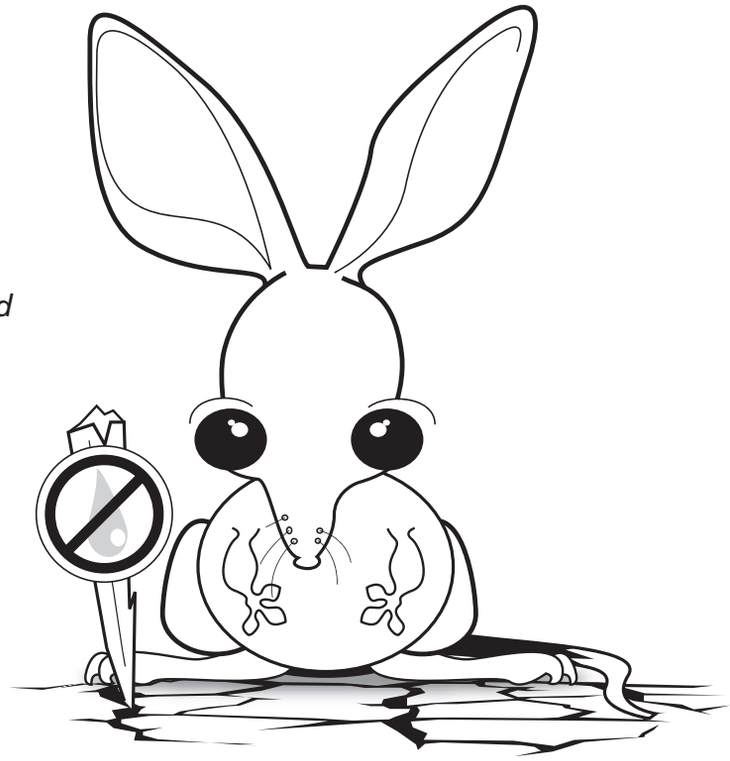
Use the following websites to research how each of these factors causes desertification:
www.fao.org/desertification/default.asp?lang=en
www.gse.mq.edu.au/units/gse813/CSIRO/environ/desertification.htm

Did You Know?

One third of the earth's land surface is arid or semi-arid, including most of Australia, the western part of North America and much of the Andean region of South America.

Did You Know?

It is estimated that seventy percent of all arid and semi-arid land is affected by desertification.

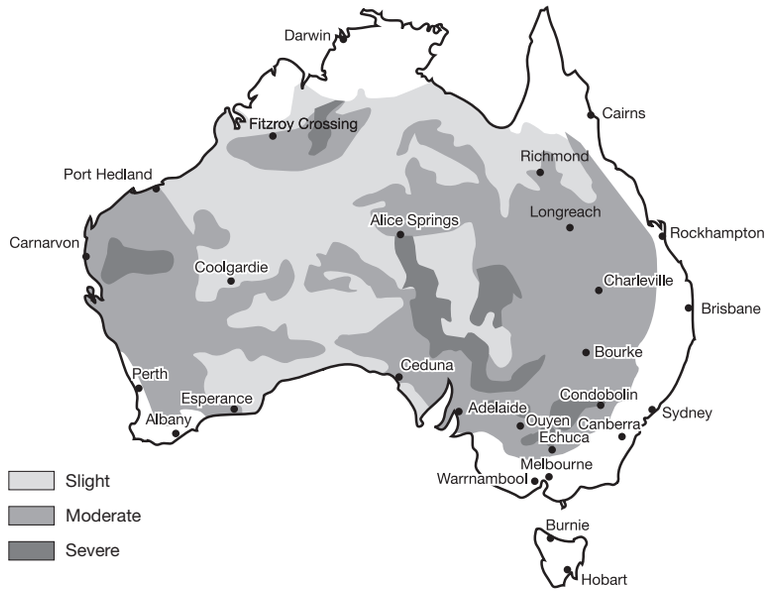


Erosion by Wind and Water

Erosion is the wearing away of land by wind, water and general weather conditions. This is a natural process but some land management practices, such as the overgrazing of sandy and poorly structured soils, have the potential to greatly increase the rate at which this occurs. The rate of erosion varies according to rainfall, wind, vegetation cover, slope of the land, soil type and stability.

Eroded soil from land cleared for urban development has led to the accumulation of sediment in the gully at the foot of the slope. Source: EPA

Desertification in Australia



Source: www.ciesin.org/docs/002-193/002-193.html

ACTIVITY – EXAMINING THE CAUSES AND EFFECTS OF LAND DEGRADATION

1. Use the map above, "Desertification in Australia" to answer the following questions.
   - Have students estimate the percentage of Australia affected by severe desertification.
   - What are the major towns and agricultural activities carried out in these areas?
   - What is being done to combat desertification in these areas?
2. Have students investigate the greatest land degradation issue affecting their local, or closest regional area?

Wind erosion of cleared land Source: www.dpi.vic.gov.au

EXPERIMENT – WATER EROSION

Aim: To investigate how vegetation affects water erosion.

Materials: 3 trays (planting/baking) at least 8cm deep, soil, soil with grass growing in it, watering can/container, a few books.

Procedure: Put 3-5cm of the soil in one tray and 3-5cm of the soil with grass in it in the other tray. Prop up one end of both trays at a moderate angle with the books to simulate a hill. Water each tray equally.

Have students record their observations including the effect the water had on each tray of soil, the tray in which the soil eroded most, and their hypothesis for why this happened. Have students write a conclusion explaining the effects of erosion on vegetated and non-vegetated land and how this information can be used to combat land erosion.

Link:
www.bright.net/~double/erode.htm

Extension: Have students construct a simulated arid ecosystem, including plants, animals and landforms. Put together a presentation on how each part of the ecosystem interacts and how sustainability is achieved in this ecosystem. What will happen if you take out one part of the ecosystem or over-exploit one part of it?

Websites

A wonderful list of Australian resources for primary students about arid environments and issues affecting the people, plants and animals that live there.
www.amlib.eddept.wa.edu.au/webquery.dll

EXPERIMENT – WIND EROSION

Aim:
To demonstrate the process of wind erosion.

Materials:
About a cup of confetti, a box lid or shallow cake pan, hair dryer, two or three heavy objects, such as rocks or wooden blocks. Suggestion - also try the experiment with popcorn, rice and green lentils to illustrate different soil types.

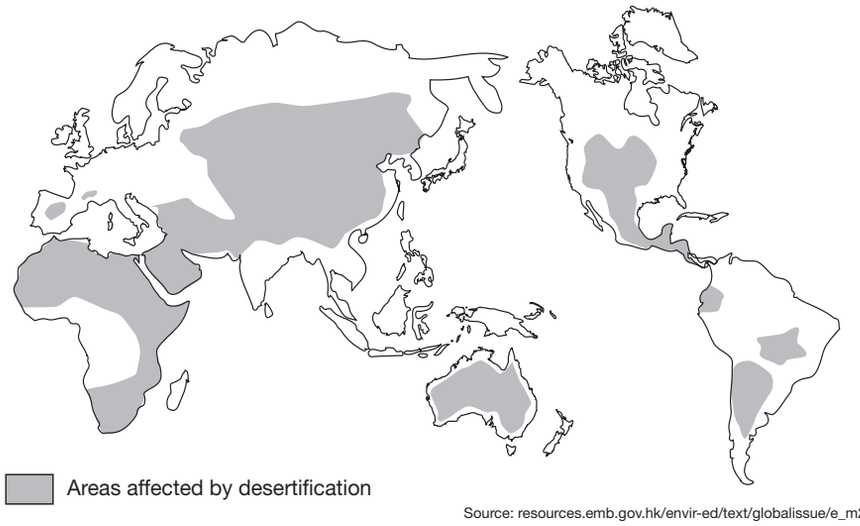
Procedure:
Place seceral layers of confetti (popcorn or lentils) in the pan – this is the soil. 2. Use a hair dryer on different cold settings at varying distances from the tray to study the effects of different amounts of wind. 3. Have the students observe and record the effects on the "soil" including what happened to the "soil" when blown by the "wind" and whether the "soil" dispersed evenly throughout the pan.

Extension:
Use either cotton wool or sand or wood chips to represent ground cover and repeat the experiment. Record the results. What difference does ground cover make to the effects of erosion?

Discuss what could be done to prevent the effects of wind erosion.

Link:
www.dpi.vic.gov.au/dpi/nrenfa.nsf/childdocs/-80E62E2EAB672EE24A256B520005A0AF-D2CE6E07DE84A2644A256B52000AA0A6?open

Areas of the world affected by desertification



Source: resources.emb.gov.hk/envir-ed/text/globalissue/e_m2_6_1.htm

Who does desertification affect?

Desertification affects about two-thirds of the countries of the world, and one-third of the earth's surface, on which one billion people live. Desertification affects one-fifth of the world population.

Did You Know?

There is desertification in Iceland.

Printed

Parish, S, (2003) *Discover and Learn about Australian Deserts and Aridlands,* Steve Parish Publishing Pty Ltd. Australia

Hiddins, L, (2000), *The Living Desert,* Penguin Books Australia Ltd.

ACTIVITY – COMBATTING LAND DEGRADATION

1. Visit the Landcare Australia website on www.landcareonline.com.au. Investigate the type of projects they run in your state and the success that they are having in improving land quality in Australia.
2. In a group, investigate an issue that threatens the health of the environment in your school or local community - it could be weeds in a local park, land susceptible to erosion in your school playground, destruction of a local habitat through land clearing.
3. List the causes and possible long-term effects of this issue.
4. Contact your local Landcare coordinator and seek their advice on overcoming the issue.

Case Studies

1. **The Lajamanu Community**, traditional owners of the Tanami Desert, teach their children how to look after their country using a combination of traditional and contemporary techniques. To read about their successes go to: www.deh.gov.au

2. **Developing a management plan for The Great Sandy Desert**

   An Indigenous Protected Area (IPA) has been declared in consultation with the Kimberley Land Council in the Western Australian region of the Great Sandy Desert. The project is about "getting people back onto country to make sure things are happening as they're supposed to and reclaiming ownership of their country and their identity". To read about indigenous land management in this region go to: www.deh.gov.au

3. **The Biograze Project**

   To learn about issues concerned with managing the interactions between grazing and biodiversity in Australia's rangelands go to: www.cazr.csiro.au/modelling.htm#biograze

Printed

McLeish, E, (1989), *The Spread of Deserts*, Wayland Publishers Ltd, UK.

The South Australian Rangelands (Arid Lands) Student Book, The Department of Water, Land and Biodiversity Conservation.

Lowe, P. with Pike, J, (1990), *Jilji: Life in the Great Sandy Desert*, Magabala Books, Broome, WA.

Websites

All about desertification
www.acnatsci.org/education/kye/nr/kye32002.html#p5
www.abc.net.au/landline/stories/s116302.htm
www.fao.org/desertification/default.asp?lang=en
www.gse.mq.edu.au/units/gse813/CSIRO/environ/desertification.htm
www.nrm.gov.au

Definitions, themes and resources for desertification
www.eddept.wa.edu.au/cmis/eval/curriculum/pathfinders/deserts/

SALINITY

What is salinity?

Salinity is the accumulation of salt in land and water to a level that impacts on the natural and built environment. Salinity occurs naturally in many parts of the Australian landscape but in many cases has been exacerbated where human activities accelerate the mobilisation and accumulation of salt. Today the spread of salinity impacts farms, irrigation areas, wetlands, rivers, drinking water and infrastructure. The different types of salinity are dryland salinity, irrigation salinity, urban salinity, river salinity and industrial salinity.

Bricks showing signs of salt and water . Source: DIPNR

Nature strip with salt crystals. Source: NSW Department of Primary Industries

A road showing signs of salt and water impacts. Source: DIPNR

Causes of Salinity

Salinity results from both natural and man-made causes - Australia is a naturally salty continent. Salt is a naturally occurring mineral that is a product of rock weathering, especially marine sedimentary rocks. It is picked up by wind blowing over the oceans and carried inland and dispersed on the soil surface. These salt deposits are buried over million of years in the sub-soil of the landscape. The natural flora and fauna are adapted to the conditions, but human activities such as vegetation clearing, cropping, and housing development have disturbed natural ecosystems accelerating the movement of salt into rivers and on land. Salinity is affecting the natural environment, reducing the viability of the agricultural sector and damaging infrastructure.

Australia's natural salinity has been intensified by changes in land use since European settlement. Dryland salinity is caused by the removal of deep-rooted perennial native vegetation which has adapted to be able to use most of the water entering the soil and its replacement largely by shallow rooted annual crops and pastures. This results in a significant reduction in water use and increased quantities being added to groundwaters. As the groundwaters rise, naturally-occurring salts (principally sodium chloride) are dissolved and brought towards the surface, where the salt is concentrated by evaporation.

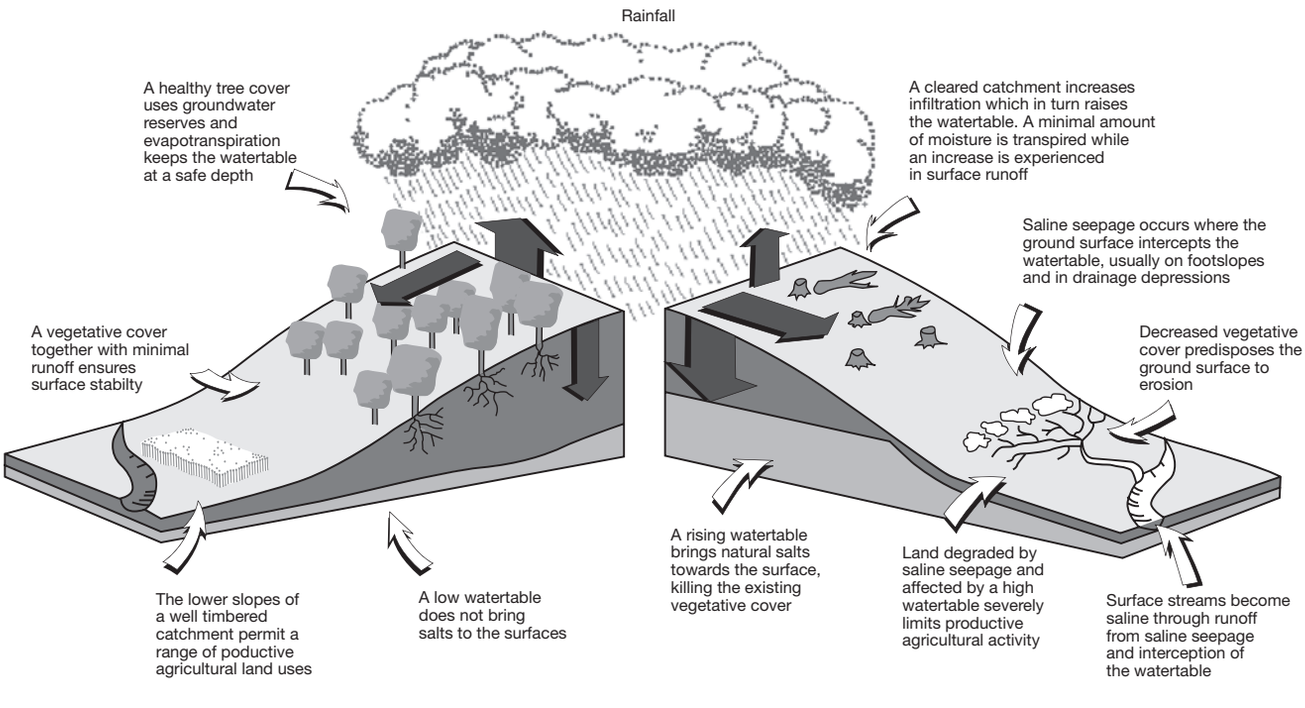
Once the water table is consistently within two metres of the surface, the land is at risk because the groundwater can move from the water table to the soil surface through fine soil pores. The salts that exist naturally in the soil are carried to the surface with the water. This phenomenon is known as capillary rise and the degree of risk depends on the type of soil, the amount of salt in the soil profile and the type of crops grown. There is also an increased risk of the watertable rising to harmful levels under rainfall and irrigation events. When the water table rises to within one metre of the surface, waterlogging and salinisation occur, interfering with crop growth and causing substantial productivity losses. Because this extra salt affects the composition of the soil, it can then become very difficult for plants to grow in salt-affected areas.

Websites

Streamwatch - for schools in the Sydney Basin and Hawkesbury Nepean Catchment, the Sydney Water Streamwatch program offers the excellent "Streams Alive" program for primary schools.
For more information visit www.streamwatch.org.au *or phone 02 8752 6400*

Three detailed diagrams illustrating the process of dryland salinity
www.audit.ea.gov.au/ANRA/land/land_frame.cfm?region_type=AUS&region_code=AUS&info=sal_context -

The Water Cycle and Dryland Salinity



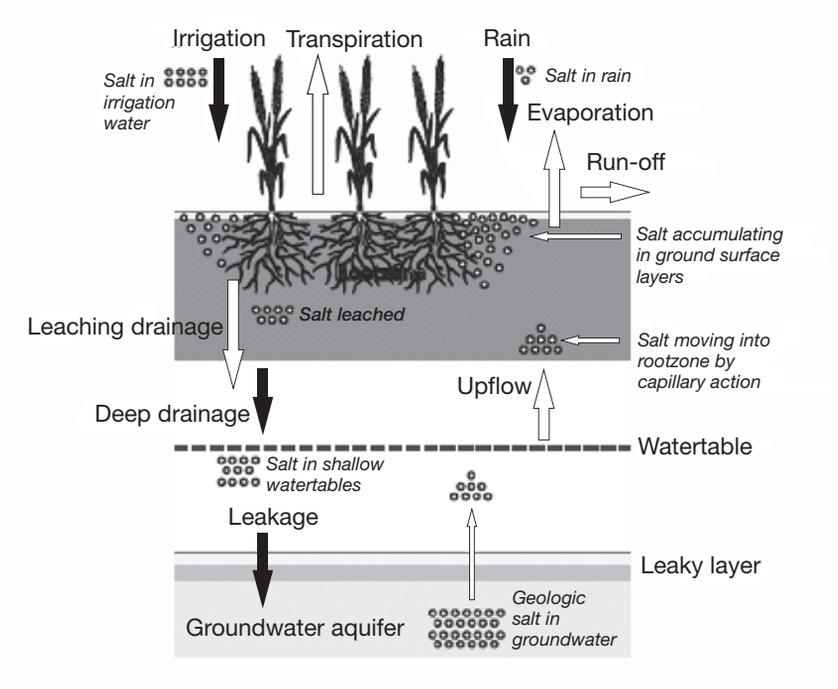
Source: Murray-Darling Basin Commission

Irrigation Salinity

It is estimated that approximately 70-80 percent of all irrigated land in NSW is threatened by rising water tables and associated salinity problems.

Link: www.epa.nsw.gov.au/soe/97/ch2/3_2.htm#0_3_2_1_0_0_0

Processes involved in irrigated salinity



Source: www.cmis.csiro.au/healthycountry/reports/Irrigation_perspectiveV2.pdf

EXPERIMENT – HOW DOES SALINITY AFFECT CROP GERMINATION?

Links:

www.saltwatch.org.au/saltwatch/book/33_page.html

www.nrm.qld.gov.au/education/teachers/land/activities/activity03.html

Two experiments which test the effect of salinity on seed germination using two types of seeds and different concentrations of salty water.

Case Study – Saltbush

Saltbush (Rhagodia spinescens) has many adaptations that enable it to survive in harsh arid environments. These adaptations include: grey leaves which reflect heat and decrease evaporative loss, wide seed dispersal, and the ability to tolerate salty ground water.

Link:

www.anbg.gov.au/education/pdfs/mallee-2002.pdf

Did You Know?

In south-west New South Wales about 34 percent of state roads and 21 percent of national highways are affected by dryland salinity.

Link: www.nlwra.gov.au/atlas

Websites

Games/activities and information about issues concerning management of the Murray-Darling Basin
www.mdbc.gov.au/nrm - Basin Kids

This resource book contains a range of teaching ideas to assist teachers and community groups in teaching about salinity and associated environmental issues. It is designed for both Primary and Secondary students.

\www.saltwatch.org.au/saltwatch/book/index.html

Printed

MDBC article, "The Murray-Darling Basin", from Healey, K (1998) *Water Resources, Issues in Society Volume 89*, The Spinney Press, Balmain.

More great ideas for demonstrating how plants absorb water.
Jenkins, C, Sweeny, J et al, (1991) *Science Scene 3*, Edward Arnold, Australia.

CD-ROM

A wonderful collection of hands-on activities/ experiments/illustrations accompanied by a comprehensive library of photos and curriculum links
Salinity North Central Catchment Management Authority - www.nccma.vic.gov.au

Saltbush at Yealering WA.

Photo courtesy of Hayley Norman/SGSL 'Pride in saltland management' photography competition.

EXPERIMENT – WHAT IS SALT?

Aim:
Determine the chemical composition of salt.

Materials:
Two pieces of copper wire, a battery, a 250 ml beaker (or glass) of water, salt

Procedure:
1. Dissolve three tablespoons of salt in the beaker of water.
2. Fix the copper wire to the contacts of the battery.
3. Hang the other ends of the copper wire in the beaker of salty water – have students explain why bubbles are forming.
4. From the wire attached to the positive pole of the battery, a yellowish-green deposit will begin to form – have students explain why this happens.

Link:
www.saltwatch.org.au/saltwatch/book/25_page.html

EXTENSION – SALT EQUATIONS

Have students:
1. Write the chemical word equation for each of the two reactions that they saw in the experiment;
2. Write a balanced symbol equation for each reaction;
3. Determine the mass number of each element from the information contained in the experiment;
4. Write the chemical symbol of each element, showing the mass number and atomic numbers in their correct configuration.

EXPERIMENT – INVISIBLE SALT

An experiment that demonstrates the difference between dissolved and suspended solids in water.

Link:
www.saltwatch.org.au/saltwatch/book/22_page.html

Discussion:
1. Which material was dissolved in the water and which was suspended?
2. Which material would be easier to remove? Why?
3. How could we detect the presence of the salt in the water (without putting it in your mouth)?

Capillary Rise

Capillary rise is the movement of water upwards from the water table into the unsaturated soil above. When a water table is within approximately two metres of the surface, water can enter the plant root zone by capillary rise. When this water is removed by plant use and evaporation from the soil, the salt carried up with the water is left behind. The build-up of salt in the root zone reduces plant yields and eventually may cause a bare salt patch to develop. Capillary rise occurs regardless of the depth of a water table. However, if the water table is below approximately two metres, capillary rise does not reach the root zone of agricultural plants.

EXPERIMENT – CAPILLARY RISE

An experiment which demonstrates the effect that capillary rise has on saline soils.

Link:
www.saltwatch.org.au/saltwatch/book/25_page.html

Questions:
1. What is the downward force that capillary rise defies?
2. Capillary rise occurs in all soils. Why is it such a problem if the water table is within two metres of the soil surface?
3. What effect does evaporation from the soil surface have on the rate of capillary rise? Why?
4. Explain what effect a good plant cover or a layer of mulch on the soil surface would have on the evaporation rate of soil water.
5. What effect would the following cropping practices have on the rate of capillary rise: fallowing, pasture rotations?
6. What conclusions can you draw from this experiment?

Did You Know?

The crystals of table salt (NaCl) are held together by the attraction between the positive sodium ions and the negative chloride ions.

Case Study – The Murray-Darling Basin

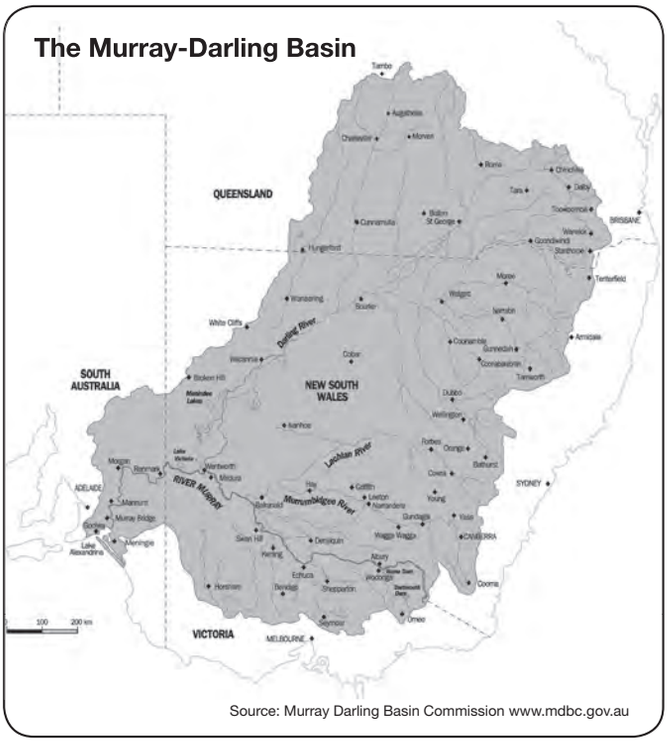
The Murray-Darling is Australia's largest river system. The Murray-Darling Basin is just over one million square kilometres covering almost the whole of inland south-eastern Australia, including parts of QLD, NSW, Victoria and South Australia. The Basin includes the Darling River at 2740 km, the Murray at 2530 km and the Murrumbidgee at 1690 km - the three largest rivers in Australia

The Murray-Darling Basin is one of Australia's most important agricultural regions containing 52,000 farms and representing 43 percent of the total number of farms in Australia and containing 45 percent of the Australian crop area. Wheat is the major crop within the Murray-Darling Basin with production representing 34 percent of the Australian total. Other agriculture includes wool, sheep, cattle, dairy produce, cotton, rice, oil seed, wine, fruit and vegetables. **The Basin's most valuable resource is water. It receives about 4 percent of the continents run-off but provides about 75 percent of all the water consumed by Australians (1998)**. Poor management and over-exploitation of the resources of the Murray Darling Basin have lead to widespread land degradation, including soil erosion, salinity, soil acidity and loss of native flora and fauna.

Reference: 1. Healey, K, (1998) pp 11-19

Link: www.deh.gov.au

The Murray-Darling Basin



Source: Murray Darling Basin Commission www.mdbc.gov.au

Case Study - Salinity on a farm in Temora

Isolated outbreaks of dryland salinity have begun to occur on farms in southern NSW. On-farm strategies to quantify and reduce the impact of dryland salinity are reported in a case study from Temora.

Link: www.regional.org.au/au/asa/2001/3/b/mcallum.htm

Case Study - Urban salinity in Wagga Wagga

The salinity problem in the Wagga Wagga City region is essentially a high water table problem.

Link: www.journalism.uts.edu.au/archive/salinity/publications/salinity_wagga.html

EXPERIMENT – BUILD YOUR OWN EASY-READ TEST WELL

An experiment to construct and install a ground water observation bore.

Note: Before starting this activity check the depth of your local watertable. If it is deeper than three metres this activity will be too difficult to do. A license to install a testwell <3 metres deep is not required in Victoria.

Link:
www.saltwatch.org.au/saltwatch/book/30_page.html

Websites

Information about the Murray-Darling Basin
www.mdbc.gov.au,

To order the CD-ROM: Salinity from Waterwatch
www.dipnr.nsw.gov.au/salinity/basics/index.htm

Great resources and classroom activities
www.nccma.vic.gov.au

Australian National Botanic Gardens
www.anbg.gov.au/education/pdfs/mallee-2002.pdf

Lots of information about salinity
www.nrm.qld.gov.au/factsheets/pdf/water/w55.pdf

Great interactive site about the effects of current water and land use on the future
www.futurescapes.com.au/

Facts and figures about salinity in Australia
www.audit.ea.gov.au/ANRA/docs/fast_facts/fast_facts_21.html

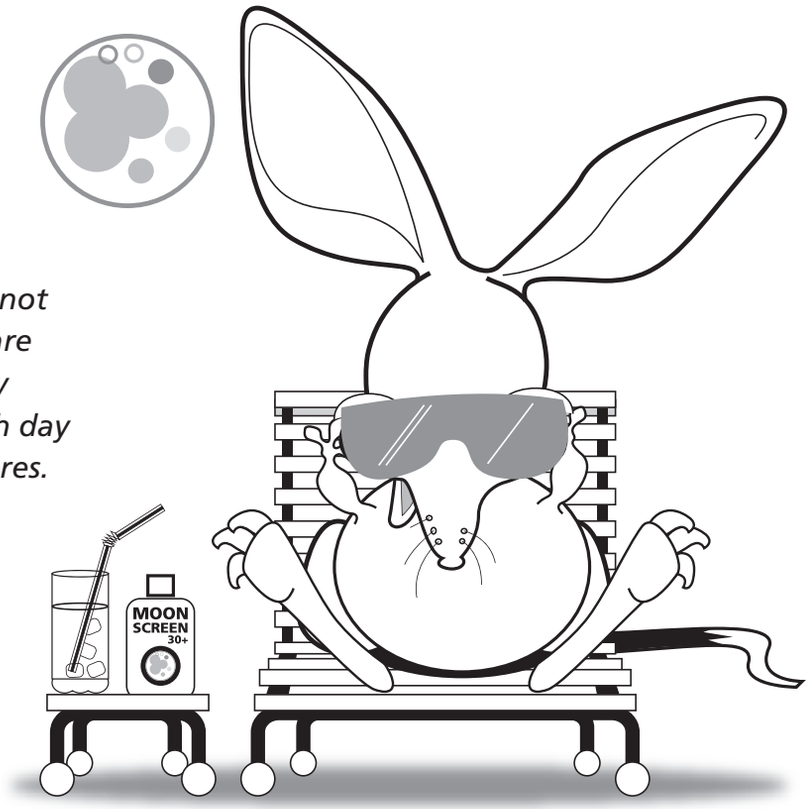
Audio-visual

Salinity: Australia's Silent Flood
www.abc.net.au/learn/silentflood/edu.htm. A 4-part ABC documentary produced by ABC Education in conjunction with Land and Water Australia. presenting an online study guide for teachers of Years 7-10

Printed

1. Healey, K (1998), *Water Resources, Issues in Society Vol 89*, The Spinney Press, Australia.

ADAPTING TO ARID AREAS



The climatic conditions in arid environments present a number of challenges to animals, plants and humans inhabiting the area. Rainfall is not consistent and often years of drought are followed by deluges. Temperatures vary extremely in a 24-hour period with high day temperatures and low night temperatures.

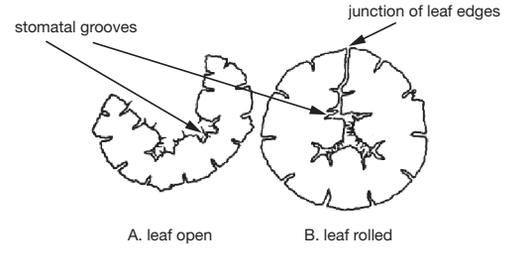
1. PLANT ADAPTATIONS

Plants and the arid environment

Plants have adapted to dry conditions by using behavioural or physical modifications. Plants that have adapted using physical structure are called xerophytes. Xerophytes have adapted to cope with dry environments by reducing the surface area of their leaves in order to minimise water loss. They can do this in a number of ways:

- By having tiny leaves which reduce transpiration - Callitris species (Cypress Pines), Phebalium species
- By rolling their leaves during the hottest part of the day - grasses such as Triodia species (porcupine grasses), Phebalium species, Dianella species (flax lilies). When the leaf is rolled fewer stomatal grooves are exposed to the drying atmosphere- stomates are the pores on the leaf of the plant which allow gas exchange and water loss. Plants generally have more stomata on the underside of their leaves.

Section through a leaf of *Trioda* species



- Having long narrow leaves
- Having leaves which reflect heat and light – such as the waxy cuticle on eucalypt leaves
- Having leaves which hang vertically and edge-on to the sun
- Having reduced numbers of leaves
- Having very extensive and deep root systems to reach for water (phreatophytes)

ACTIVITY – PLANTS NEED WATER

Aim:
Determine the amount of water plants require to survive.

Method:
Set up an experiment to test what happens to seedlings if they are deprived of water.

Hint – purchase some vegetable seedlings or grow your own wheat seedlings and give them different amounts of water (make sure one lot of seedlings get no water). Observe what happens to the seedlings after one day, two days, four days and a week. You could also try the experiment with cactus plants, although you would need to run the experiment for a lot longer to see results. Record your observations. Write a conclusion explaining your findings.

ACTIVITY – THE CACTUS

Cacti are an example of a xerophyte. Draw a picture of a cactus and label the adaptations it has to cope with arid environments. For example:

- Fleshy stems which swell up to hold moisture
- Small spikey leaves that reduce transpiration
- Shallow wide-spreading root system
- Waxy coat to reduce evaporation
- Ribs which channel the water to the roots

Compare a cactus plant to a fern (eg. Maidenhair fern). Describe what would happen to the fern in an arid environment. What would the fern need to change to adapt to its new environment?

Extension: Slice a small cactus into sections and examine with a hand lens. How does the tissue compare with:

a) a leaf from a tree

b) a fern

Cactus plant

Maidenhair fern

Case study – Ephemerals and Annuals

Ephemerals e.g. Rhodanthe diffusa, are plants that are highly opportunistic. They can complete their life cycles very quickly and set large quantities of seed that can resist heat and drought for long periods. The seeds germinate quickly when rain comes.

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Annuals e.g. Senecio species and Bracteantha species (Paper Daisies) often occur where winter rains are more regular. They germinate, grow, flower and set seed for the following year and die off in summer.

Bracteantha bracteata (Paper Daisy)

Source: Australian National Botanic Gardens

ACTIVITY – EPHEMERALS AND ANNUALS

Ask students to do an internet search to discover more about ephemerals and annuals. Draw up a table showing how each plant has adapted to its environment. Sketch a lifecycle of one of these plants.

Links:

www.anbg.gov.au/education/pdfs/mallee-2002.pdf

www.nma.gov.au/libraries/attachments/schools/resources/extremes/extremes_kit_science/files/9087/Extremes%20kit%20science.pdf

EXPERIMENT – GERMINATION AND WATER

Aim:
Design an experiment to show how much moisture seeds need to germinate.

Hint: Seeds are easy to observe and germinate if they are put on wet cotton wool – vary the amount of water on the cotton wool.

EXPERIMENT – HOW DO PLANTS MINIMISE WATER LOSS?

Aim:
To determine what effect leaf shape has on transpiration.

Materials:
Two different types of leaves - one narrow (eg. willow) and one broad (eg. bougainvillea). Ensure the leaves are of a similar, colour and thickness so that the only variable is leaf shape.

Procedure:

1. Take the two different types of leaves and place the stem of each leaf in a jar of water (ensure the leaf itself is not in the water).
2. Cover the surface of the water with oil to avoid any evaporation.
3. Weigh each container before starting the experiment and then every day for three days.
4. Record the loss in weight - this is a measure of the amount of transpiration by each leaf.

Questions: Which leaf loses the least water? What does this suggest about leaf shape and adaptation to arid conditions? As an extension activity calculate the transpiration per sq cm of leaf.

EXPERIMENT – HOW DOES A CUTICLE HELP PLANTS ADAPT TO ARID CONDITIONS?

Aim: To determine what affect a cuticle has on transpiration.

Procedure: Obtain two similar leaves from one tree. Cover the upper surface of one leaf with sticky tape or Vaseline to simulate a waxy cuticle. Carry out the same experiment as outlined in the activity.

Question: How would a waxy cuticle help a plant adapt to arid conditions?

EXPERIMENT – LEAF COLOUR AND TEMPERATURE

Aim: To determine what effect leaf colour has on the temperature of a plant?

Materials: Shoe boxes, varying shades of green paint, thermometer.

Procedure: Paint shoe boxes in varying shades of green. Place a thermometer in each box. Leave the boxes in the sun for two hours. Check the temperature in each box.

Questions: How does the temperature vary with the colour of the box? What does this suggest about leaf colour in hot environments?

EXPERIMENT – WATER MOVEMENT IN PLANTS

Aim: To observe water movement in plants.

Materials: A stalk of celery, food dye

Procedure:
Place a stalk of celery, which still has its leaves attached, into a container of water coloured with food dye. Leave the celery for a few hours before cutting through the stem.

Questions: What do you see? Find out the name of the tubes that are carrying the water up the stem.

Did You Know?

The Australian mulga tree has a unique way of collecting water. Its leaves grow upward, forming a series of funnels that send rain water along the branches and down the trunk to the ground, where the roots are concentrated close to the base of the tree.

Did You Know?

Leaves hang at different angles to minimise heat absorption. Observe some trees in the playground and observe the angles at which the leaves hang.

EXPERIMENT – TRANSPIRATION

Aim:
To observe transpiration.

Procedure:
Tie a plastic bag over the leaves on a tree – observe what happens over a few hours. Observe what happens on hot days and compare this with what happens on cold days. Test the substance in the plastic bag with dehydrated copper sulphate to see if it is water.
(NB. Copper sulphate turns blue when it is wet)

2. ANIMAL ADAPTATIONS

Animals and the arid environment

Lack of water is the major challenge facing animals and plants in arid environments. Animals in arid environments are susceptible to extremes of temperature. They receive heat directly by radiation from the sun and indirectly by conduction from the soil and convection from the air. The biological processes of animal tissue can function only within a relatively narrow temperature range. For up to half the year the temperature in the desert often exceeds the temperature range in which animals can cope. Most native animals have evolved behavioural and physiological mechanisms to cope with the excess of heat and lack of water in arid Australia. Most animals native to arid Australia are small, which reduces heat gain and loss. Many desert mammals are nocturnal which reduces exposure to high daytime temperatures.

Case Study – Rabbits: An adaptation Australia didn't need!

Rabbits contribute significantly to land degradation of pastoral lands and are a major economic and environmental concern for land managers. Twenty four wild rabbits, were introduced to Australia in 1859 and spread their way into the arid zone due to their ability to adapt to the conditions. During wet periods in arid areas rabbits re-produce rapidly. During a dry period the rabbit populations would then compete with native herbivores for the available vegetation. The rabbit was especially successful because in Australia it had escaped its usual attendant parasites, predators and competitors.

Case Study – The Bilby

Bilbies are native marsupials that live in desert environments.

Photo courtesy of Bert & Babs Wells, Department of Conservation and Land Management

How does the Bilby thermoregulate?
The Bilby has large, densely vascular ears which provide extra surface area for heat loss or thermoregulation. Bilbies also demonstrate behavioural thermoregulation - they are nocturnal and forage at night when it is cooler. Bilbies live in burrows during the day as the temperature underground is much cooler.

How do Bilbies get enough water?
Bilbies get water from the food they eat (insects, fungi, roots and seeds).

Breeding
Bilbies have a high breeding rate when food is plentiful and conditions favourable and can breed throughout the year, an adaptation which allows them to quickly take advantage of good seasons in the harsh desert environment.

EXPERIMENT – THERMOREGULATION

Aim:
Observe the effect of surface area on temperature.

Materials:
Hot cooked rice, wax paper, thermometer.

Procedure:
1. Make two piles of hot cooked rice on pieces of wax paper (1/2 cup each). 2. Measure the temperature of each pile. It should be the same. 3. Use the paper to wrap the rice and make one in to a ball and flatten the other out to about 1cm thickness. 4. Measure the temperature of each shape every minute.

Questions:
Which shape loses heat more quickly? What does this say about the best shape for thermoregulation?

Case Study - Droughtmaster Cattle

Heat stress has a major impact on livestock farming in arid areas. During the early 1900's several Queensland cattlemen crossed Zebu or Brahman cattle from Africa with their existing herds of "British-bred" animals to develop a breed more tolerant to arid conditions. Heat tolerance in the Droughtmaster comes from:

- Short-haired sleek coat
- Increased number and size of sweat glands
- Large area of loose skin
- A slow metabolic rate

Droughtmaster bull – Strathfield Upton. Photo courtesy of Perry Pastoral Company

Did You Know?

The water-holding frog lives in a deep burrow and only emerges after rain. Most of its life is spent underground. In its burrow, it secretes a mucus lining on the inside of its chamber and over itself. This hardens forming a membrane sack or shell that keeps the frog from desiccation. After rain, the frog emerges by tearing apart the membrane. Aboriginals have found this a handy water source in the absence of any other alternative.

www.naturewriting.com/frogand.htm

Did You Know?

The sand sliding skinks do not have to drink. They can get all their water from their food if they have to. They have kidneys that get rid of waste without losing very much water and they escape the drying sun by burrowing through the sand.

www.samuseum.sa.gov.au/water/riteframe.htm

Did You Know?

The Spinifex hopping mouse recycles water by drinking the urine of its young.

www.samuseum.sa.gov.au/water/riteframe.htm

Did You Know?

The Thorny Devil can drink with its feet. It places them in a puddle and water moves up by capillary action along grooves to the corner of its mouth.

www.ayersrockresort.com.au/fauna/

Thorny Devil - Image courtesy of Voyages Ayers Rock Resort

3. HUMAN ADAPTATIONS

Land use in arid areas

Arid areas of Australia are the source of 41 percent of Australia's mining production, 14 percent of tourism and 13 percent of grazing. Arid Australia is also home to 18 percent of the Australian aboriginal population.

The vegetation of the arid lands has a major influence on the land use. The saltbush, mulga and grassy plains provide pasture for sheep and cattle as well as habitats for unique mammals and birds. In the dry infertile interior, the spinifex-covered sand plains and stony deserts are too tough for livestock. Instead they are home to a variety of termite species and the world's richest lizard fauna.

Land use is also dependent on the variable climate. A typical pattern could be a year of sporadic rain resulting in large population increases of plants and animals. Wildfires often follow and then there could be several years of low rainfall or drought resulting in death of vegetation (and animals) and land degradation caused by erosion.

Agriculture

The pastoral industry is the major land user of arid Australia, with cattle grazing in the north and sheep grazing in the southern regions.

Aboriginal cultural and subsistence activities.

Firestick farming is one of the most widely used indigenous land management strategies in arid areas. Indigenous people use fire to encourage the new growth of plants which will attract animals for food. This is in contrast to non-indigenous farming strategies which involve digging up fields and planting crops.

Tourism and Conservation

Arid regions and particulary deserts are becoming popular tourist destinations. Tourists are attracted by the amazing land formations and the variable climate. After rain periods tourists often visit arid areas to experience the wildflowers which bloom and set new seeds after rain.

ACTIVITY – VISITING INLAND AUSTRALIA

Find out what time of year would be best for visiting desert areas in Australia. Consider when the weather would be most appropriate and at what times of the year the vegetation would be most spectacular. Find out when the wild flowers appear and when you would be most likely see animals in the desert.

Did You Know?

Land degradation is affecting at least 44 percent of the arid areas of Australia, costing the nation an estimated $200 - $300 million a year. www.cazr.csiro.au

Websites

Pertinent facts about flora and fauna native to arid Australia
www.kidcyber.com.au/

Interesting infomration about deserts and how animals adapt
www.desertusa.com/survive.html

Biodiversity in arid regions of Australia
www.deh.gov.au/biodiversity/threatened/publications/insight/arid.html

All about the bilby
www.calm.wa.gov.au/plants_animals/odd_bilby.html
www.abc.net.au/science/scribblygum/april2006

Case study – The importance of conservation as tourism increases

Uluru has hundreds of thousands of visitors each year. The constant stream of visitors walking in certain areas has led to the compaction of soil in these areas. Vegetation does not grow in the compacted areas. As the vegetation diminishes the area is exposed to wind and water erosion leading to land degradation.

Uluru-Kata Tjuta National Park - A World Heritage Area

Mining

The geological and climatic history of Australia has meant that some of the driest parts of the continent are also the richest in mineral resources. A variety of minerals including gold, nickel, iron ore, copper, manganese and salt are currently extracted from mines in arid areas. Potentially economic uranium and phosphate resources also occur in our semi arid to arid environments.

There are a number of potential environmental impacts associated with mining operations. Land clearing for the creation of open cut pits, tailings storage facilities, evaporation ponds, road building and processing mills. Tailings storage and waste rock dumps require rehabilitation, and the use and disposal of processing chemicals and petroleum products also presents particular environmental management issues.

? ***Did You Know?***

The energy used for heating and cooling a typical home generates more than one and a half tonnes of greenhouse gas each year. Compare this to an average family's transport which produce six tonnes each year.

www.greenhouse.gov.au/gwci/heat.html

Case Study: Olympic Dam Mine

WMC Limited (formerly known as Western Mining Corporation) is one of Australia's largest mining companies. Its main business is the discovery, development and processing of mineral resources.

WMC has progressively introduced process changes at its Olympic Dam mine site and processing plant in the arid north of South Australia to reduce its water consumption per unit of production, and is continuing to investigate further water conservation possibilities.

A QUESTION

Visit www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/wmc.html

What initiatives are WMC Ltd. using to reduce the impact to mining on the arid environment? Why is WMC undertaking to implement these initiatives?

Living in arid areas

Case Study – Sustainable House in Central Australia

Long hot summers and the dramatic change in temperatures during winter are taxing on materials and challenge the designer's ability to achieve comfortable living conditions without the support of energy consuming, artificial air conditioning systems. To find out about this Sustainable House visit www.abc.net.au/rn/science/earth/handouts/alicespring.htm

WWW.

Websites

Official site of the Australian droughmaster
www.droughtmaster.com.au/

Guidelines for mining in arid environments
www.doir.wa.gov.au/documents/environment/Shed_env_guide_aridenviron.pdf

Mining in Western Australia
www.ecu.edu.au/chs/cem/research/reviews%20&%20articles/articles/S_Vellekoop_art.pdf

Excellent resource about plant and animal adaptations. Excursion opportunities for local schools.
www.anbg.gov.au/education/pdfs/mallee-2002.pdf

ACTIVITY – DESIGN A HOUSE FOR ARID AUSTRALIA

Design a house suitable for a family living in arid Australia. Think about issues such as the way to face the house to minimise heat, what shape the roof should be and the use of verandahs.

Would solar electricity be a viable option? How would you take advantage of the variable rainfall?
For help visit www.greenhouse.gov.au/gwci/index.html and www.greenhouse.gov.au/yourhome/technical/fs11.htm

You may want to use SmartDraw software which can be downloaded free at www.SmartDraw.com

Case study – Living Underground

Soldiers returning to Coober Pedy from World War One introduced an unusual style of underground living – 'dug-outs'. Living in 'dug-outs' has become a necessity in Coober Pedy due to the searing summer temperatures (up to 35 °C on average) and the occasional fierce dust storms. Cold winter months are also typical of the desert and with an average temperature of 23°C - 25°C all year round, these 'Small Luxury Hotels of the World' provide protection against the varied climatic conditions of arid Australia.

The Desert Cave Hotel in Coober Pedy gives tourists the opportunity to experience underground living. For more information visit www.desertcave.com.au

An underground room at the Desert Cave Hotel in Coober Pedy - Source: Desert Cave Hotel

ACTIVITY – TEMPERATURE UNDERGROUND

Aim:
Analyse the temperature difference on top and under the ground.

Procedure:
Measure the temperature outside in the middle of the day in the sun. In the same area dig a hole 10cm deep and measure the temperature at the base of the hole. Do the same for a hole 20cm deep.

Questions:
What is the difference in temperature? Why does this occur? Do the same in an area which has had a few hours of shade. Why do you think animals and sometimes humans choose to live underground in arid areas?

Case Study – Making it rain

Cloud seeding involves artificially making rain clouds produce rain. The cloud seeding is carried out by sprinkling particles into the clouds from a plane.

Find out about the science behind cloud seeding, visit www.evac.ou.edu/okwmdp/physics.html

EXPERIMENT – MAKING CLOUDS

Aim:
To demonstrate how clouds are formed.

Materials:

a large jar, water, rubber glove.

Procedure:
Cover the bottom of a large jar (eg. a large olive jar) with water. Stretch a glove over the top of the jar so the fingers are dangling into the jar. The glove needs to seal the top of the jar. Insert your hand into the glove and pull it quickly upwards without breaking the seal. Nothing will happen. The next step is to remove the glove, drop a lit match in to the jar and replace the glove. Pull the glove out once more. Fog should from in the jar when the glove is pulled out and disappear when the glove snaps back.

Questions:

What is happening here? Describe how clouds are formed. For more information about this experiment visit www.exploratorium.edu/snacks/fog_chamber.html

4. INDIGENOUS ADAPTATIONS TO THE ARID ENVIRONMENT

Mallee shrublands are found in the arid areas of Australia. Indigenous people knew how to obtain water from the trees of the Mallee area. One way was to dig a trench around the base of a certain type of tree, locating the roots which run out from just under the surface of the soil. They then removed the roots of the tree, cut them into pieces up to a metre long and stood them against the tree. The water draining from these pieces was collected for drinking.

Grass Tree (Xanthorrhoea species) after burning. The Grass Tree is an example of a native plant which flowers in response to fire.

Fire as a management tool

In some areas of Australia indigenous land managers use fire to manage the forests. Indigenous people light fires before the fuel source has built up too much so the fire will not be as hot and be less likely to burn out of control. This lower temperature fire also helps with the germination of the seeds of some native plants.

Managing underground water

Aboriginal people had extensive knowledge of the groundwater system. Indigenous Australians dug underground water reservoirs that helped them live on one of the world's driest continents for tens of thousands of years.

Link:
www.abc.net.au/science/news/stories/s1590192.htm

ACTIVITY – HEAT AND SEED GERMINATION

Aim:
Compare the effect of heat on the germination of native and non-native seeds.

Suggested seeds to use are acacia (can be purchased from www. shaman-australis.com.au) and radish seeds.

Procedure:
Place five radish seeds in a beaker and five acacia seeds in a seperate beaker. Cover both of the beakers with boiling water and leave overnight. The seeds that have been heat treated can be germinated on cotton wool and compared to seeds which have been planted directly without any heat treatment and the germination rates recorded in a table.

Question:
What effect does heat treatment have on the two different seeds?

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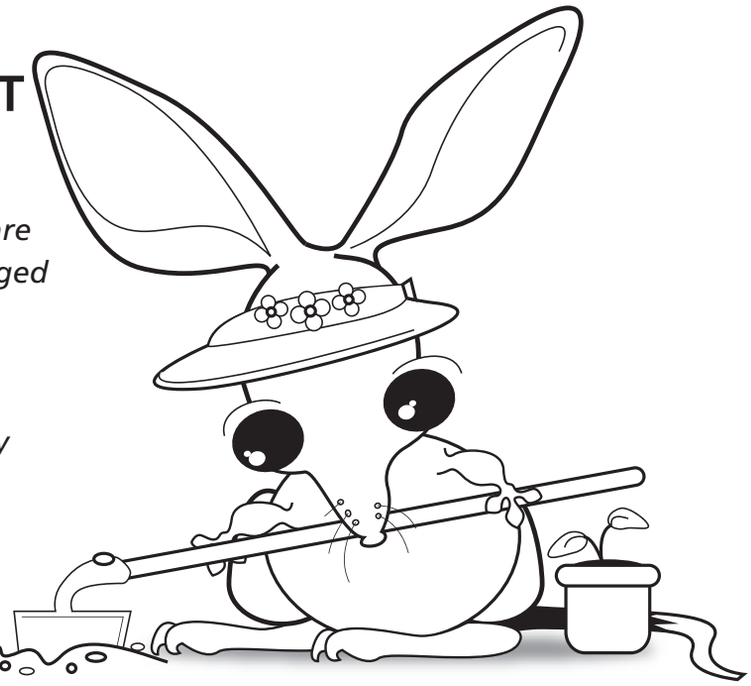
Heffernan, D.A (1984) *The World of Science 2*, Longman Cheshire Pty Ltd. Australia

Sharwood, J, Khun, M, (2005), *Science Edge 3*, Nelson Australia Pty Ltd, Vic.

Farmhand Foundation, (2004) *Talking Water,* Australia.

SUSTAINABLE NATURAL RESOURCE MANAGEMENT



Australia has a range of fragile ecosystems and environments to preserve. Arid areas are particularly sensitive and need to be managed carefully to ensure that the environment, indigenous communities and agriculture can co-exist. Agricultural industries rely on healthy water and land and are affected by their limited and often degraded supply. Sustainable resource management is the key to preserving our fragile environment and, as owners and managers of over sixty percent of land in Australia, farmers must continue to lead the way in adopting sustainable land-use practices.

Agriculture

Agriculture is Australia's most extensive form of land use, occupying 461 million hectares. Cities and towns take up less than one percent of the total land area (7.6 million hectares).

Did You Know?

70 percent of Australia's water consumption is used by agriculture.

www.deh.gov.au

The main cause of land degradation in arid areas is over-grazing, land clearing and invasion of weeds. Problems such as soil salinity, acidification and rising groundwater all appear to be on the increase.

The future of Australia's rural communities is dependent on the development and improvement of land management practices that are economically viable, environmentally sustainable and socially acceptable.

Vegetation and agriculture

Native vegetation is an integral part of the arid lands grazing environment. Native plants often produce an abundance of seed during wet seasons which is then stored as a seed bank in the ground. Over grazing of the arid lands leads to a decline in soil stability which results in erosion. Erosion, in particular wind erosion, causes the seeds in the seed bank to be blown away and the vegetation cover is reduced.

There are grasses and shrubs which change in abundance and location according to grazing pressure.

As a result of the highly variable climate and the type of landscape, changing grazing pressure and fire are the main tools available to manage the vegetation in arid areas. For more information visit: www.cazr.csiro.au/pastoral.htm

EXPERIMENT – GRAZING PRESSURE

Aim:
To determine the effect of grazing pressure on vegetation.

Procedure:
Observe the vegetation growth in different areas of the school. For example, look at areas where students walk all of the time and compare that to areas which are not walked over regularly. Compare the amount and type of vegetation in the different areas.

Questions:
Are plants there different? Are there more weeds in areas which have been walked over more frequently? How does this relate to grazing animals and the impact on vegetation?

Case Study – Adapting plant genetics to suit dry conditions

Production of sorghum in semi-arid areas is limited by drought. Results from breeding programs in the USA and Australia suggest that advances in crop improvement under water-limited conditions are more likely if drought resistance traits are selected in addition to yield traits. Stay-green in sorghum is one such trait. Stay-green keeps some leaves green during dry conditions so that the plant can continue photosynthesising and survive. Studies suggest that sorghum hybrids possessing the stay-green trait have a significant yield advantage under water-limited conditions compared with hybrids not possessing this trait.

Link:
www.regional.org.au/au/asit/compendium/m-02.htm

Agriculture and waterways

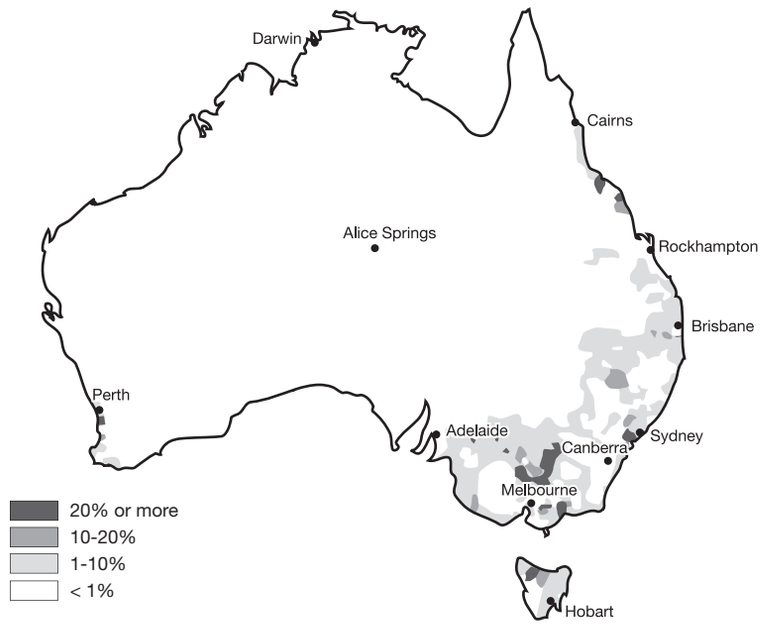
As the world's driest inhabited continent, many of Australia's rivers have highly variable flows. Droughts and floods are common. This high variability of flows has necessitated the regulation of rivers and groundwater resources to accommodate irrigated agriculture and domestic water demands. This has had a negative impact on many species of fish and plants that were adapted to the natural flow regime. Poor land practices and water use in Australia in the past have had a negative impact on the amount and quality of our water supply.

Many dams have been built to control our water supply resulting in a water storage capacity of 4,000KL per person. This is the highest water storage per capita of any country in the world.

Irrigation

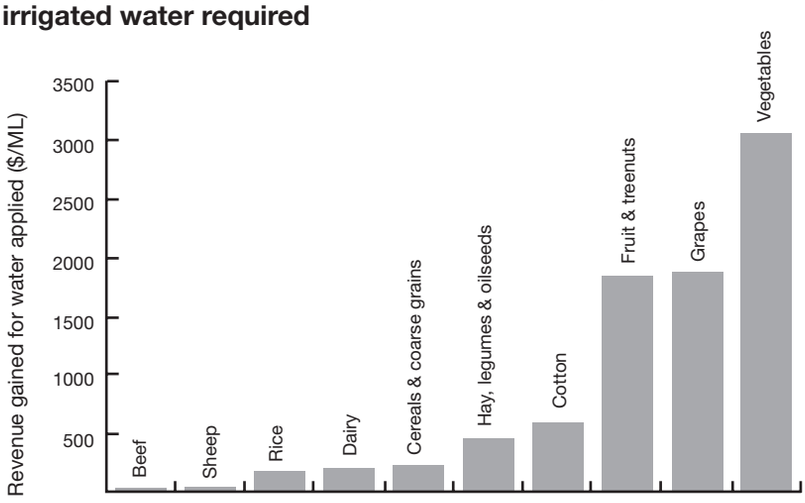
Irrigation means taking water mechanically from one place to another for agriculture. Irrigation generally occurs in Australia where the rain falls at a different time to when the crops need it. Water for irrigation comes from rivers or underground basins.

Irrigated areas of Australia (permission from Australian Bureau of Statistics)



Source: www.cmis.csiro.au/healthycountry/reports/Irrigation_perspectiveV2.pdf)

Average farm gate revenue generated per megalitre of irrigated water required



Source: 'Irrigation in perspective – Irrigation in the Murray and Murrimbidgee Basins' CRC for Irrigation Futures
www.cmis.csiro.au/healthycountry/reports/Irrigation_perspectiveV2.pdf

Did You Know?

Approximately 75 percent of water is used in irrigated agriculture, 20 percent for urban and industrial uses and around 5 percent for other rural uses such as stock and domestic needs. www.daff.gov.au

Irrigation – Benefits and Issues

Irrigation has allowed agriculture to be carried out productively in many areas of Australia, particularly areas of variable or non-seasonal rainfall. Even in areas of high rainfall, irrigation can be used to supplement the water supply at certain times of the year.

There are a number of issues associated with the use of irrigation:-

1. Water that is taken from a river or dam can be lost through seepage or evaporation before it actually gets to the farm gate. Up to 85 percent of water can be lost when open earthen channel supplies are used.
2. Irrigation can result in rising saline groundwater tables and subsequent salt build up in the soil. The salt build up in the soil can then lead to run-off and increased salinity in waterways. This is a particular problem in arid areas.
3. Contamination of waterways from irrigation can also result when drainage water from irrigation systems, contaminated with pesticides and fertilisers is released into waterways.
4. Water that is removed from rivers can upset the ecosystem balance such as fish spawning opportunities.

A centre pivot irrigation system used for irrigation on a dairy farm.

Case Study – Irrigation techniques to reduce water use.

1. Neutron probe

Irrigators realise the importance of checking soil moisture content before irrigating. In the past irrigation was carried out following a set regime. Testing soil moisture using devices such as a neutron probe allows water to be applied only when it is required leading to a reduction in the amount of water required to produce a crop.

2. Varieties of rice

Water use efficiency has improved in rice production as a result of the development of higher yielding, shorter season rice varieties. This assists rice farmers in achieving the greatest rice yield possible with the least amount of water usage.

Link:
www.aboutrice.com/handout14.htm

ACTIVITY – IRRIGATION

Aim:
To determine the most effective method of irrigating crops.

Procedure:
Design an experiment to investigate the most effective method to irrigate plants. Think about growing the same plant in a number of different pots and then using different irrigation systems such as drip or flood irrigation. Work out how much water is needed to keep the plants alive using each system. Consider which method would have the most water loss due to evaporation and wastage.

Links:
www.clw.csiro.au/research/agriculture/irrigation/ and www.cottonaustralia.com.au

ACTIVITY – SOIL MOISTURE CONTENT

Aim:
To determine which soils have higher soil moisture content

Procedure:
Collect a number of different soil samples. It would be useful to collect the soil samples a day or two after rain or irrigation. This will allow a measure of soil moisture at field capacity i.e. after water that is not readily available to plants has drained. Try to include some sandier ones and some more clay type ones. Feel each sample to see how moist it is. Record the results. Then take about 100 g of each soil and weigh. Dry each sample in the oven – ensuring they are labelled so can be identified afterwards. Weigh each sample after drying. Calculate the amount of moisture each soil contains. Which type of soil holds the most moisture? Re-wet the dried soil with 200ml of water to measure run off to find 'saturated soil water content'.

Climate Change

Changes to Australian climate due to greenhouse gas production are already occurring over and above natural variability and these changes are impacting on Australian ecosystems. Ecosystems that are particularly vulnerable to climate change include coral reefs, arid and semi-arid habitats in south-west and inland Australia and Australian alpine systems.

Using global climate model simulations, the CSIRO has projected future climatic conditions in Australia, which include:

- an increase in average annual temperature of 1-6 °C by 2070 over most of Australia
- an increase in the average number of extreme hot days and decrease in the average number of extreme cold days
- a decrease in annual average rainfall in the south-west and in parts of the south-east and in Queensland
- an overall drying trend for Australia due to increased temperatures and evaporation and changes in rainfall
- an increase in maximum wind speed of tropical cyclones of 5-10 percent in some parts of the globe by 2100 and increase in precipitation rates by 20-30 percent

Climate Change and Vegetation

The arid areas of Australia incorporate a diversity of plant and animal species. Climate change and rising carbon dioxide levels have the potential to significantly alter the interactions between plant species in these environments. Temperature and rainfall have a major imapct on where individual species of plants can grow. As these change the vegetation in arid areas will change accordingly followed by the animals that use the vegetation for food or shelter.

Climate change and Agriculture

A drying trend is indicated for most of Australia and is particularly strong for southwest Western Australia. Australian agriculture needs to prepare for a reduction in average rainfall. Even if rainfall stayed the same, increasing temperatures would see soil water balances decline.

Did You Know?

Increases in carbon dioxide will enhance plant growth and water-use efficiency, but changes in climate may offset these benefits. For example, wheat yield would rise unless rainfall decreases by 20 percent and the warming exceeds 2°C.

www.csiro.au

Management changes recommended to farmers could include:-

- changes in varieties and planting dates, eg. Ultra narrow row cotton uses less water to produce equivalent yields.
- changes in crop species, eg. Cropping native species which are resistant to dry periods.
- erosion and salinity management, for more information on this see the relevant section of this book.
- pest and disease management, eg. using pre-emptive pest management strategies to combat the increased pest numbers
- greater use of seasonal forecast information eg. Drought prediction data and climate modelling.

Case Study – Climate Modelling

Researchers at the Queensland Department of Natural Resources and Mines used a pasture production model to explore the impact of climate change on native grasses.

With large increases in temperature and decreased rainfall, average pasture growth across Australia was reduced by between 30-70 percent by 2030, with reductions increasing to 30-100 precent by 2070.

For more information about this visit:
www.bom.gov.au/inside/eiab/reports/caa03/chapter4/agriculture_forestry.shtml

ACTIVITY – CLIMATE CHANGE

Aim:
To determine what effect climate has on the growth rate of plants.

Procedure:
Design an experiment to work out what effect different temperatures and rainfall would have on the growth rate of grasses.

Question:
What would be the ideal climatic conditions for the grass you are growing?

Climate Change and Water Resources

" By the middle of this century, at worst seven billion people in 60 countries will be faced with water scarcity, at best two billion in 48 countries, depending on factors like population growth and policy-making. Climate change will account for an estimated 20 percent of this increase in global water scarcity ...
Water quality will worsen with rising pollution levels and water temperatures."

Source: www.greenhouse.gov.au/science/guide/pubs/chapter4.pdf

Case Study – Lake Bullenmerri and Evaporation

Researchers from the University of Melbourne and CSIRO have found signs that recent warming is affecting evaporation from crater lakes in western Victoria.
The lakes have no streams flowing in or out, so their levels are dominated by rainfall and evaporations. The researchers have found that rainfall is currently 80 percent of lake evaporation, whereas to maintain the historic lake levels rainfall would have had to have been 95 percent of lake evaporation.
This trend is going to have an impact on water supplies in these areas.

Link:
www.bom.gov.au/inside/eiab/reports/caa03/chapter4/water_resources.shtml

Printed

Brown, L, Hindmarsh, R, McGregor, R, (1992), *Dynamic Agriculture Book 1*, McGraw-Hill Book Company, Roseville. Australia

Macleod, D.A., R.G. Francis, et.al (1985), *Soils and Climate in Agricultural Production Systems*, University of New England Press. Australia.

Scientific Basis of Modern Agriculture (1988), edited by Keith O. Campbell and John W. Bowyer, Sydney University Press

Websites

Government portal for information about natural resource management
www.deh.gov.au

Publications and resources available for land and water management
www.clw.csiro.au/issues/landuse/

Information about the research done on stay-green in sorghum
www.regional.org.au/au/asit/compendium/m-02.htm

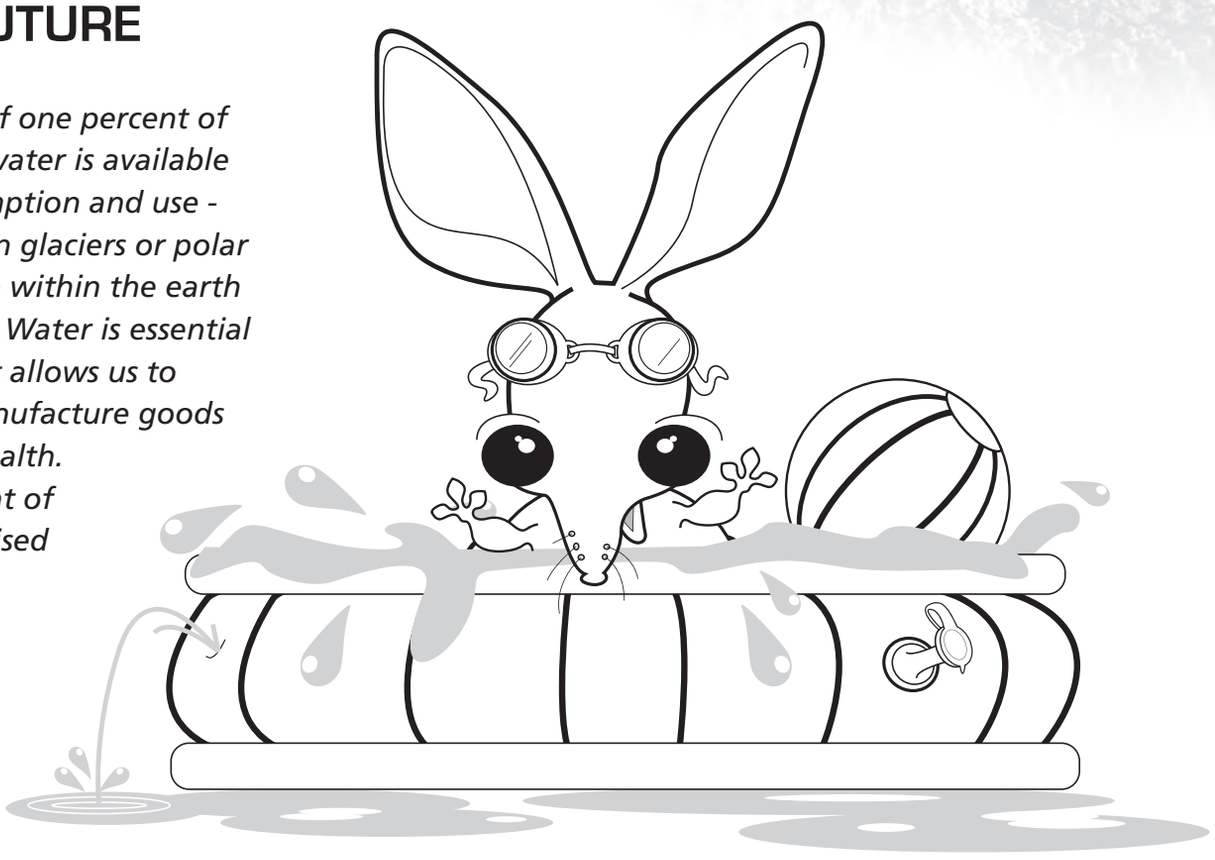
School project information and fact sheets
www.cazr.csiro.au/pastoral.htm

Activities and resources on climate change and greenhouse
www.greenhouse.gov.au

Extensive information about the effect of climate change on agriculture
www.bom.gov.au/inside/eiab/reports/caa03/chapter4/agriculture_forestry.shtml

Information and links about natural resource management
www.daff.gov.au/corporate_docs/publications/pdf/greenhouse/farm_journal_article.pdf

WATER - CONSERVING IT FOR THE FUTURE



Less than a third of one percent of the world's fresh water is available for human consumption and use - the rest is frozen in glaciers or polar ice caps, or is deep within the earth beyond our reach. Water is essential to our existence; it allows us to produce food, manufacture goods and sustain our health. About sixty percent of our body is comprised of water.

Global freshwater supplies are finite. One of Australia's most significant natural resource issues is the sustainable management of our water resources. We must achieve a balance between managing the demands for water by the urban, agricultural and industrial sectors whilst retaining the health of our rivers, wetlands and estuaries.

> *" When the well's dry, we know the worth of water"*
>
> Benjamin Franklin, (1746)), Poor Richard's Almanac, as quoted in *Talking Water* p. 145

Did You Know?

A person needs about five litres of water a day to survive.

QUESTION

What did Benjamin Franklin mean when he wrote these words? Even though this was written in 1746, why are his words still relevant today in terms of our dry continent?

EXPERIMENT – WHAT IS WATER?

Aim:
To determine the chemical make up of water

Materials:
Voltameter, water, test tube, taper.

Procedure:
1. Fill a voltameter with water and close the taps.
2. Connect the voltameter to a power supply and turn it on. Bubbles will form.
3. Place a test tube over the arm of the voltameter and collect the gas.
4. Test the gas with a burning taper.

Questions:
What gas has been produced? What is the chemical symbol for water? Can you draw a diagram of this?

ACTIVITY – THE WORTH OF WATER

Have students conduct a water audit of dripping taps at school. Pairs of students take one cup and a stopwatch and visit the different toilet and bubbler facilities in the school. Any drops are caught for one minute from each tap/bubbler. Back in the classroom all of the water is measured. Students then calculate the amount that's being lost in an hour, day, month, year and calculate the actual monetary cost to the school. Strategies can then be put in place for each age group to correct the 'drips'.

ACTIVITY – WATER IS LIFE

Take a walk around your school. List the different uses of water around your school. In groups, develop an advertising campaign to publicise the scarcity of water. Design a logo or icon representing the value of water. Explain the meaning behind your logo and your campaign. Design posters and hang them around the school.

Did You Know?

If 100 litres represents the world's water, little more than half a tablespoon of it is fresh water available for our use.

Did You Know?

The Snowy River, has been reduced to about one percent of its original flow

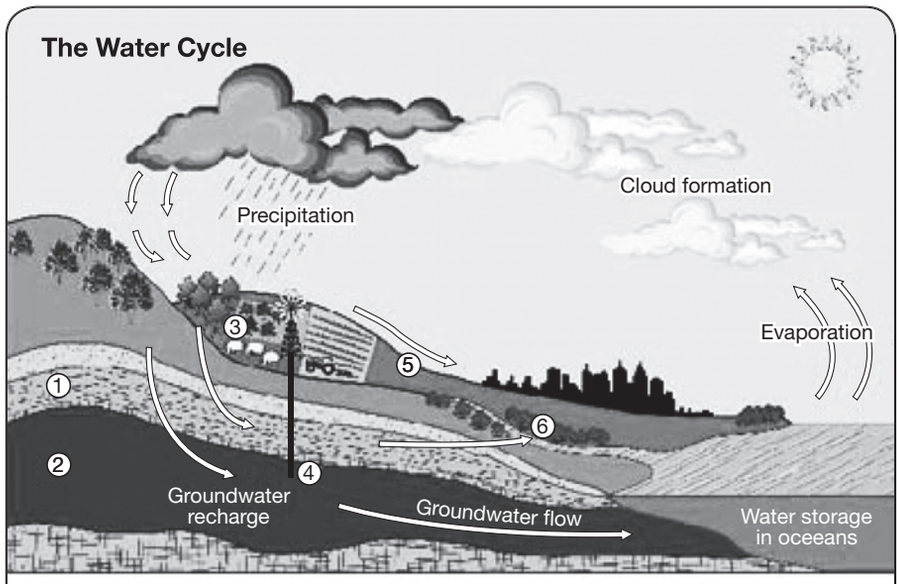
Did You Know?

Global water consumption has risen almost tenfold since 1900.

www.awa.asn.au/AM/Template.cfm?Section=Information

Water makes the world go round

The water cycle is the simplest natural cycle on Earth. Water is continually on the move around the world. Solar energy evaporates millions of litres of water into the atmosphere as water vapour. As the water vapour is pushed over the land by winds and rises over mountains, the water vapour cools and turns back into tiny water droplets, forming clouds. These droplets fall to earth as rain. The rain runs into streams and rivers, which eventually flow into lakes or the sea and some seeps into the soil where it makes its way to becoming groundwater and the cycle begins all over again.



ACTIVITY – THE WATER CYCLE

Look at the diagram above. In your own words describe the water cycle. Research the meaning of evaporation, transpiration, condensation, precipitation, infiltration, percolation, run-off. Explain how these processes work together to create the water cycle.

EXPERIMENT – THE WATER CYCLE

Aim:
To demonstrate how the water cycle works.

Materials:
a jar, bottle cap or shell of water, soil, sand, pebbles.

Procedure:
1. Fill the jar with a layer of pebbles, then a layer of sand, then soil.
2. Fill a bottle cap with water and put it in the jar. Put the lid on.
3. Put the jar in a sunny place.
4. Observe and record what you see happen in the jar over the next 3 days.

Questions:
1. Was there evaporation? Explain what part of the experiment demonstrated this.
2. Was there condensation? Explain what part of the experiment demonstrated this.
3. Was there precipitation? Explain what part of the experiment demonstrated this.

Link:
www.epa.gov/OGWDW/kids/grades_k-3_watercycle_activity.html

Questions:
Rain and snow bring water to Earths surface. Where does the water go from there? How does water move around the planet? Will Earth ever run out of water? Write a hypothesis that explains the movement of water between the ocean and the atmosphere.

ACTIVITY – SOLAR STILL

Aim:
To make a solar still

Materials:
Clear plastic sheet at least one metre square, a bucket or cup, a shovel.

Procedure:
1. In a sunny spot dig a hole that is slightly smaller than your sheet and 30-40cm deep.
2. Place the bucket/cup in the centre of the hole and spread the plastic sheet over it.
3. Use stones to hold the edges of the sheet down.
4. Put a few small stones in the middle of the sheets so that it forms a "v" shape directly over the bucket/cup.
5. Record your observations, including how long it takes to see results.

Links:
www.csiro.au/helix/experiments/dhexpsolarstill.shtml

Did You Know?

No new water is ever made. The existing water is recycled over and over again.

Printed

Wakefield, J and Houghton (1990), G, *Deserts and Grasslands*, Macmillan. Australia.

Websites

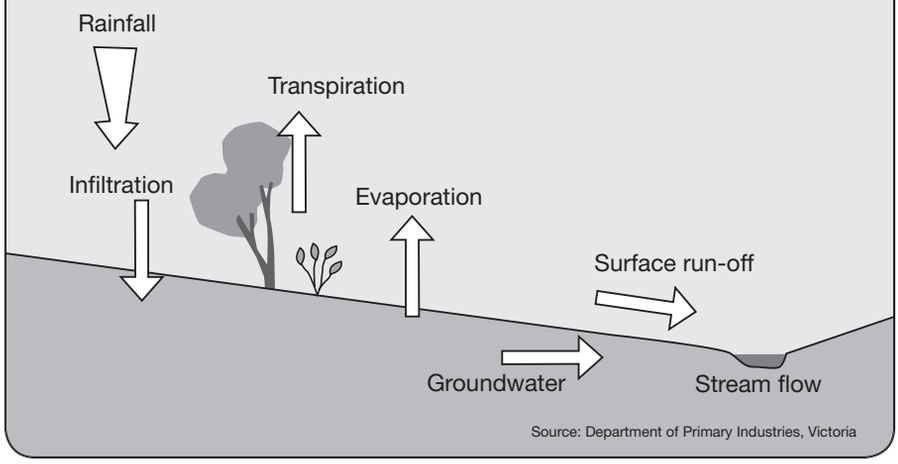
Evaporation experiment
www.abcteach.com/Desert/science.htm

Experiments and activities to do with water and the water cycle.
www.eagle.ca/~matink/themes/Biomes/waterweb.html

River Catchments

A catchment is the area of land drained by a river and its tributaries. A catchment is made up of soil, water, air and vegetation. Together these components support life and make up an ecosystem in which a range of biophysical processes occur.

Catchment and the Water Cycle



Source: Department of Primary Industries, Victoria

ACTIVITY – IDENTIFY CATCHMENT

Identify where the catchment or sub-catchment boundaries are in relation to the landscape using topographic maps of the area. The catchment may be defined by surrounding hills or in the case of larger catchments, the catchment boundaries may be hundreds of kilometres away.

Link:
www.environment.nsw.gov.au/stormwater/hsieteachguide/index.htm

ACTIVITY – CATCHMENT MANAGEMENT SKETCH MAP

Visit a local catchment and gather the following information for a sketch map of the catchment: catchment boundaries, flow and path of water course, general gradients (drainage patterns of surrounding lands), native vegetation, parks and playing fields, cleared land, erosion, land-use zones (residential, industrial, commercial), location of school, major roads, potential pollution sources, including, stormwater drains entering the waterway and sewage overflow points.

Link:
www.environment.nsw.gov.au/stormwater/hsieteachguide/index.htm

ACTIVITY – WATER POLLUTION

Aim:
To investigate how a river becomes polluted.

Materials:
Large bowl or deep-sided tray, funnel, sieve, water, 'pollutants' such as grass clippings, oil, detergent, dirt, green food colouring (pesticide/herbicide).

Procedure:

1. Fill the tray or bowl with water. This represents your local creek or waterway. The funnel represents a storm drain.
2. Place some of the pollutants into the funnel, holding your finger over the bottom so that they stay inside. Hold the funnel over the 'waterway' and remove your finger.
3. Pour some water on top of the pollutants in the funnel. This is like the rain washing things into the storm drain. What happens to the water in the bowl?
4. Try the experiment again, this time holding the sieve over the funnel. What happens this time? Does the sieve stop all the pollutants? What kind of pollutants still entered the 'waterway'?

Link:
www.csiro.au/helix/experiments/WaterPollution.shtml

Questions:
Discuss stormwater pollution with students: what sort of pollutants float into a drain, where the water and objects that float into the drain go, how does each pollutant damage the environment.

Websites

Department of Environment and Conservation (NSW) has a comprehensive list of primary and secondary curriculum links and resources on this site.
www.environment.nsw.gov.au/stormwater/hsieteachguide/index.htm

North Central Catchment Management Authority CD-Rom, 'Waterways'. For extensive ideas and resources on the topic of waterways contact the North Central Catchment Management Authority.
www.nccma.vic.gov.au

Streams Alive Lesson One – Story of a River focuses on the issue of water in the environment for Years 5&6
www.streamwatch.org.au/streamwatch/connect/Streamwatch/Home/Library/Manuals+%26+field+guides/

River Murray Resource Pack for K-6 students told through Danny the Drip examining issues such as pollution and catchment management -
www.rivermurray.sa.gov.au/work/pdfs/River%20Murray%20Story.pdf

Streams Alive Resource Kit by Anne Forbes and David Cleary for middle school students. It focuses on catchment issues
www.gresswell.vic.edu.au/projects/streamsalive.htm

Printed

Jenkins, C et. al, (1990), *Science Scene 1*, Edward Arnold Australia Pty Ltd

Farmhand Foundation, *Talking Water*, Australia

EXPERIMENT– STORMWATER POLLUTION

Reference:
This activity is taken from the CD-Rom - Waterwatch Victoria Urban Stormwater Education Program. Published by Waterwatch Victoria, East Melbourne.

Aim:
To investigate the effect of oil on the water-proofing capacity of feathers.

Materials:
Glass/jar, fresh water, feathers, oil, Gateway Sanctuary stormwater sub-catchment map provided.

Procedure:
1. Fill a glass or jar with clean fresh water. Dip a feather in the water. Pull the feather out. Record on your record sheet how the feather looks and feels.
2. Add oil to the glass of water. Put the feather into the oil and water mixture. Pull the feather out. Record what your feather looks like now.
3. Discuss how the feather stayed dry the first time the students dipped it in the clean water. Why do birds feathers need to be waterproof?
4. Discuss how oil might enter a waterbody such as Gateway Sanctuary. What might happen to birds if they are exposed to oils? How can we reduce the likelihood of oil entering areas our waterways.

Extension:
Contact your local council or sewage treatment plant to investigate how water is recycled and re-used in your local government area.

EXPERIMENT – ALGAL BLOOM IN THE CLASSROOM

Aim:
To determine the effect of different levels of nutrient on algal growth.

Link:
www.bigelow.org/edhab/building_bloom.html#Stepnine - an excellent classroom experiment where students grow their own algae. The experiment introduces students to the concept of algal growth relating to colour and shows how to graph the results.

Drinking Water

"Drinking water" is water that is safe for humans to drink and to use for other domestic purposes, such as cooking, washing up, bathing and showering. According to the Australian Drinking Water Guidelines: *Ideally, drinking water should be clear, colourless, and well aerated, with no unpalatable taste or odour, and it should contain no suspended matter, harmful chemical substances, or pathogenic microorganisms".* Water undergoes a rigorous water treatment process to remove all harmful substances before distribution. **Link:** www.waterquality.crc.org.au

EXPERIMENT – WATER TREATMENT

This experiment demonstrates the procedures that water treatment plants may use to purify water for drinking.

Link:
www.epa.gov/safewater/kids/grades_4-8_water_filtration.html

EXPERIMENT – JOURNEY DOWN THE DRAIN

This experiment engages students in thinking about sewage and its treatment. A mixture is prepared to represent sewage and then students use a variety of techniques to separate different components from the mixture.

Link:
www.environment.nsw.gov.au/stormwater/hsieteachguide/stg2activity31.htm

EXPERIMENT – WATER TREATMENT

Have students design a water filtration system to clean muddy water. Discuss with them the types of materials they could use eg. plastic bottle, cotton wool, sand, leaves, twigs.

Links: www.library.thinkquest.org/04apr/00222/text/filter.htm
www.epa.gov/safewater/kids/teachers_4-8.html

Printed

Taylor B, (1992), *Rivers and Oceans*, Kingfisher Books, London. UK

Case Study – Water Pollution in the City of Sydney Local Government Area

Pollution is a threat to the ecological health and our use and enjoyment of natural water systems such as Sydney Harbour. There are a number of historical and ongoing sources of water pollution originating within the City of Sydney Local Government Area (LGA).

Link:
www.cityofsydney.nsw.gov.au/Environment/Water/CurrentStatus/WaterPollution.asp

ACTIVITY – STREAMWATCH

Streamwatch is a school and community education and action program that raises awareness of the natural environment through testing water quality in local rivers and streams.

Link:
www.streamwatch.org.au/streamwatch/connect/Streamwatch/Home/About+Streamwatch/What+is+Streamwatch/

Case study - Farm Water Management

Collecting a year's irrigation water in one rainfall event.

Link:
www.landcareaustralia.com.au/FarmingCaseStudies.asp

Issues of water degradation
www.clw.csiro.au/priorities/water/rivers_estuaries/faq.html

A comprehensive site of information and activities to illustrate the concept of catchments and water management.
www.cwmb.sa.gov.au/kwc/main.htm.

Water conservation
www.australian-aridlands-botanic-garden.org/general/water/water0.htm

Keeping water clean
www.waterquality.crc.org.au/aboutdw_dwfacts.htm

Did You Know?

The average family uses about 1,020 litres of water around the home everyday. That's 118 full buckets of water.

Water usage around the house

Daily household activity	Usage*
Brushing teeth	5 litres
Washing hands	5 litres
Flushing toilet	12 litres
Shower	40-250 litres
Bath	50-150 litres
Trickling toilet	6,000 litres/year
Washing machine	40-265 litres
Drinking, cooking, cleaning	8 litres/day
Dishwashing by hand	18 litres
Dishwasher	20-90 litres/load
Sprinkler	1,000 litres/hour
Washing car with a running hose	100-300 litres
Dripping tap (slow)	30 litres/day
Hand-held hose	10-20 litres/min
Filling swimming pool	up to 55,000 litres
Evaporation loss from typical home pool	up to 200 litres/day

* Figures vary due to personal habits and design of household appliances.

Source:
www.australian-aridlands-botanic-garden.org/general/water/water0.htm

ACTIVITY – CALCULATE YOUR HOUSEHOLD'S WATER USE

Visit the following links to calculate the water usage of your household. What can be done to reduce this usage?

Links:
www.ecoselect.net.au/water_calculator/ - *water calculator*

www.waterforlife.nsw.gov.au/education/index.shtml - *water saving ideas*

www.watercare.sa.gov.au/whatsnew.php#id - *DIY tips for conserving water*

www.ourwaterfuture.com.au/waterwise/content_waterwise_inside.asp - *for tips on how to save water when building a house*

Did You Know?

Australians use 24,000 Giga Litres of water every year, which is enough to fill Sydney Harbour forty eight times.

ACTIVITY – SAVE WATER AT SCHOOL

In groups, get students to carry out a water usage audit of their school. What sources of water waste can they identify around the school? What examples of water recycling can you find? Write a water saving plan for their school, including at least THREE strategies for saving water at your school, including a program for recycling water (read the case study below for ideas). Go to the websites below and the local council for more ideas on how to save water:

Competition:
Conduct a class competition to design a water awareness poster.

Game:
Have students design a game that illustrates the process of water use from the water supply to disposal.

Links:
www.sydneywater.com.au
Every Drop Counts a comprehensive Stage 3 resource kit produced by Sydney Water

www.savewater.com.au/
For more tips about conserving water visit this site

Case Study - North Merredin Primary School Water Education Policy

Context: North Merredin Primary School is situated in the Central wheatbelt of Western Australia with many students coming from farming families and thereby realizing the importance of water conservation.

Policy Statement: At North Merredin PS students are engaged in a variety of activities allowing them to fully appreciate the importance of water and to find ways that they can contribute to ensuring that this resource remains protected. These activities are: investigating the way water is used around the school and designing posters to encourage students to use water wisely, investigating the use of grey water.

Link:
www.ourwaterfuture.com.au/waterwise/content_waterwise_inside.asp

ACTIVITY – WATERWISE GARDENING

Visit the Waterwise gardening website www.ourwaterfuture.com.au/waterwise/content_waterwise_newgarden.asp

Ask students to design a garden for their backyard that will never be watered by hose or by a person taking into account the tips that they have read on the website. Include the plants they would plant and a maintenance plan for the garden. Ask students to explain why they have chosen the plants and what the water conservation benefits of their garden are.

Case Studies: Indigenous communities on the way to better water supplies

Remote indigenous communities in Gunbalanya, Northern Territory, are set to gain better water supplies thanks to the dedication of a civil engineering student at the University of Western Sydney. Naomi Herben from UWS aims to develop a Strategic Asset Management Plan (SAMP) of the community's water assets. "Access to clean water can be directly related to people's economic and social well-being as well as their health," Ms Herben says.

Link: www.irrigationfutures.org.au/)

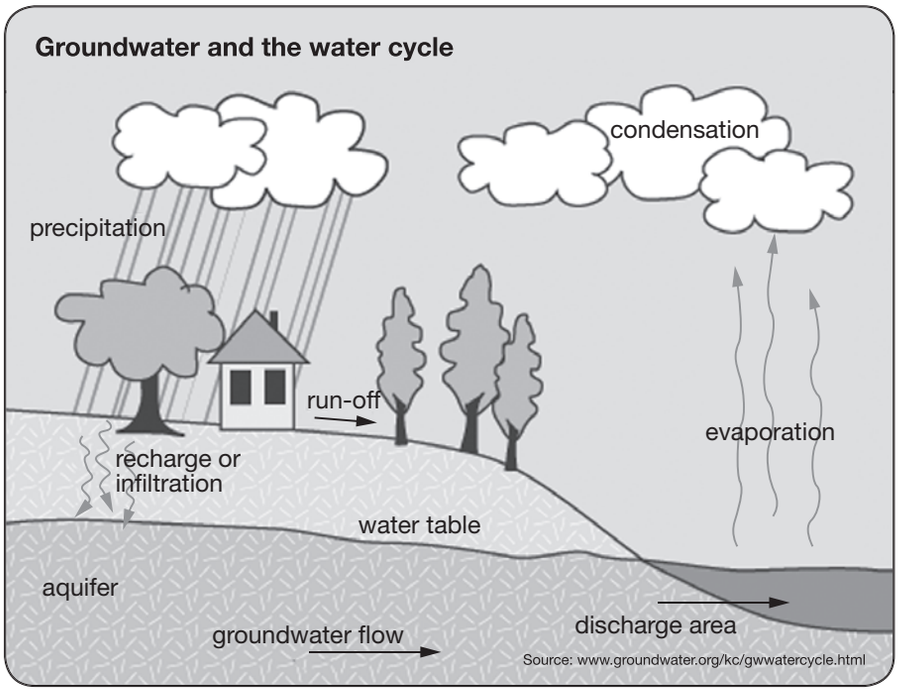
Groundwater – Our Other Water Supply

Groundwater is a vital water resource allowing people to live in places where surface water is scarce. Groundwater plays a vital role in agriculture and commerce, providing water for irrigation and industry. It is also used for recreational facilities such as sports fields and domestic water use and most spring and mineral water supplies are obtained from the groundwater resources of the Mount Lofty Ranges, SA. Many of Australia's wetlands and freshwater systems rely on a supply of groundwater as does the surrounding natural wildlife. Groundwater supplies approximately 65 percent of all irrigation demand in South Australia.

Groundwater is by far the world's largest source of fresh water. It is estimated that the amount of groundwater is 400 times greater than all the surface water in lakes, reservoirs, streams, and rivers.

Website

Interactive groundwater activity
www.cwmb.sa.gov.au/kwc/interactive/groundwater/index.htm



Where does groundwater come from?

Groundwater is derived from rain that percolates down through soil or fractures in rock, filling up the pores between sand grains or the fissures in rocks. Anything from none to half of the rainfall in a given area may reach the water table and thus recharge the groundwater. The time that water takes to reach the water table and deeper aquifers varies depending on soil and geology. For example the rate of water movement through sandstone can vary between 1 and 5 metres per year. Some water in the Great Artesian Basin was found to be almost 2 million years old.

Aquifers

Geological formations such as those composed of sand, sandstone and limestone, containing useable quantities of groundwater, are called aquifers. The aquifer closest to the ground surface is called the shallow, or unconfined, aquifer (its upper surface is the water table). There are also deeper, confined (sometimes called artesian) aquifers where the water is confined under pressure between relatively impervious layers.

Windmill used for the extraction of groundwater

EXPERIMENT – MAKE YOUR OWN AQUIFER

Aim:
To demonstrate how groundwater is trapped underground in aquifers.

Procedure:

1. Fill the cup with sand, gravel, clay, or dirt and pour water in the top. Repeat this trying out each material to figure out which is the most permeable (meaning water flows through it easily) and which is the least permeable.
2. Now that the students know more about materials that are found in the ground, they are ready to make an aquifer. Ask them to choose the material that they found to be the least permeable and make a layer of it at the bottom of the cup. Then, fill the rest of the cup with the material that is the most permeable.
3. Does the aquifer hold water? Pour some in and see.
4. Ask students to fill the cup and see how much water they can trap in their aquifer.

Questions:
Even though the cup is full of sand and dirt some water can still go through it. The water will fill the pore spaces between the pieces of material. Which material holds the most water in it? Why do you think this is? If there are few or no pore spaces in a material, then it will not let much water into it and it will not let water flow through it and out of the cup. Did you find a material that did not soak up much water and wouldn't allow the water to drain from the cup?

Link:
www.eo.ucar.edu/kids/wwe/ground4.htm

Case Study – Great Artesian Basin

The Great Artesian Basin (GAB) is one of Australia's most important water resources. In the more arid areas of the GAB, groundwater from the basin is the only reliable source of good-quality water – supporting human activity as well as a range of unique ecosystems.

We can run out of groundwater if more water is withdrawn by pumping (discharge) than is fed by recharge from the surface. This is a problem considering that in many areas groundwater is being withdrawn in increasing quantities to meet growing demands and development pressures.

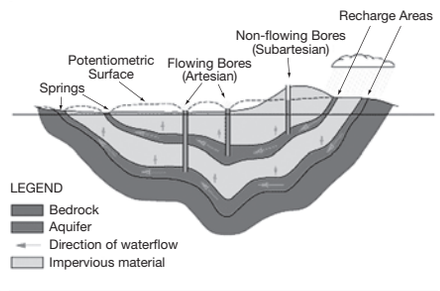
Links:
www.daff.gov.au/content/output.cfm?ObjectID=D2C48F86-BA1A-11A1-A2200060B0A06221&contType=outputs

www.nrm.qld.gov.au/water/gab/

www.ipe.nt.gov.au/whatwedo/water-resources/ground/basics/what.html

The Great Artesian Basin

Operation of an Artesian Basin



Source: www.gabcc.org.au/public/content/ViewCategory.aspx?id=52

Did You Know?

The Great Artesian Basin is the largest groundwater basin in the world. It lies beneath one-fifth of Australia and approximately one-third of South Australia.

Threats to groundwater

Salinity and pollution are the greatest threats to groundwater quality. Potential sources of pollution include microbiological contaminants from sewage and effluent, heavy metals, petroleum fuels and solvents, nutrients (phosphates and nitrogen) salt and detergents. Herbicides can pollute shallow groundwater systems if not managed correctly and high nitrate levels may result from concentrated livestock excretion and the use of nitrogenous fertilisers and nitrogen-fixing plants. Inappropriate land use management and activity is often a significant cause of pollution.

Case Study - South Australia's Groundwater

Groundwater underpins the horticultural industry in the North Adelaide Plains and is the source of water for the springs and mineral water suppliers.

Link:
www.clw.csiro.au/education/groundwater/casestudy.html

The hidden uses of water - seeing beyond the tap

There is often a high amount of 'embodied water' associated with many items we use or consume. For example:

- It takes 41,500 litres to produce a kilo of meat
- It takes 500 litres to produce one orange
- It takes 1,340,000 litres to produce one tonne of aluminium
- It takes fifty litres to produce a copy of Saturday's newspaper
- It takes about 5,000 litres of water to create one kilogram of rice
- It takes 4 litres to produce a bottle of beer

41,500 litres of water to produce a kilo of meat.

5,000 litres of water to produce one kilogram of rice.

4 litres of water to produce one bottle of beer.

500 litres of water to produce one orange.

Printed

Archer, J., Hodges, J., and LeHunt, R., (1993) *The Water Efficient Garden,* Random House, Milsons Point, NSW, Australia.

Websites

Information about how to save water in all the home, business and agriculture
www.savewater.com.au/default.asp?SectionId=469&SortTag=560

Water conservation ideas/programs designed specifically for schools
www.savewater.com.au/index.php?sectionid=16

Tips for saving water
www.murrayusers.sa.gov.au/save_the_murray.htm

A wonderful interactive game for primary students about water pollution
www.qld.waterwatch.org.au/flash/ww_game.swf

Reusing water

Currently 97 percent of our city runoff and 86 percent of effluent water is unproductive. Wastewater, rich in pollutants and nutrients, flows from our cities and farms into rivers and coastal areas. Losing this water can harm industry and the environment, inhibit future development and add to pollution in our rivers and estuaries.

Grey Water and Black Water

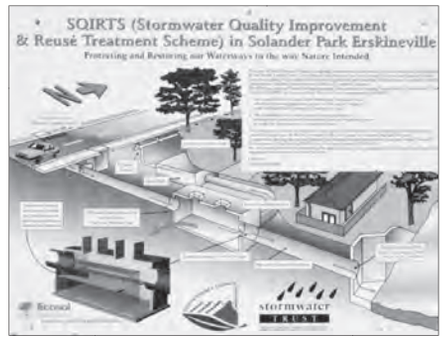
Waste water is categorised as either grey or black water. **Grey water** is made up of the wastewater from our showers, baths, spas, hand basins, laundry tubs, and washing machines (it doesn't include water from toilets.) Used appropriately, you can water your garden with grey water and save around 400 litres of fresh water each day. Approximately 61 percent of the total wastewater produced by an average household can be used as greywater, however there are very strict health guidelines that must be followed. For information about these contact your local Department of Health.

Black water is made up of the wastewater from our toilets, urinals, bidets, dishwashers and sinks. It is grossly contaminated by human excrement or high levels of chemicals and requires a detailed treatment process such as a composting toilet before it is suitable to use in the garden.

Case Study

Stormwater recycling innovation in Solander Park, Erskineville NSW.

Link:
www.cityofsydney.nsw.gov.au/Environment/Water/WhatTheCityIsDoing/WaterEfficiencyAndReuse.asp



Solander Park SQIRTS (Stormwater Quality Improvement & Reuse Treatment Scheme).

Source: City of Sydney

ACTIVITIES - RECYCLING WATER

Great for little ones

Links:
www.epa.gov/safewater/kids/
www.gippswater.com.au/education/student.asp
www.enchantedlearning.com/themes/water.shtml

Desalination

Desalination is a process that separates dissolved minerals and impurities from seawater or other salty water. Desalination is commonly used in dry climates such as the Middle East, Spain, Malta, Cyprus and in parts of the United States where traditional water supplies, such as dams or pumping from groundwater, are limited.

EXPERIMENT – DESALINATION

Link:
www.saltwatch.org.au/saltwatch/book/34_page.html

Aim:
To remove salt from water

Materials:
A large beaker which does not have a pouring lip, a small beaker (which will fit into the large beaker), a concave dish which will fit over the top of the large beaker, table salt, a lead sinker

Procedure:
1. Dissolve three tablespoons of salt in the water in a litre of water in the large beaker.
2. Sit the small beaker in the large one, ensuring that none of the saline water gets into the small beaker.
3. Place a lead sinker in the small beaker to keep it stable.
4. Place the concave dish face up over the large beaker. Place in a sunny spot. Observe what happens over several days.

Questions:
When the experiment has finished discuss with your group what has happened. Write a report describing what you have observed and explain what process has occurred. Research desalination and locate a place where it is used.

Did You Know?

Seventy percent of the drinking water on Rottnest Island is supplied by a reverse osmosis desalination plant, reducng the Islands' reliance on limited rainfall and groundwater supplies. A 600kw wind turbine has been installed to provide power for the plant.

Case Study – Desalination in Sydney.

Sydney Morning Herald, Wednesday February 8 2006, p. 1
"Desalination plant dumped: it was a stinker..."

ACTIVITY – DESALINATION: YES OR NO?

Role play the controversy that surrounded the NSW governments plans to build a desalination plant in Sydney. Divide the class in half with one group representing the government and the other representing the community. Students should develop a speech outlining their reasons for or against the plant. The teacher adjudicates the debate, with each student being given the opportunity to deliver their speech. The teacher gives points to each team and announces a winner after everyone has spoken.

Case Study: Wave Energy Technology and Desalination - September 2005

Energetech has developed and demonstrated a patented process to extract commercially viable energy from the ocean waves, and operates a full-scale unit in Port Kembla, Wollongong. This unit generates electrical power which can be supplied to the local community grid, but also has a small reverse osmosis unit to make fresh water from the same clean wave energy.

Link: www.energetech.com.au

Question:
Consider the significance of this technology in terms of the debate surrounding the desalination process.

Energetech's wave power generator. Photo courtesy of Energetech Australia Pty Ltd

Printed

For more experiments and activities on desalination
Sharwood, J and Khun, M (1994), *Science Edge 1*, Nelson Australia Pty Ltd, p. 192-195.

GLOSSARY

Annual - plants whose life cycle lasts only one year, from seed to blooms to seed.

Aquifer – a layer of porous rock which lies between layers of non-porous rock.

Arid – a climatic term that refers to an area that has an average annual rainfall of less than 250mm.

Artesian basin – a region where water is stored underground in an aquifer.

Catchment - the geographical area draining into a river or reservoir.

Climate - is the weather recorded over many years.

Condensation – is the process by which steam changes to water.

Conduction – the transfer of heat from one medium to another, usually between substances of different temperature.

Convection - heat conveyed to the body by a moving warm medium, such as air or water.

Cuticle – the waxy coating of leaves that reduces water loss.

Degradation – a gradual wearing down or wasting of water or land.

Desertification - is the degradation of land in arid and semi arid areas resulting from various factors including climatic variations and human activities.

Desiccation – to dry out thoroughly.

Ecosystem - an interconnected community of living things and the physical environment within which they interact.

Ephemeral plants – plants that grow, flower and seed quickly after significant rain falls in dry areas.

Evaporation – the process by which water changes to steam.

Geology – the study of the origin, structure and history of the earth.

Germination – when plants begin growing.

Giga Litres - one billion litres.

Habitat - place where a plant or animal can get the food, water, shelter and space it needs to survive.

Humidity – the concentration of water contained in air. Humidity is measured using a hygrometer.

Indigenous – originating and living in Australia.

Nocturnal – animals that are active at night.

Mallee - small multi-stemmed eucalypts that often dominate semi-arid and arid areas.

Mammal - warm-blooded vertebrate animals, characterised by a covering of hair on the skin and, in the female, milk-producing mammary glands for nourishing the young.

Phreatophytes – a deep-rooted plant that obtains water from a permanent ground supply or from the water table.

Precipitation - any form of water, such as rain, snow, sleet, or hail, that falls to the earth's surface.

Rangelands - regions where rainfall is too low or too variable for dryland cropping or grazing of improved pastures to be the dominant agricultural activities.

Salinity - is the accumulation of salt in land and water to a level that impacts on the natural and built environment.

Semi arid – a climatic description that refers to an area that has an average annual rainfall of less than 500mm per year.

Stomates - one of the minute pores in the epidermis of a leaf or stem through which gases and water vapour pass.

Subsistence – a means of just surviving.

Sustainability – actions relating to environmental, social, economic responsibility.

Thermoregulate - to regulate body temperature.

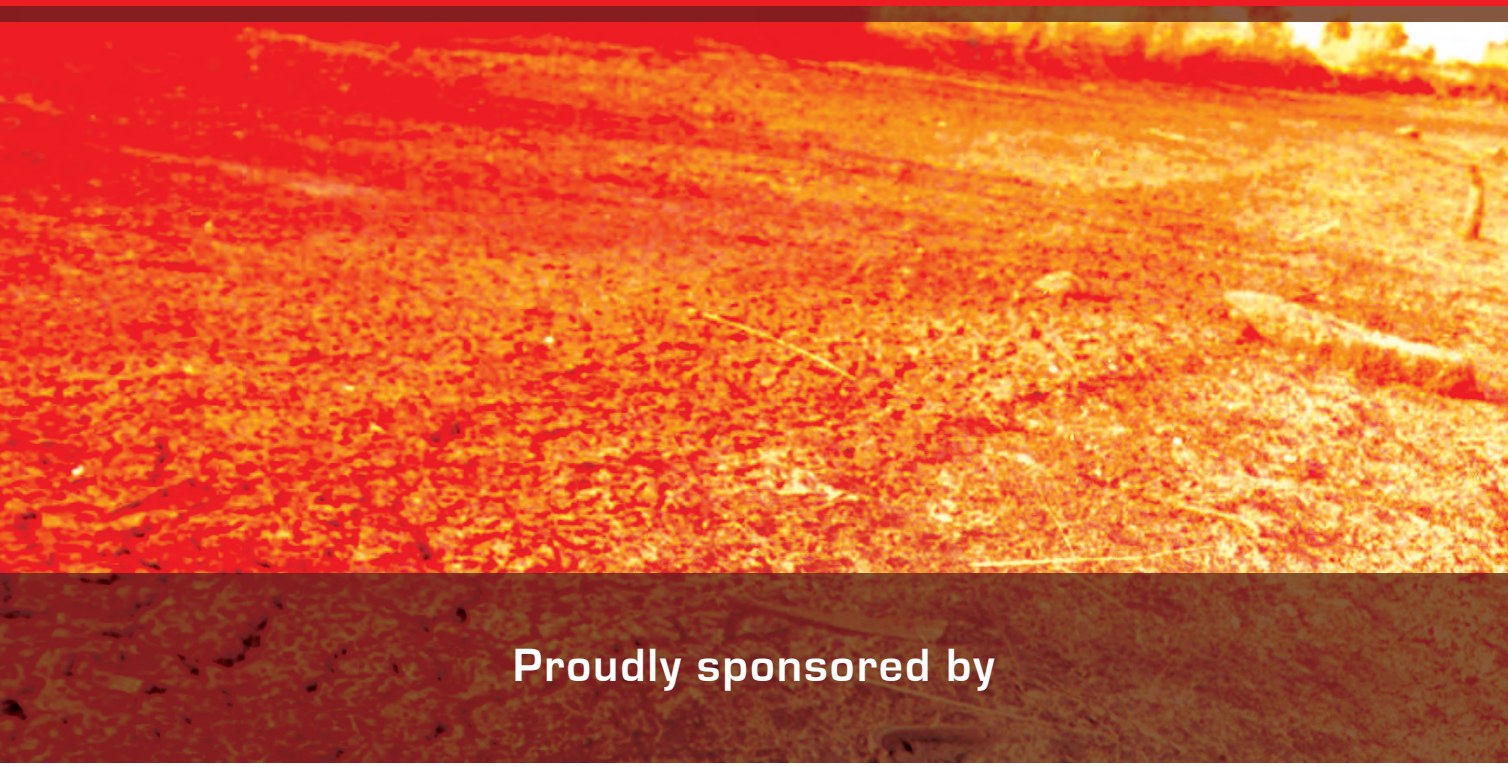
Transpiration - the release of moisture through the leaves of a plant.

Turbidity - having sediment or foreign particles stirred up or suspended, as in water.

Vascular - containing vessels that carry or circulate fluids, such as blood, lymph, or sap, through the body of an animal or plant.

Weather – describes all of the changes that happen in our atmosphere.

Xerophytes - a plant that is adapted for a dry habitat, e.g. a cactus.



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