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Hydrology and Water Scarcity in MDB

John Williams
NSW Commissioner for Natural Resources

natural resources commission

World river run off

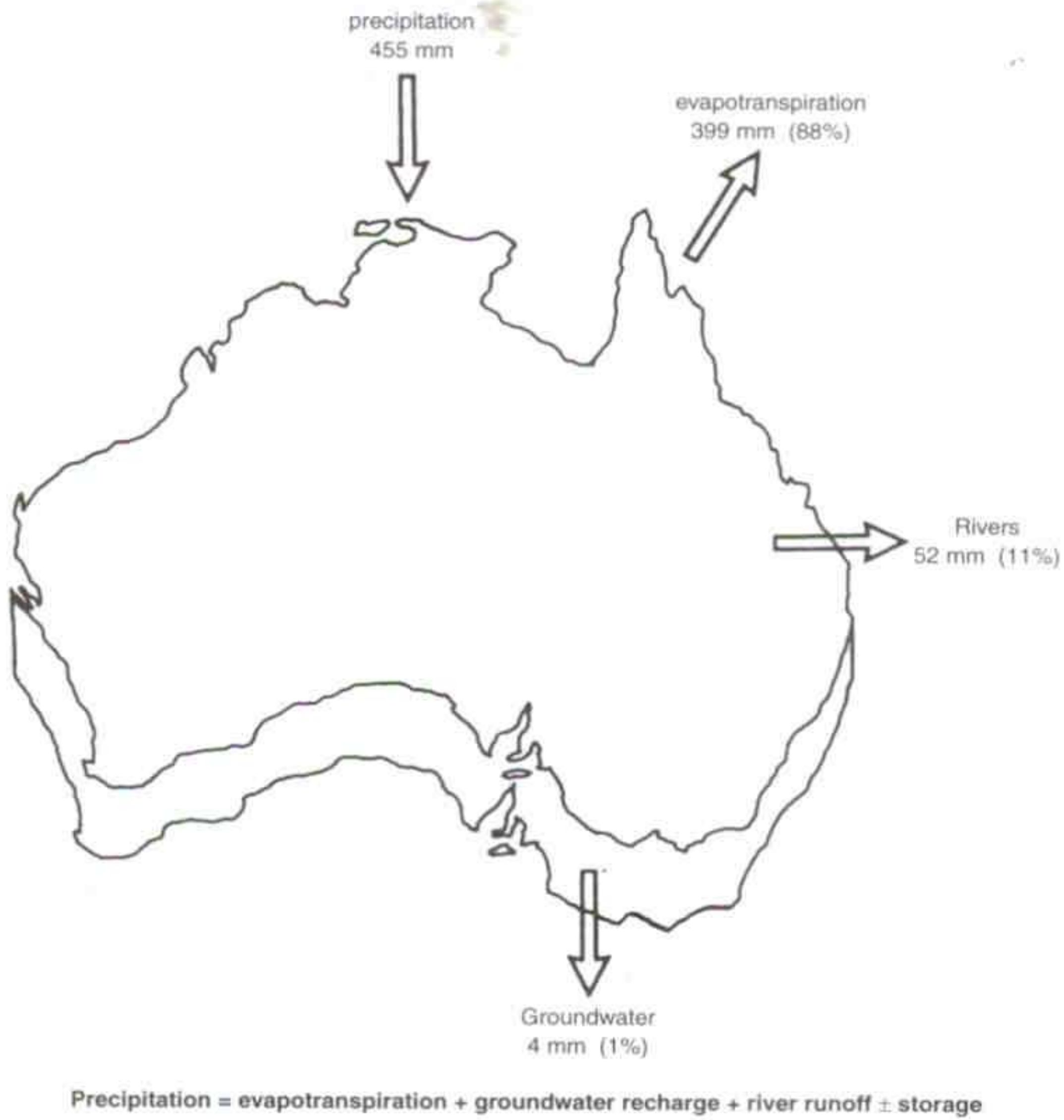
Table 1.1 Average annual river runoff for continental land masses

Territory	Annual river runoff (mm)	Annual river runoff (km^2)	Percentage of total runoff (mm)	Area (10^3 km^3)	Specific discharge (mm)
Europe	306	3210	7	10 500	9.7
Asia[1]	332	14 410	31	43 475	10.5
Africa[2]	151	4570	10	30 120	4.8
North America[3]	339	8200	17	24 200	10.7
South America	661	11 760	25	17 800	21.0
Australia	52	397	1	7683	1.6
Oceania	1610	2040	4	1267	51.1
Antarctica	160	2230	5	13 977	5.1
Total land area	314	46 770	100	149 000	10.0

1. Asia includes Japan, the Philippines, and Indonesia.
2. Africa includes Madagascar
3. North and Central America

Source: based on Gleick 1993; data for Australia from DPIE 1987

Annual Australian Hydrological cycle



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Australia – Annual rainfall variability

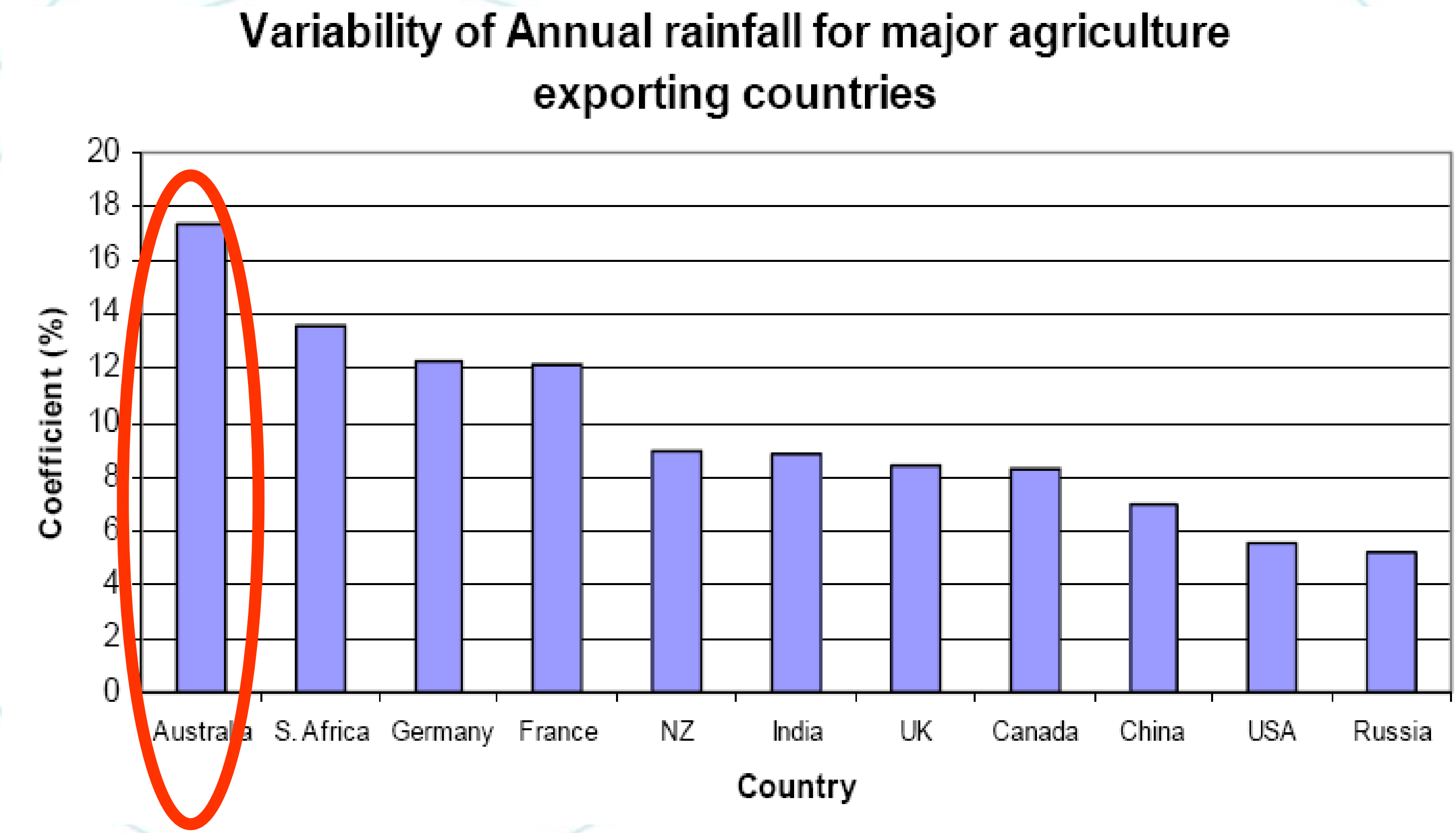


Table 1. Variability of flow in some of the world's major rivers compared with two Australian rivers.

COUNTRY	RIVER	RATIO BETWEEN THE MAXIMUM and the MINIMUM ANNUAL FLOWS
Switzerland	Rhine	1.9
China	Yangtze	2.0
Sudan	White Nile	2.4
USA	Potomac	3.9
South Africa	Orange	16.9
Australia	Murray	15.5
Australia	Hunter	54.3

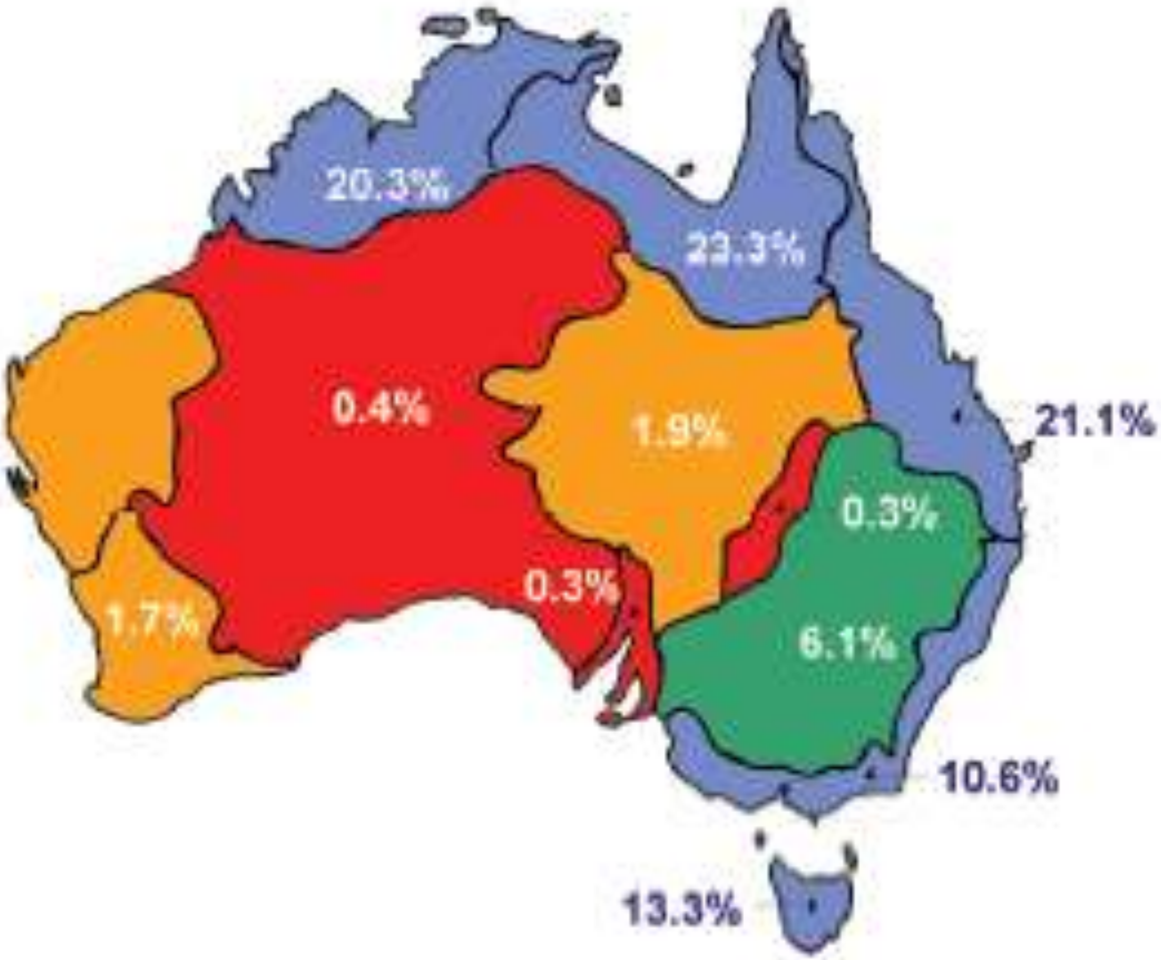


Fig. 1. Australia's distribution of run-off (Source: *Water and the Australian Economy*, April 1999).

Annual water availability/use in Australia (NLWRA, ABS.)

- **Mean Annual run-off** **387,184 GL**
- **Annual Groundwater Yield** **25,780 GL**

Water Consumed: 24,908 GL

Agriculture	**16,660 GL**
Forestry and Fishing	27 GL
Mining	401 GL
Manufacturing	866 GL
Electricity and Gas	1,688 Gl
Water supply, Sewerage/Drainage	1,794 GL
Household Water	2,182 GL
Other	3,973 GL

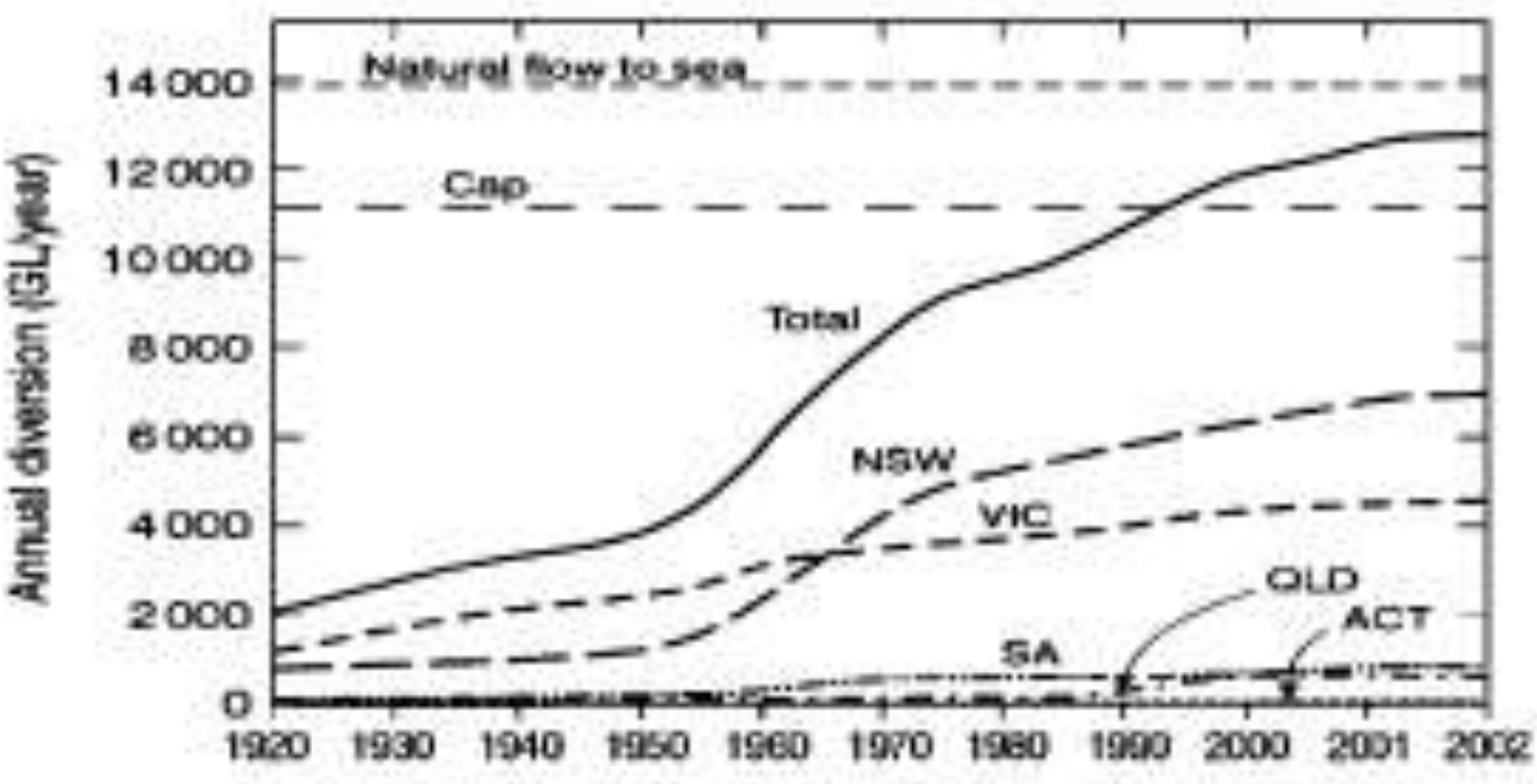
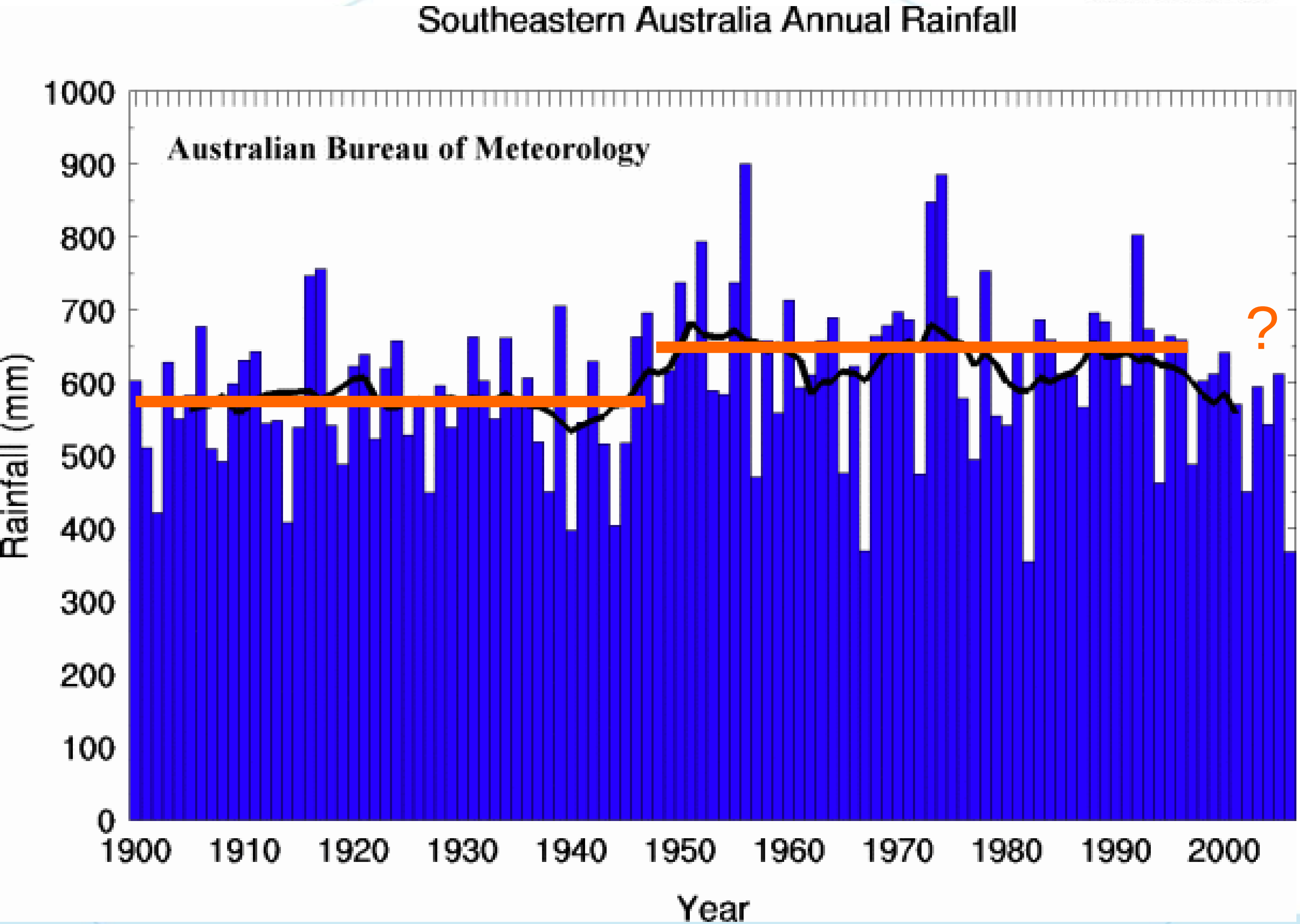


Fig. 4. Growth in water use in Murray-Darling Basin 1920 to 2000.



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resources
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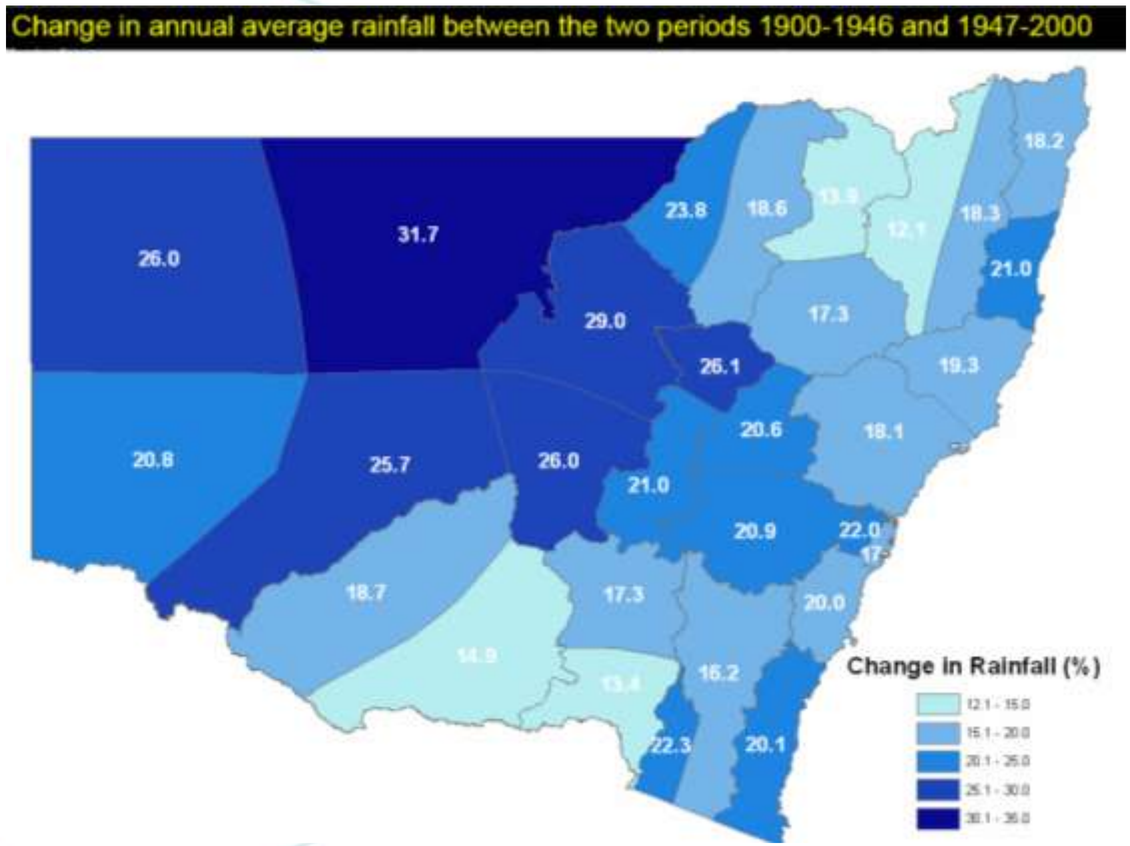
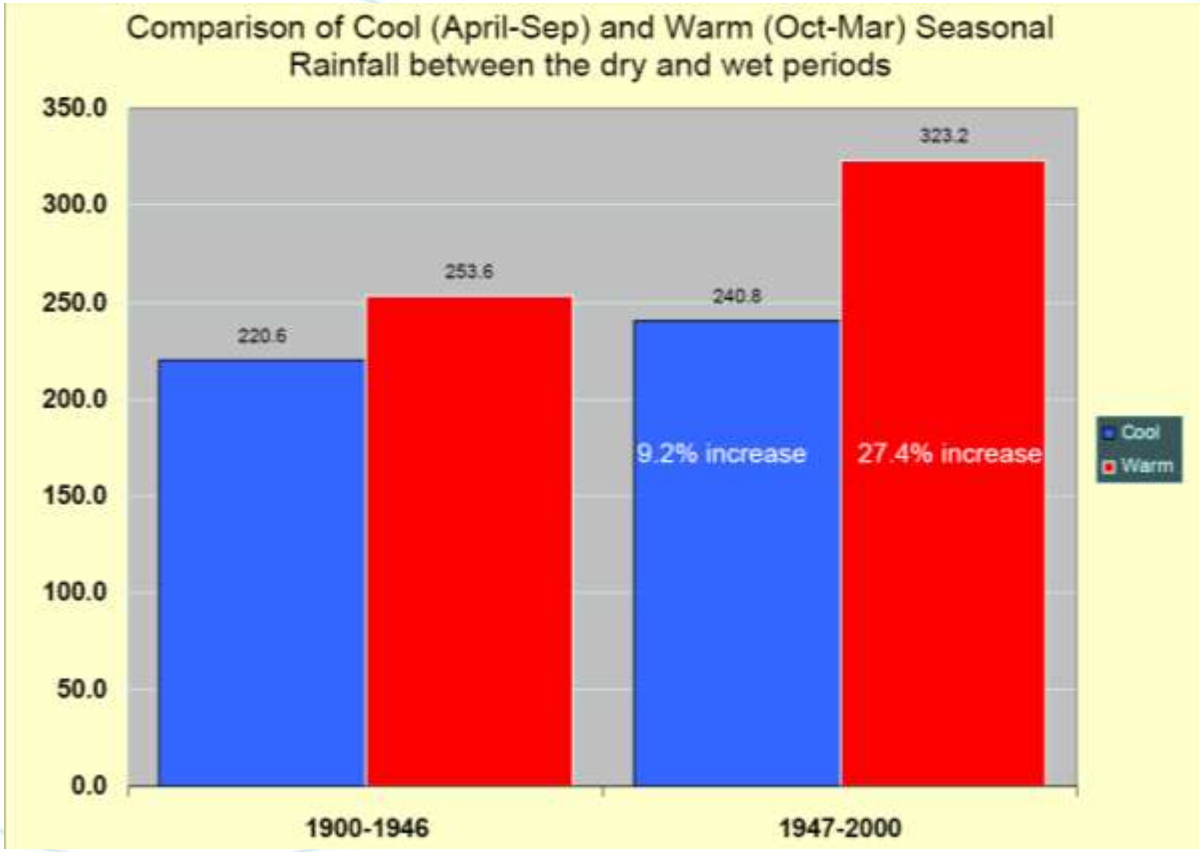
Southeastern Australia Annual Rainfall
Australian Bureau of Meteorology
Rainfall (mm)
Year
1000
900
800
700
600
500
400
300
200
100
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
?

NSW – Changes in annual average rainfall



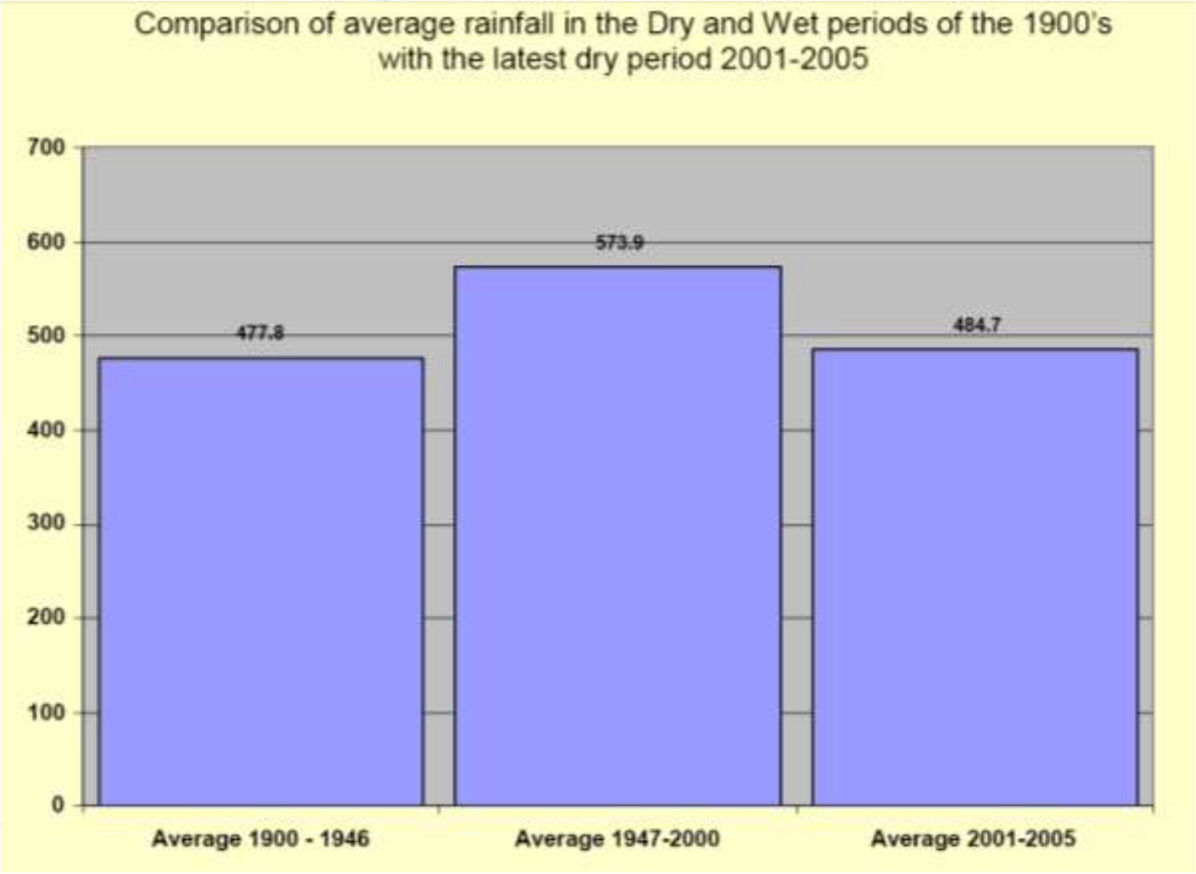
Source: Barry Hanstrum, Bureau of Meteorology

Comparison of cool and warm seasonal rainfall



Source: Barry Hanstrum, Bureau of Meteorology

Comparison of average rainfall in dry and wet periods



Source: Barry Hanstrum, Bureau of Meteorology

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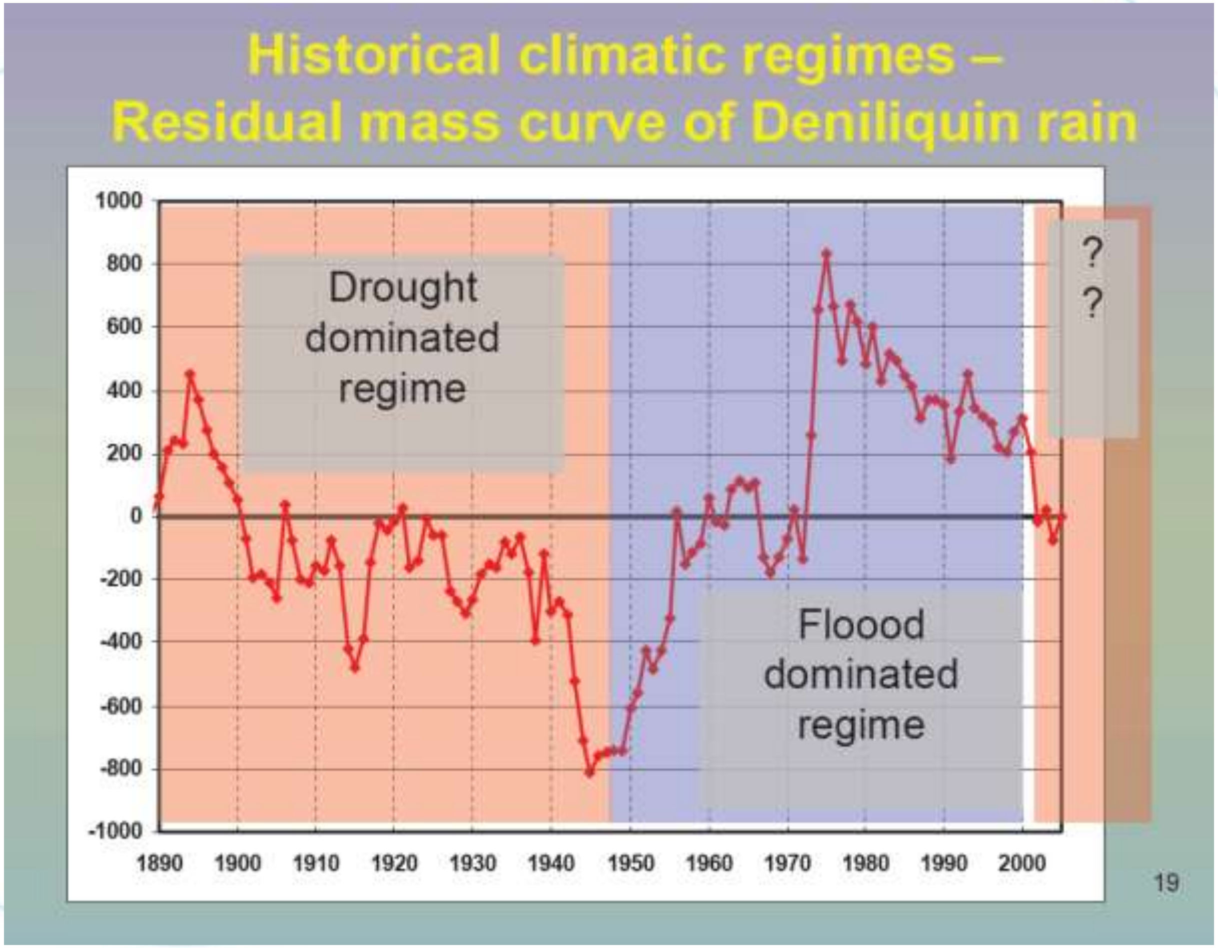
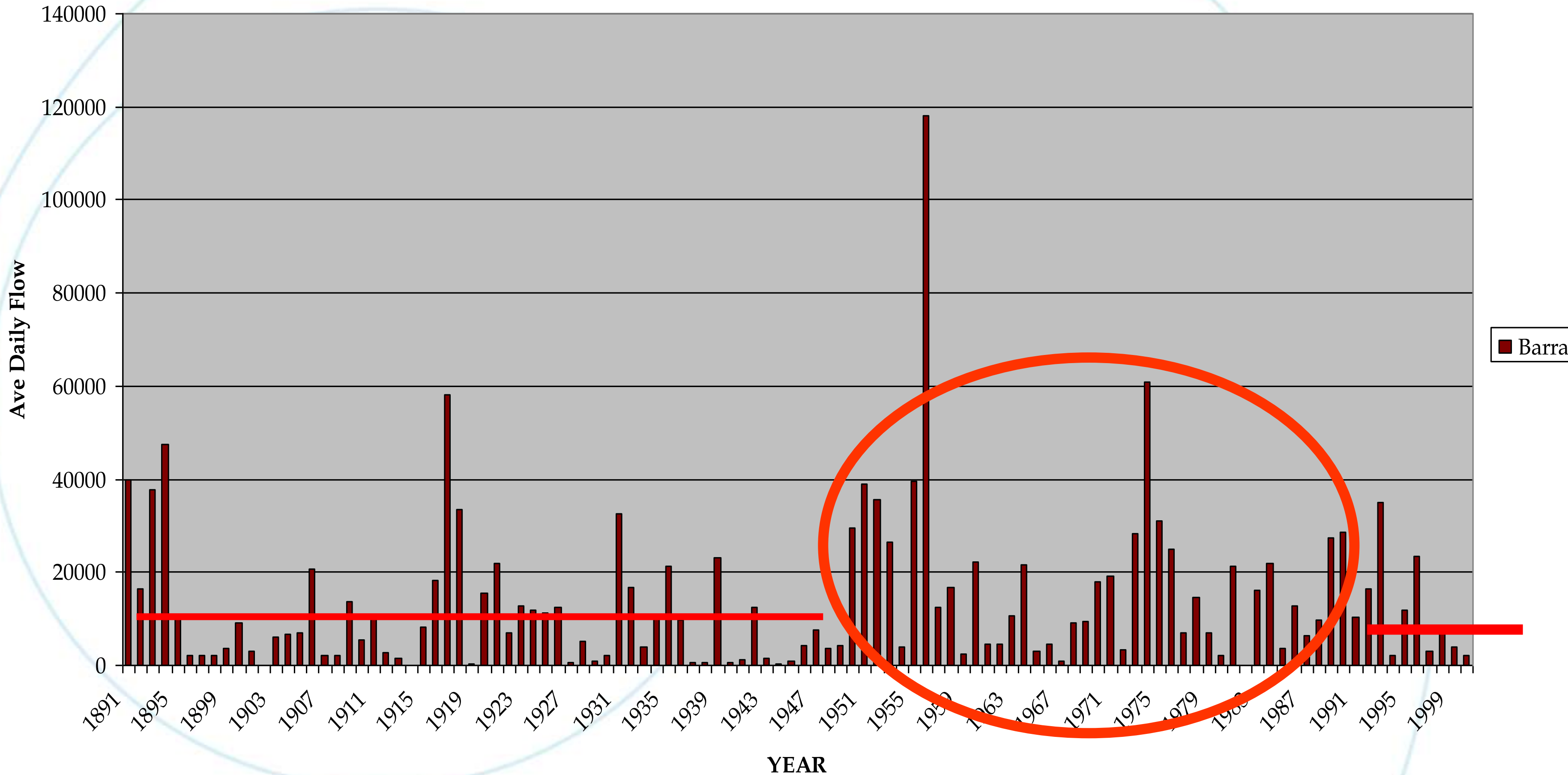
Historical climate regimes



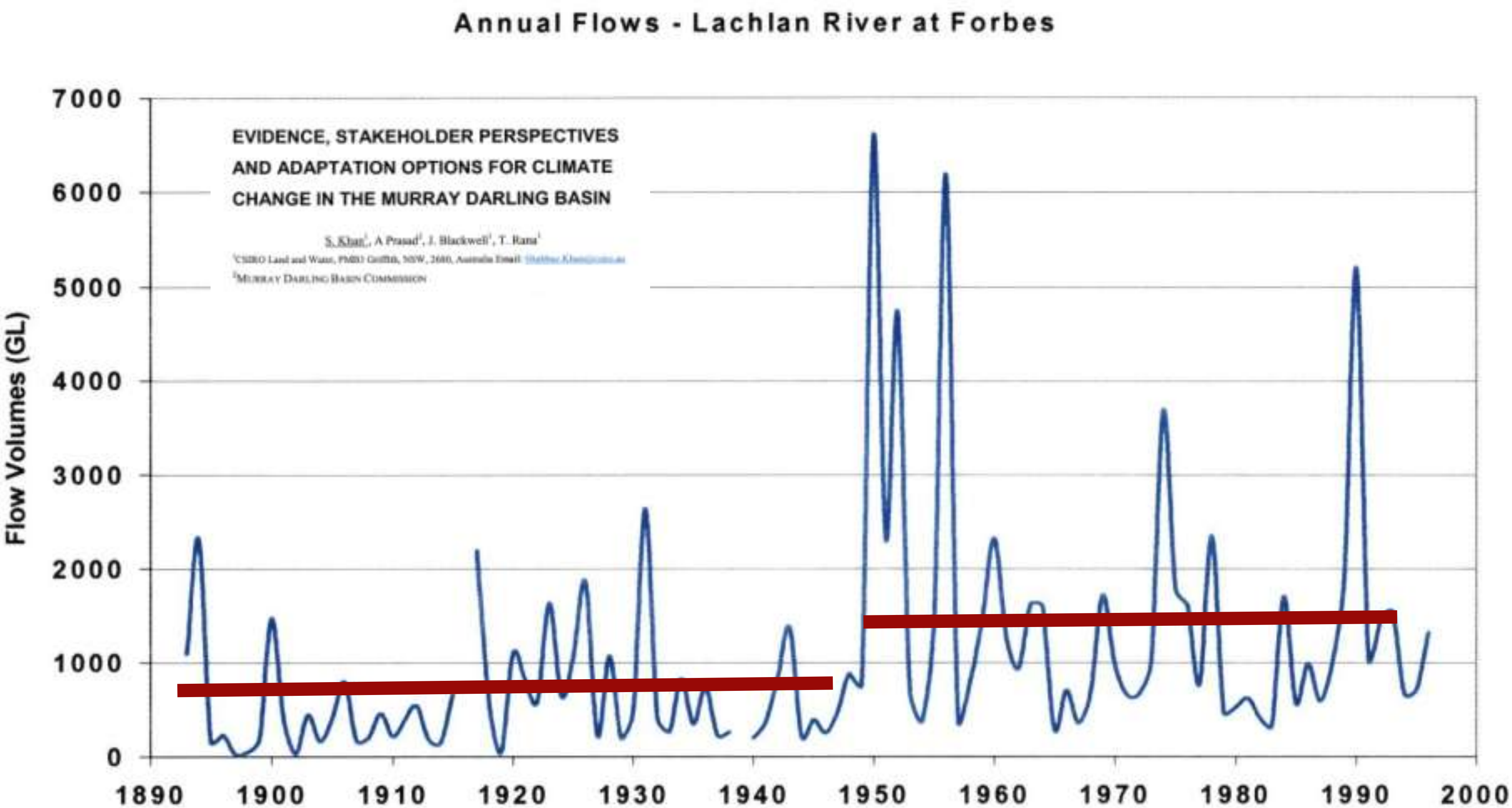
Source: Richard Beecham, Department of Environment and Climate Change

Average Daily Flow Murray River at Barrage

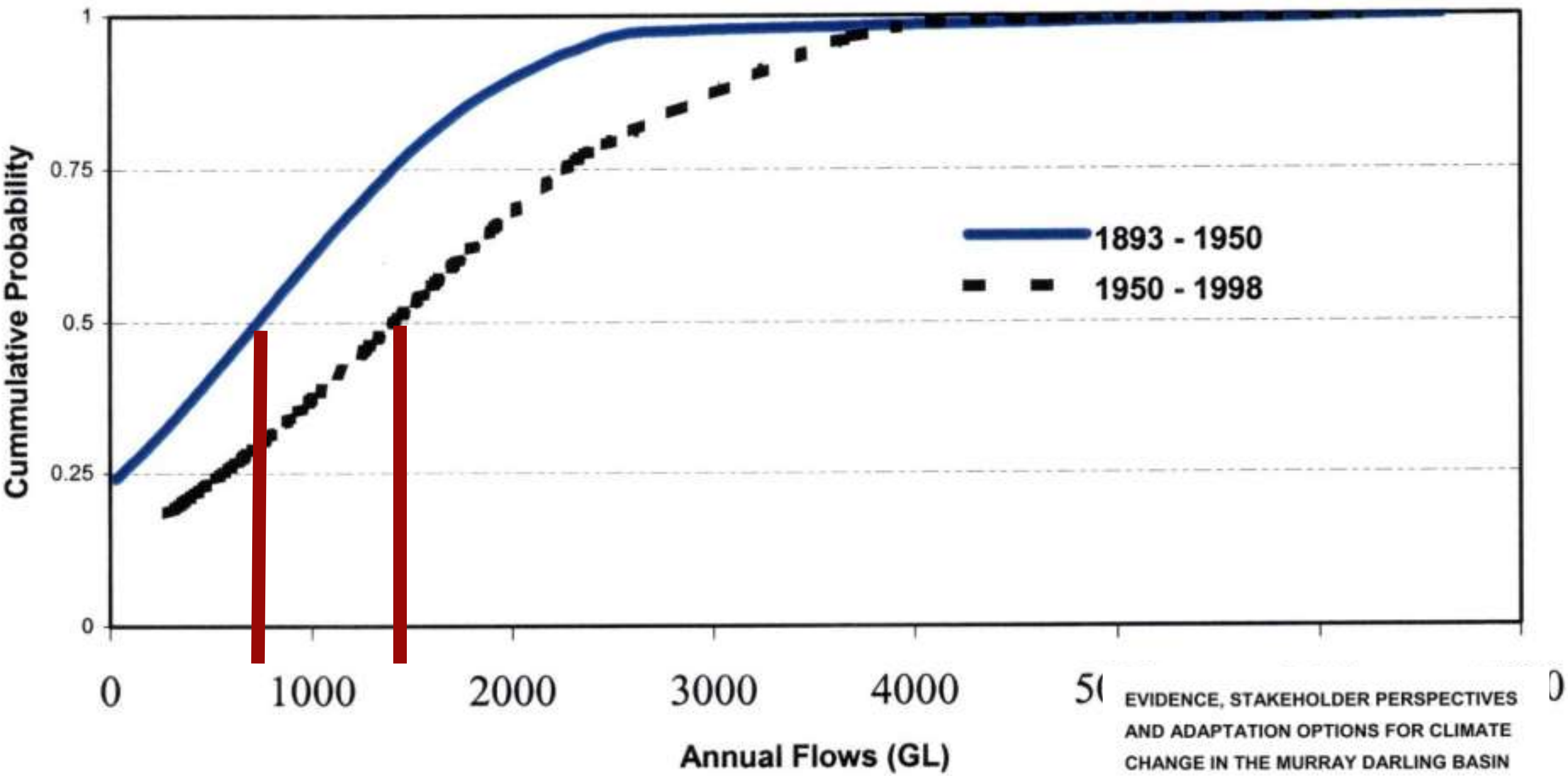


Source: Murray Darling Basin Commission

Annual Flows In Lachlan River at Forbes



Annual Flows in Lachlan River at Forbes



EVIDENCE, STAKEHOLDER PERSPECTIVES AND ADAPTATION OPTIONS FOR CLIMATE CHANGE IN THE MURRAY DARLING BASIN

S. Khan[1], A Prasad[1], J. Blackwell[1], T. Rana[1]
[1]CSIRO Land and Water, PMB3 Griffith, NSW, 2680, Australia Email:
[2]Murray Darling Basin Commission

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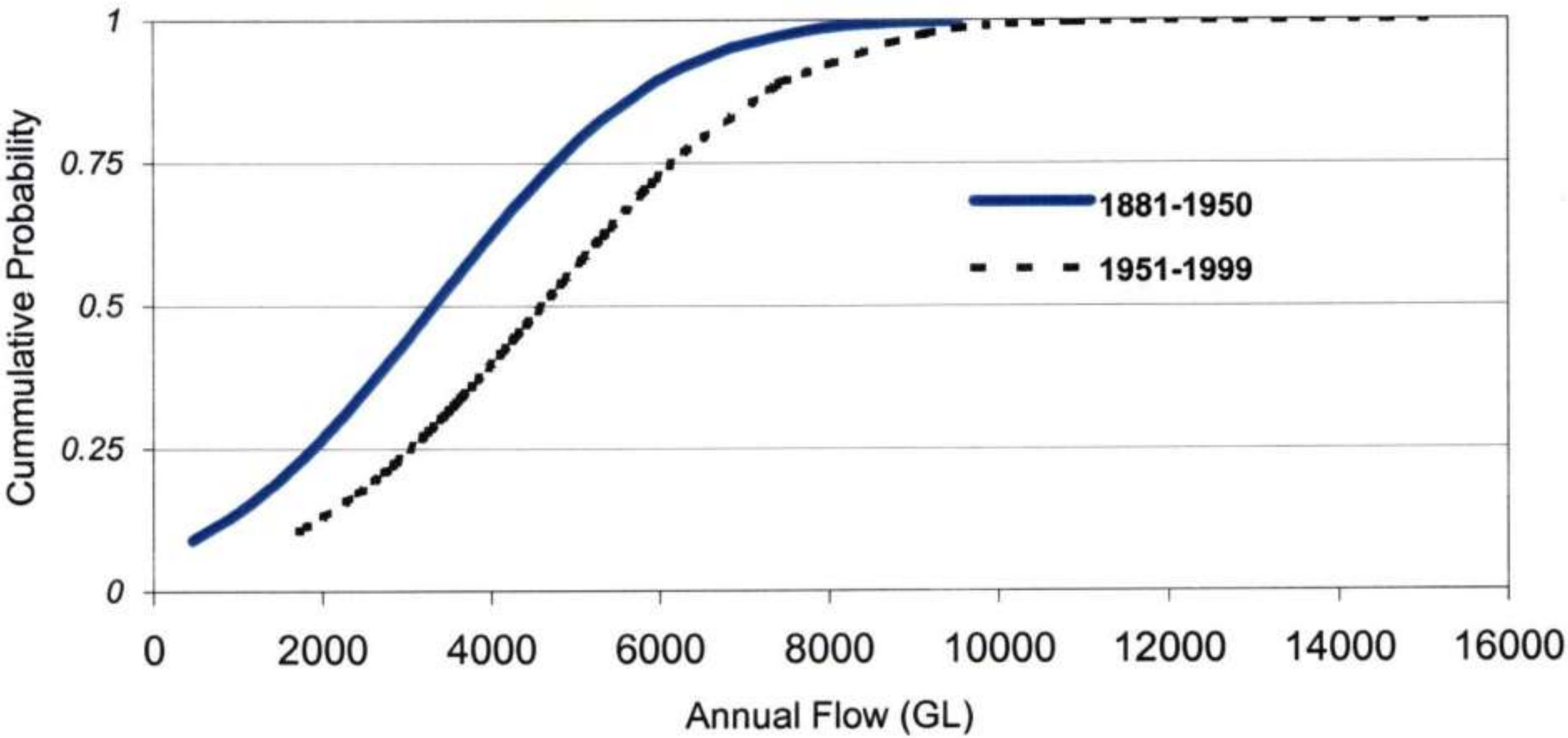
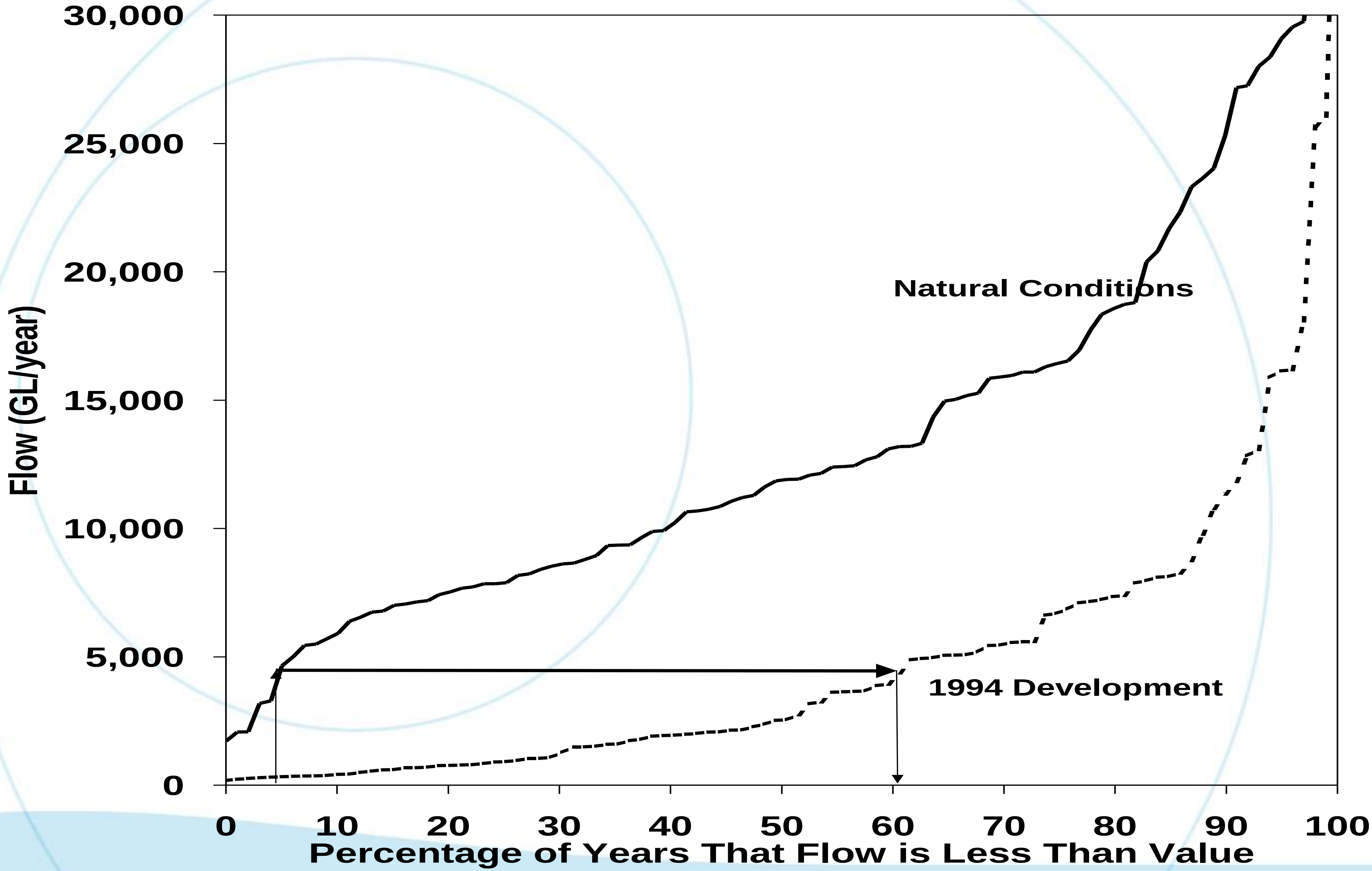
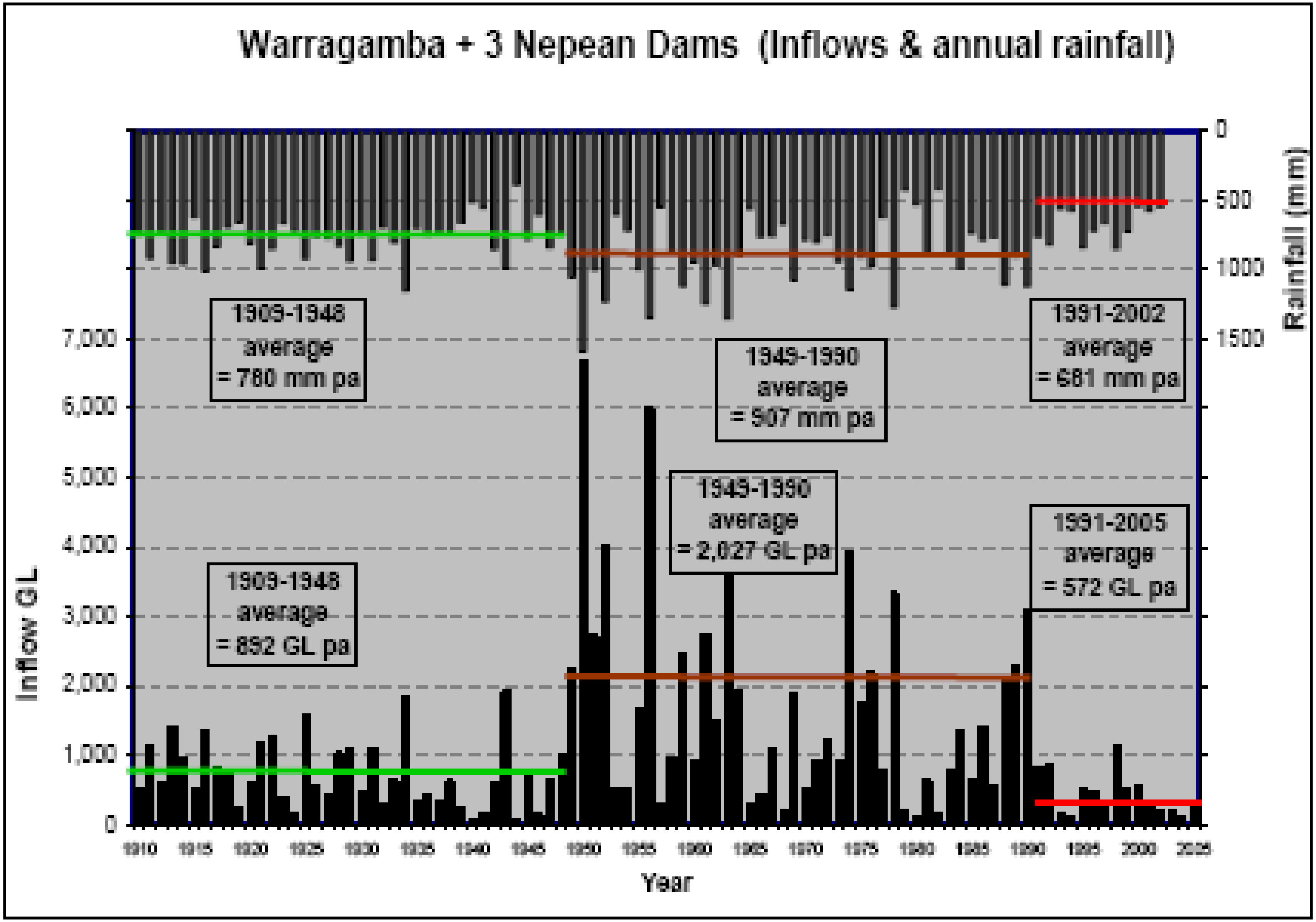
Annual Flows in Murrumbidgee at Wagga Wagga



Murray River Flow at Mouth

Source: Professor Shahbaz Khan, CSIRO Land and Water/Charles Sturt University





Source: Sydney Catchment Authority, 2006.

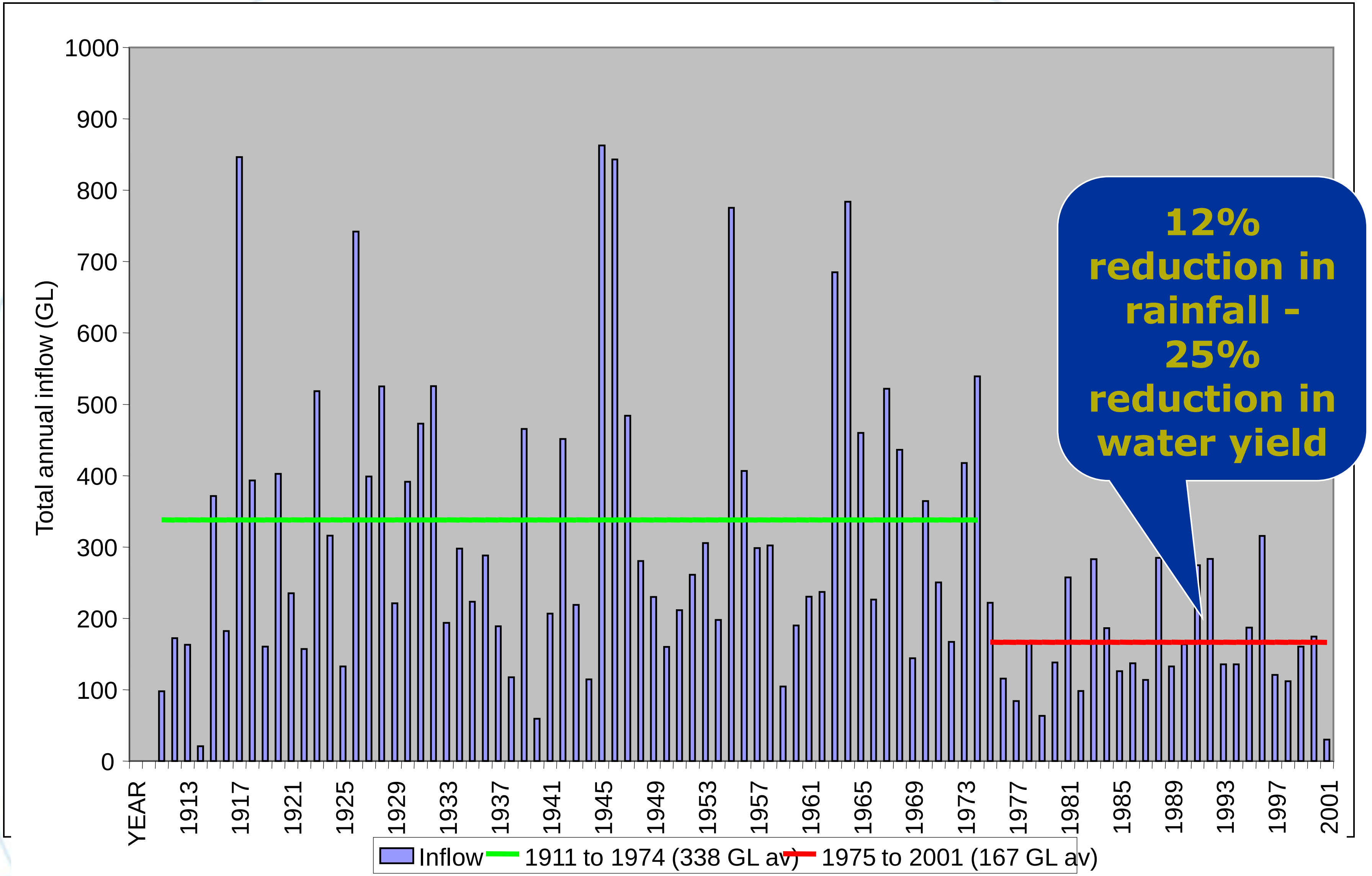
Worst case climate change scenario

Summary findings worst case climate change modelled scenario

Average annual result	% Change in valley			
	Macquarie	Gwydir	Namoi	Border Rivers
Headwater storages inflow	-26	-20	-43	-14
Irrigation extractions	-21	-11	-7	-1
End of system flows	-28	-19	-48	-19

Source: Richard Beecham, Department of Environment and Climate Change

Perth: reservoir water yield



Note: A year is taken as May to April and labelled year is start (winter) of year
Year 2001 inflows are not for a full year

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An illustrative overview of a shift to a drier regime for a 10 000GL system similar to the River Murray.

	Current long term (GL)	**With 10% reduction in mean annual rainfall (GL)**
Mean inflow	10 000	7 000
Mean evaporation	2 000	2 000
Mean flow to sea	2 000	2 000
Net volume available for discretionary use	6 000	3 000
Environmental entitlement	1 500	1 500
Consumptive user entitlement	4 500	1 500
Reduction in mean volume available to consumptive users		67%

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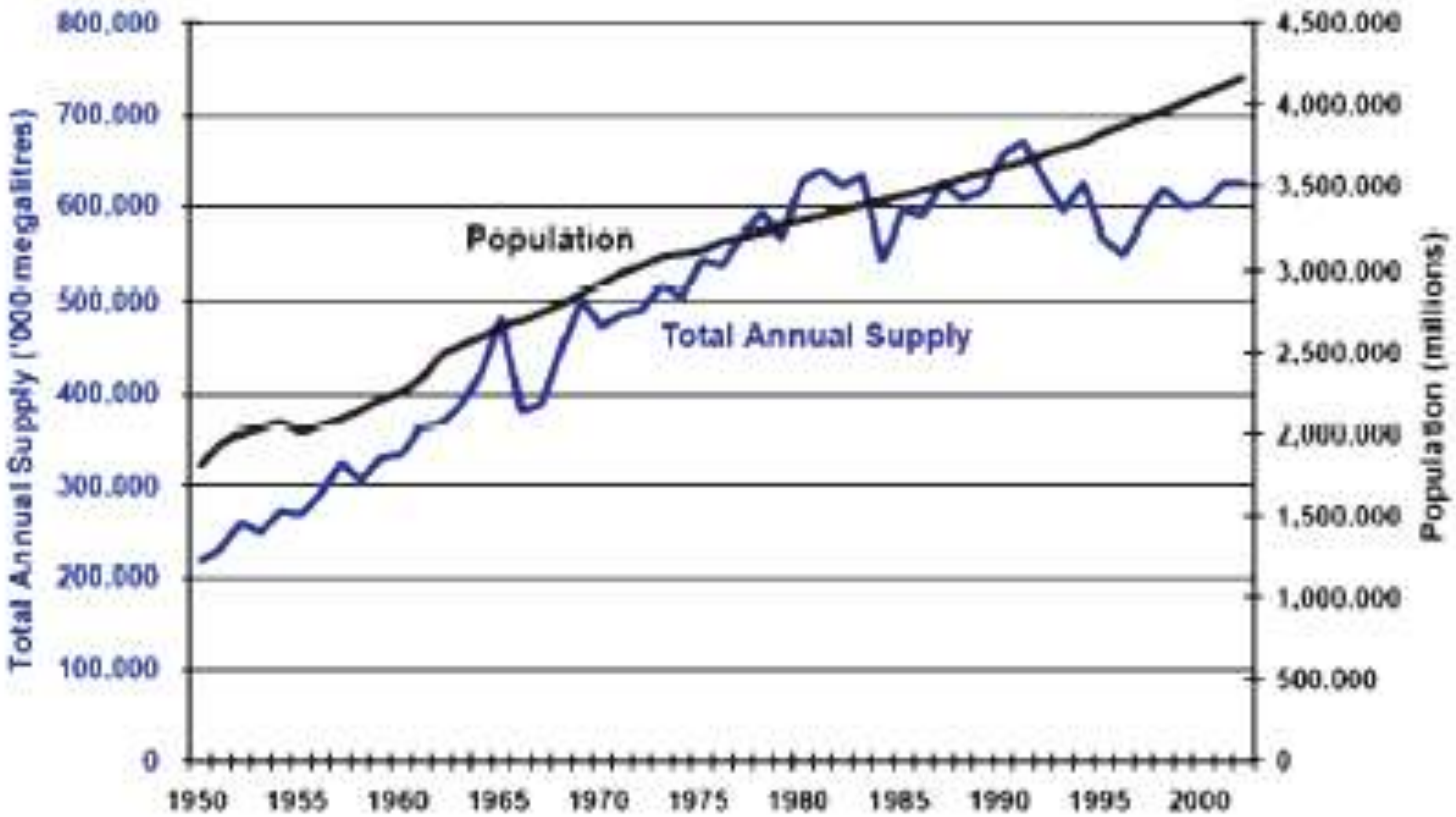
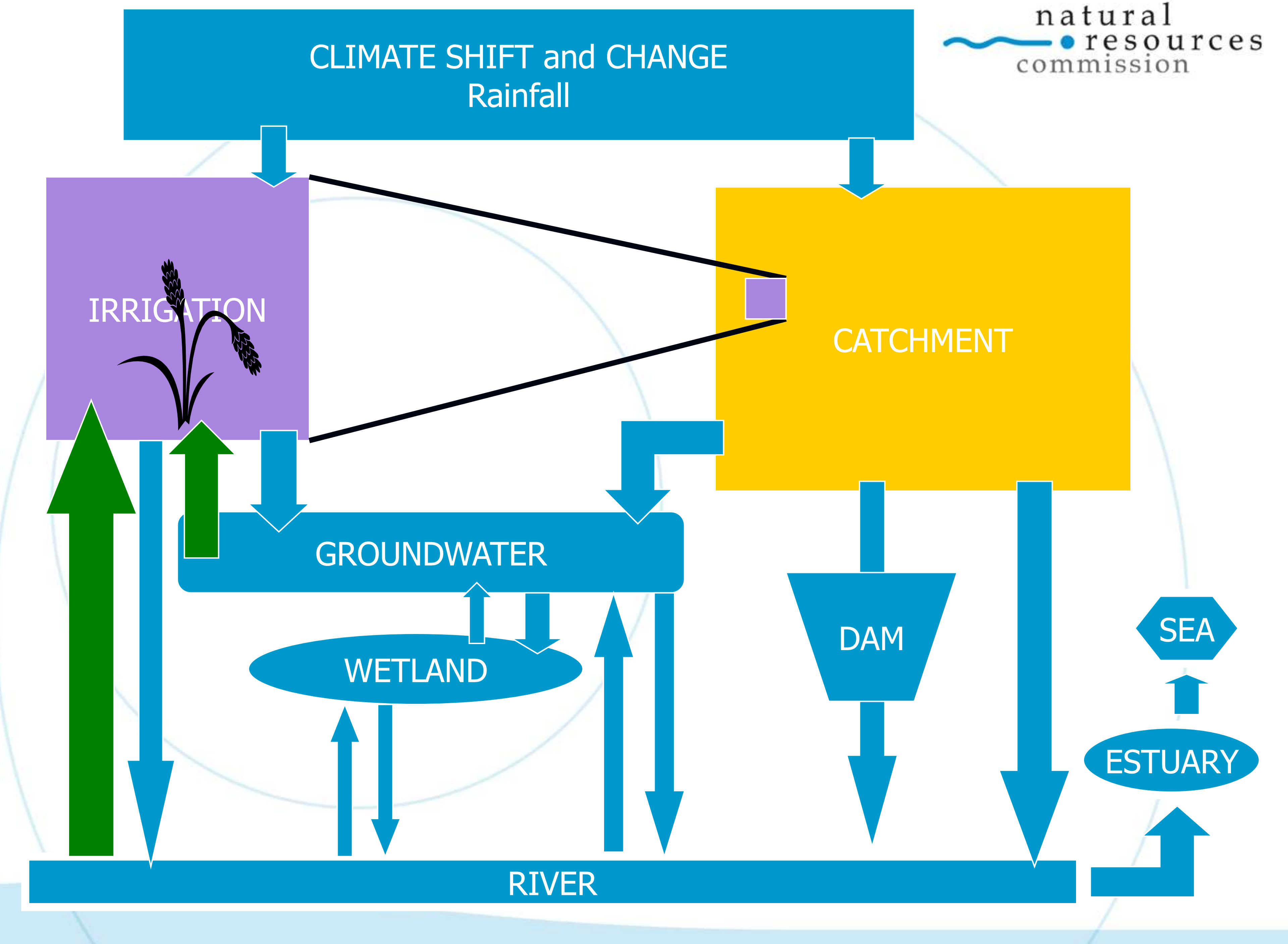


Fig. 7. Sydney's water supply in relation to its population growth (Source WSAA, 2005).


CLIMATE SHIFT and CHANGE
Rainfall
natural resources commission
IRRIGATION
CATCHMENT
GROUNDWATER
WETLAND
DAM
SEA
ESTUARY
RIVER

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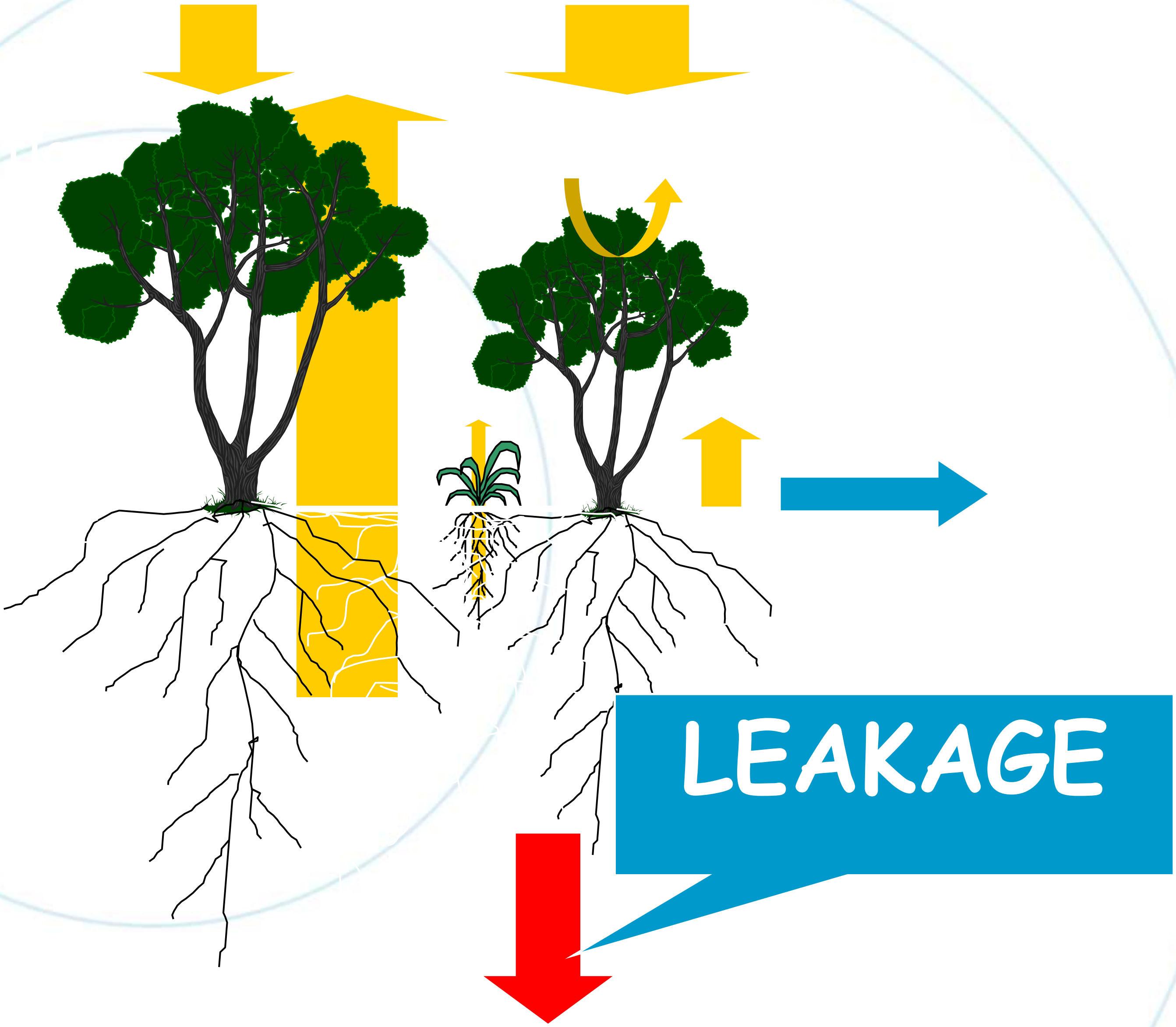

Courtesy of Val Snow

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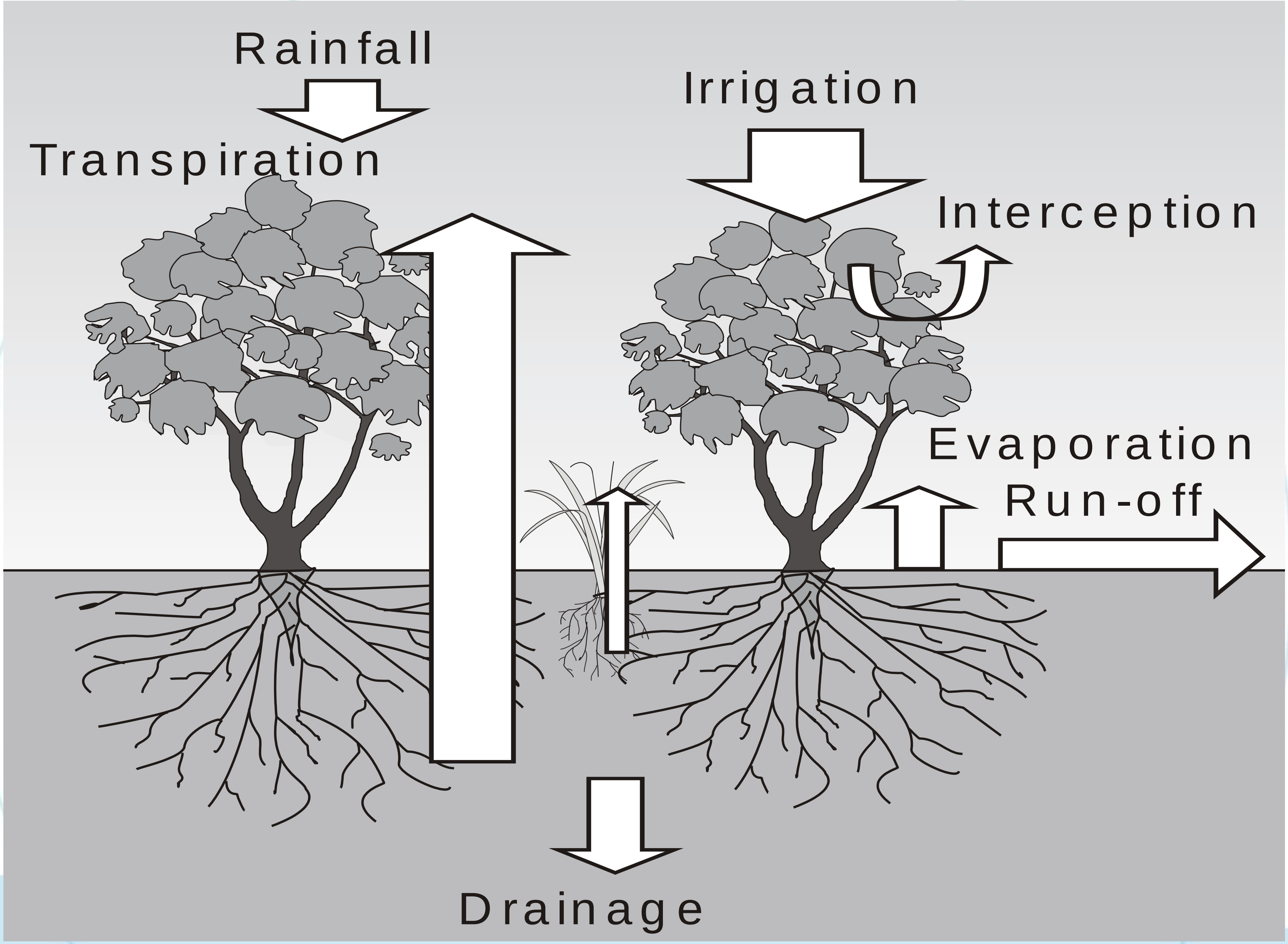
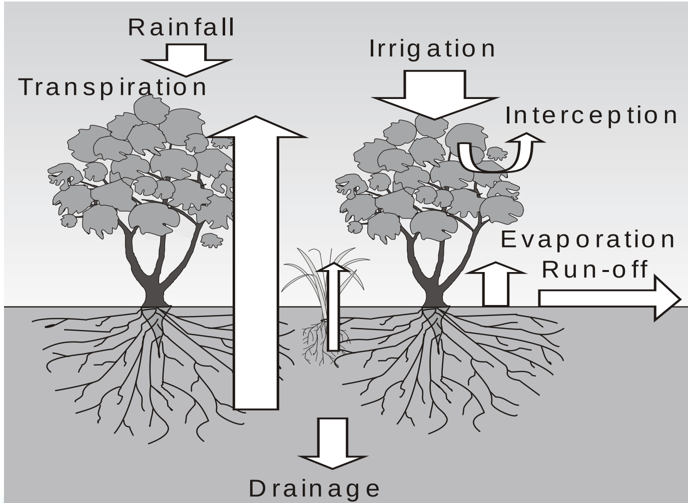


The Australian irony

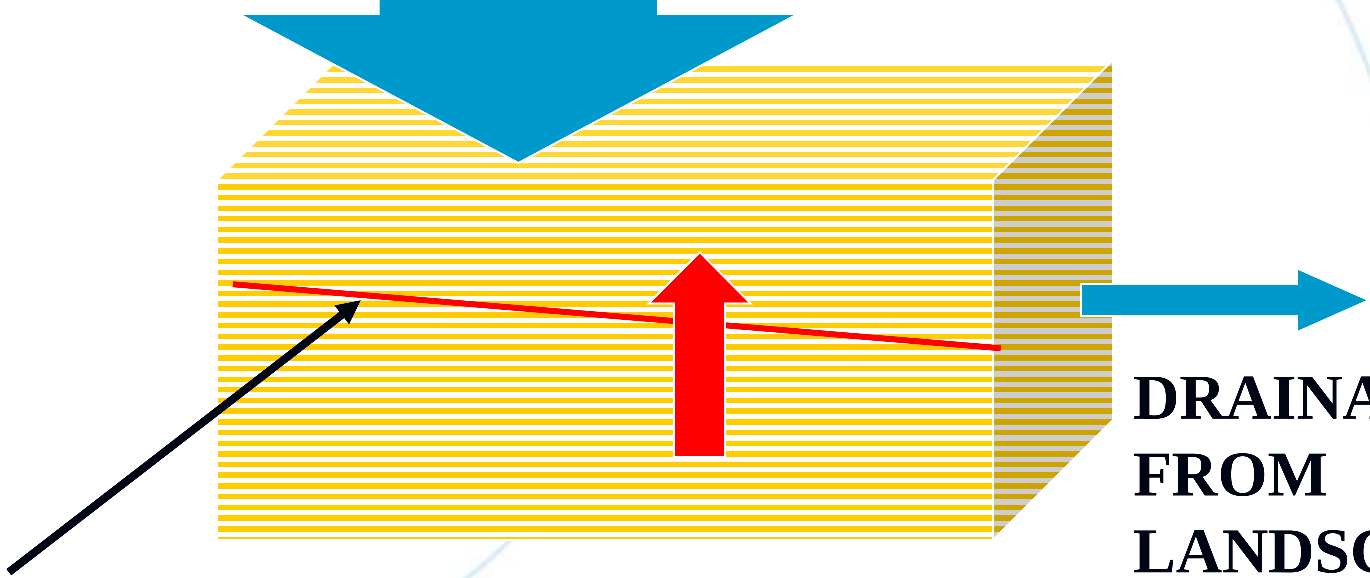
- whilst our Agricultural productivity is constrained by lack of water and nutrients

- fundamental cause of much of our land degradation is an excess of water and loss of nutrients at key periods of the year



LEAKAGE INTO LANDSCAPE FROM BENEATH AGRICUTURE

15 to 150 mm/yr

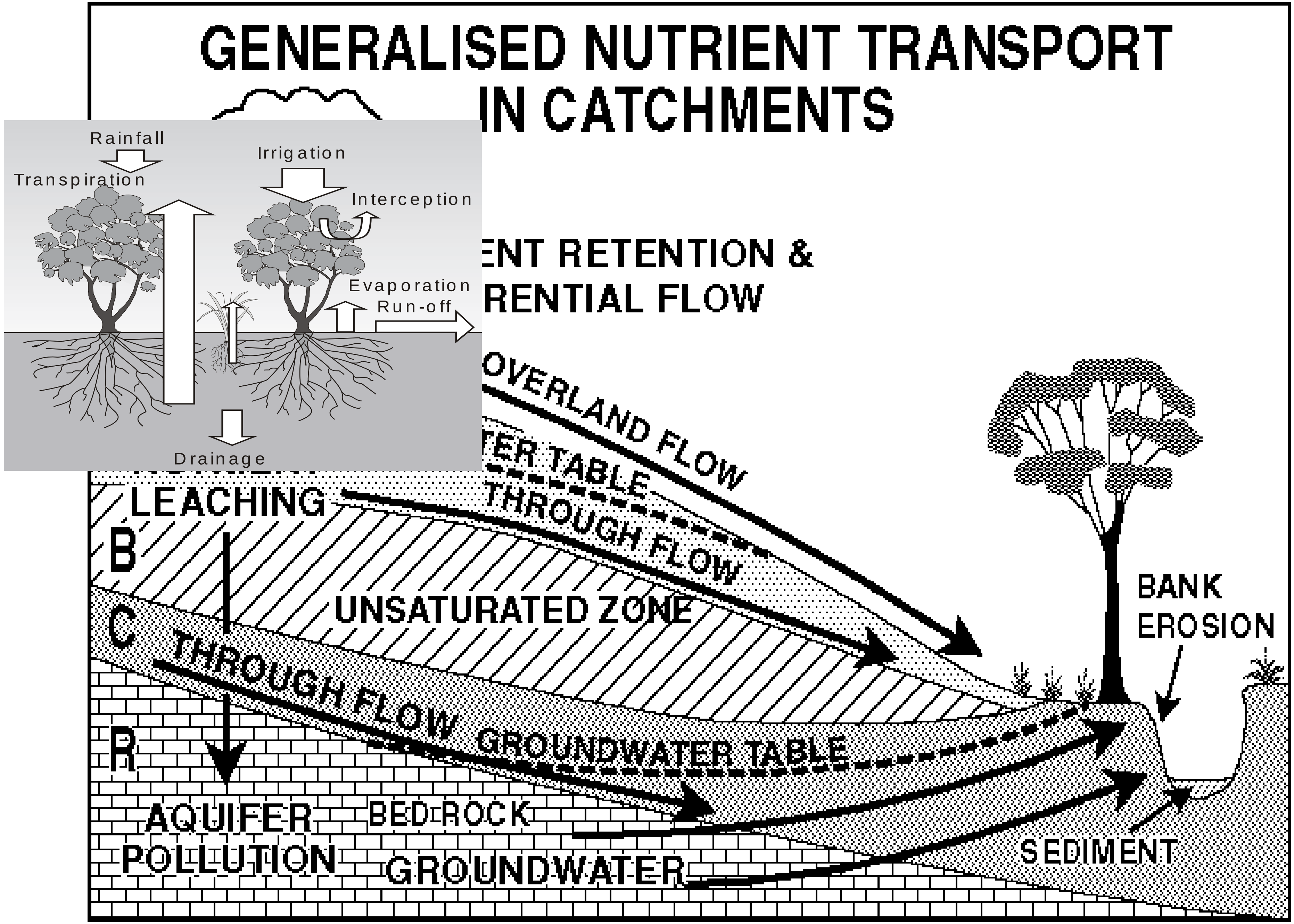


DRAINAGE FROM LANDSCAPE

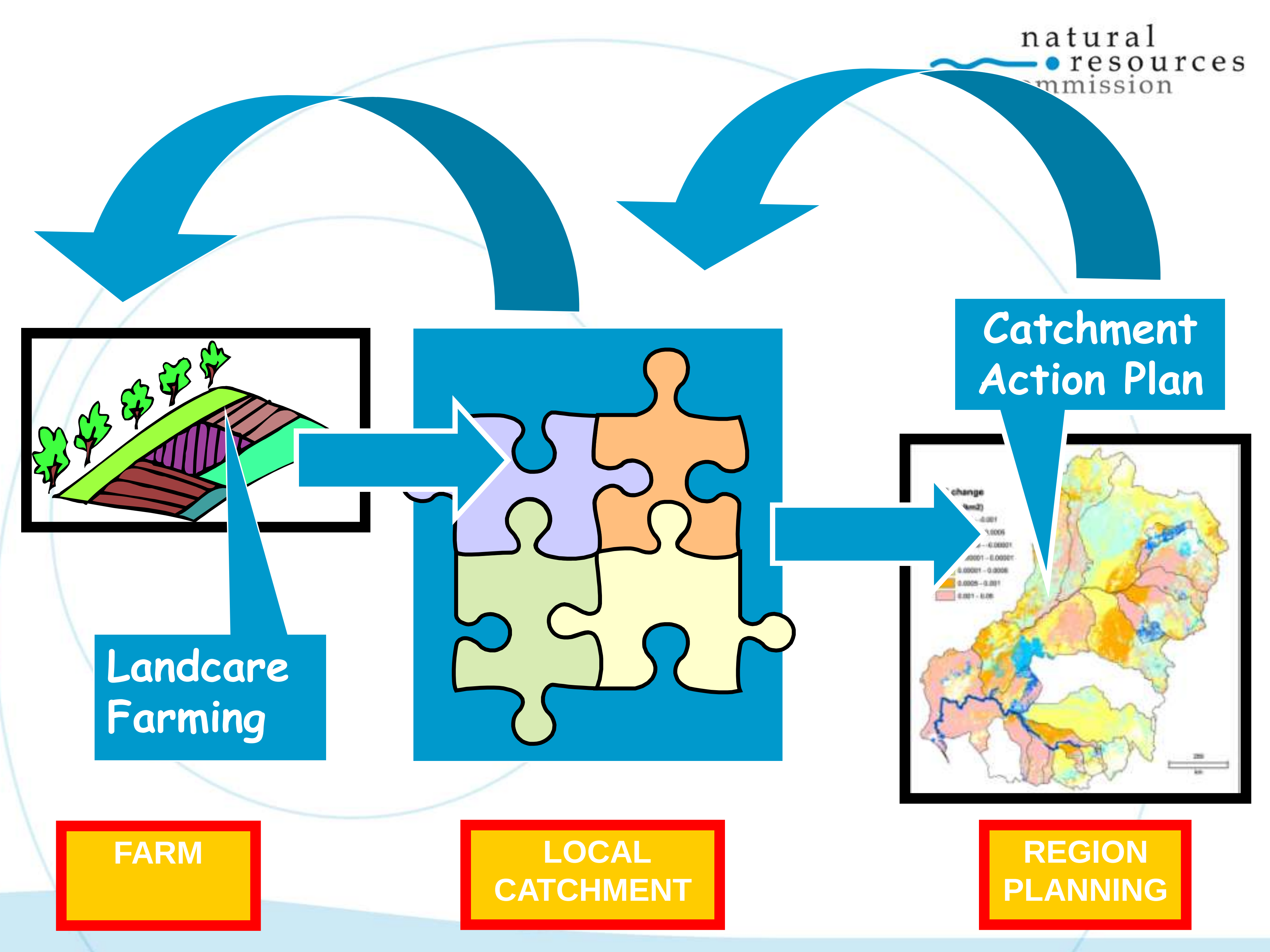
0.5 to 5 mm/yr

WATERTABLE

Leakage of water drives leaching of nutrient and accelerated acidification as well as salinity



Williams, figure 2.



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Landcare Farming
Catchment Action Plan
FARM
LOCAL CATCHMENT
REGION PLANNING

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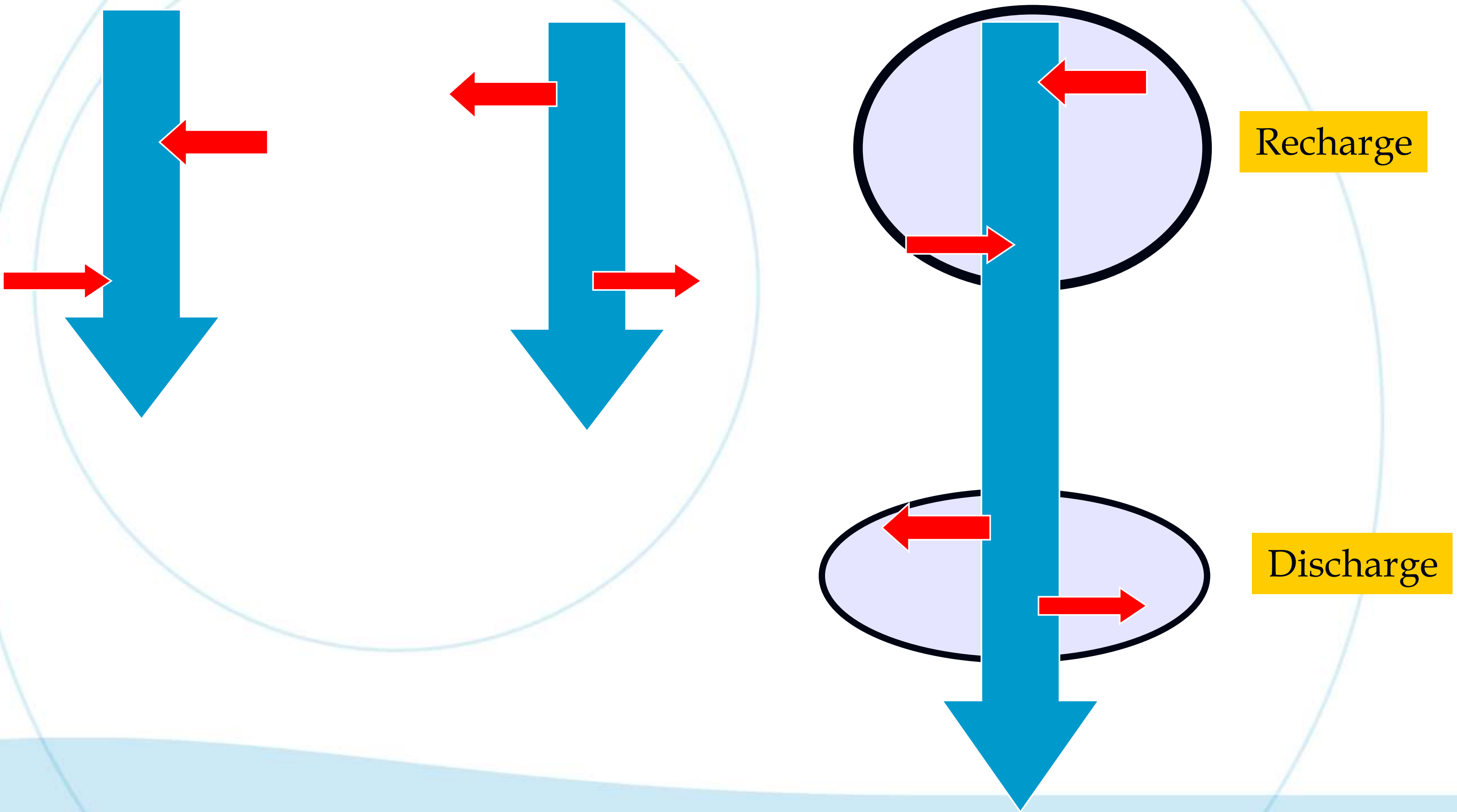
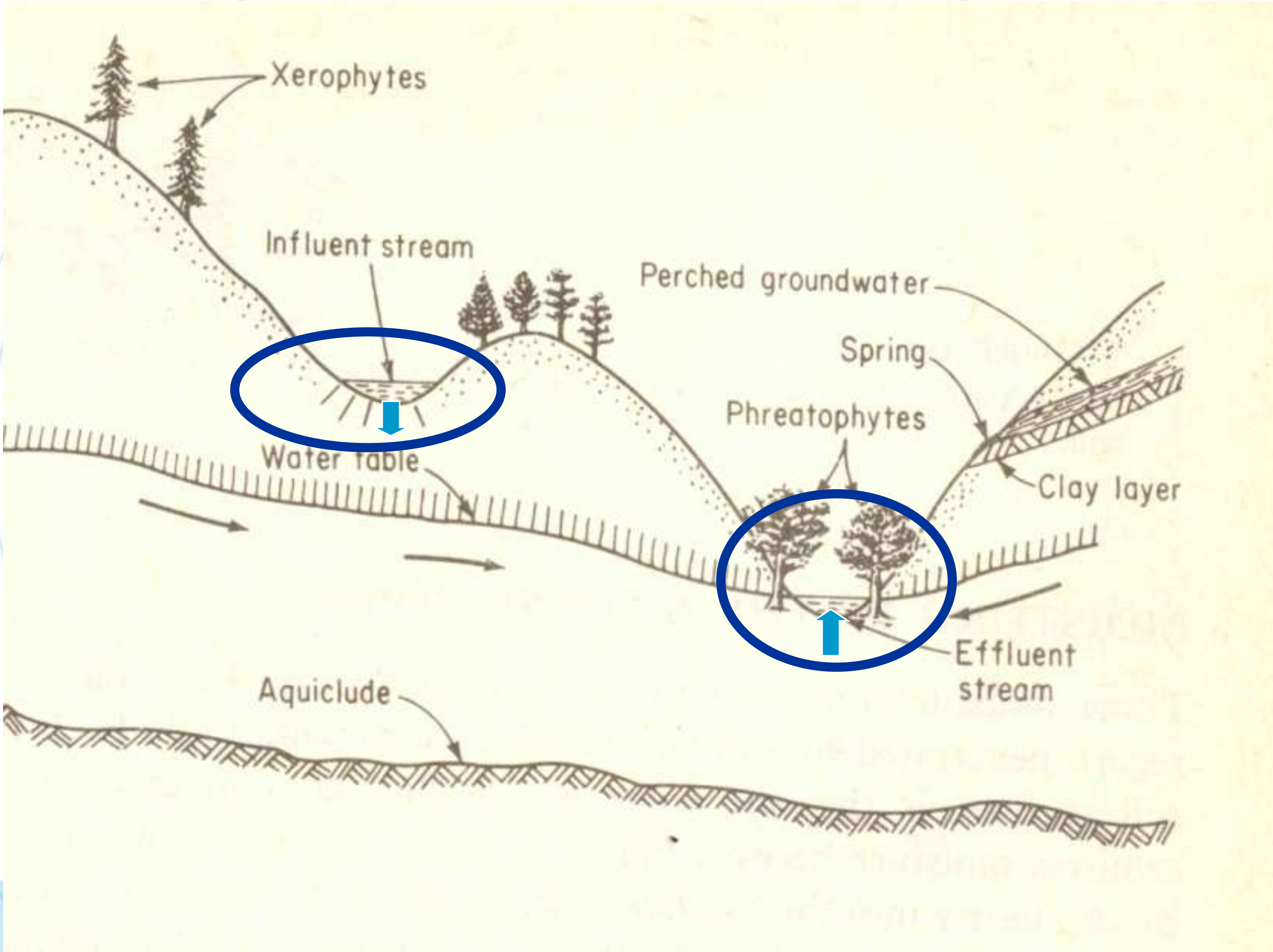
Landscape-Rivers-Groundwater




Xerophytes
Influent stream
Perched groundwater
Spring
Phreatophytes
Clay layer
Water table
Effluent stream
Aquiclude

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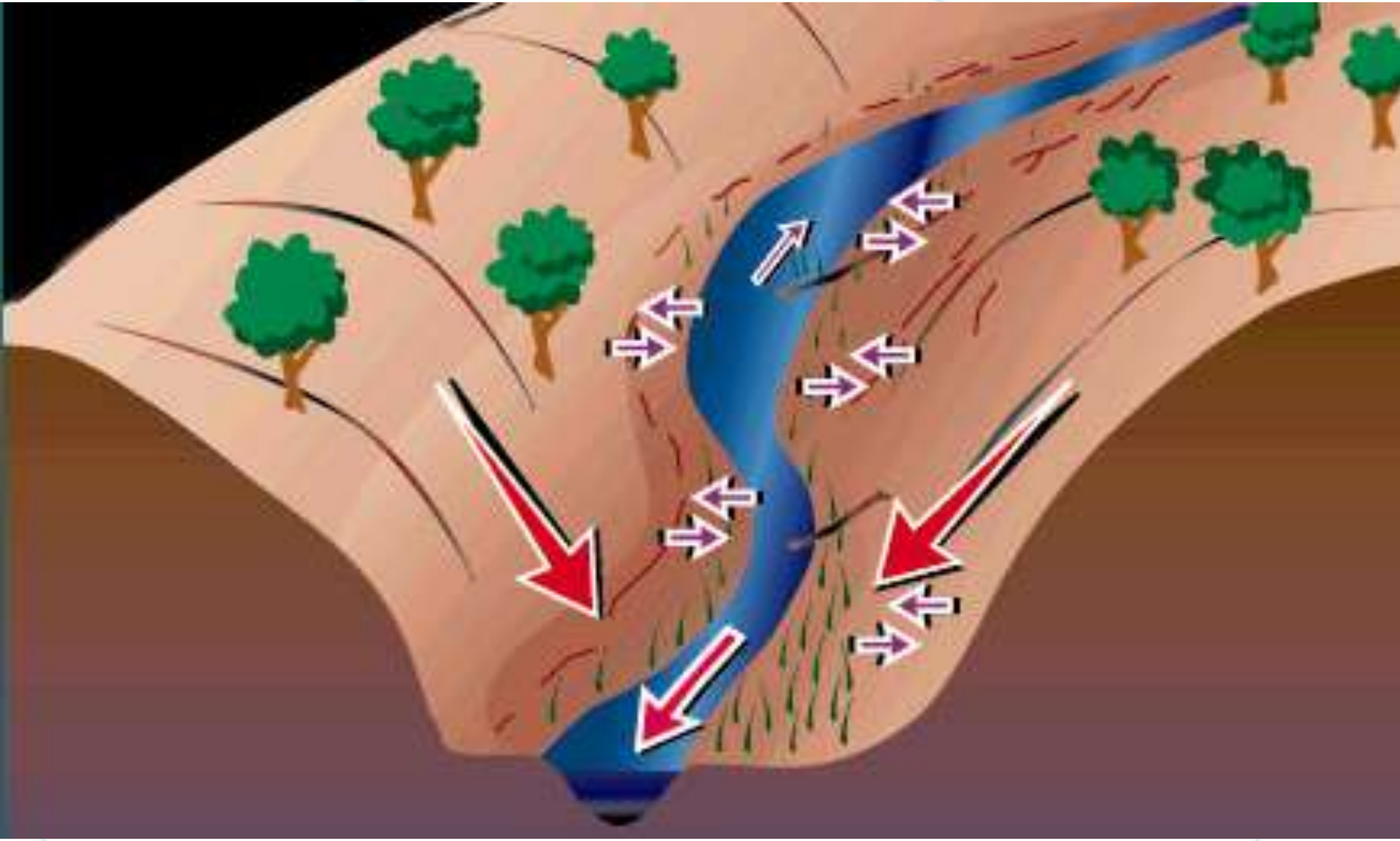
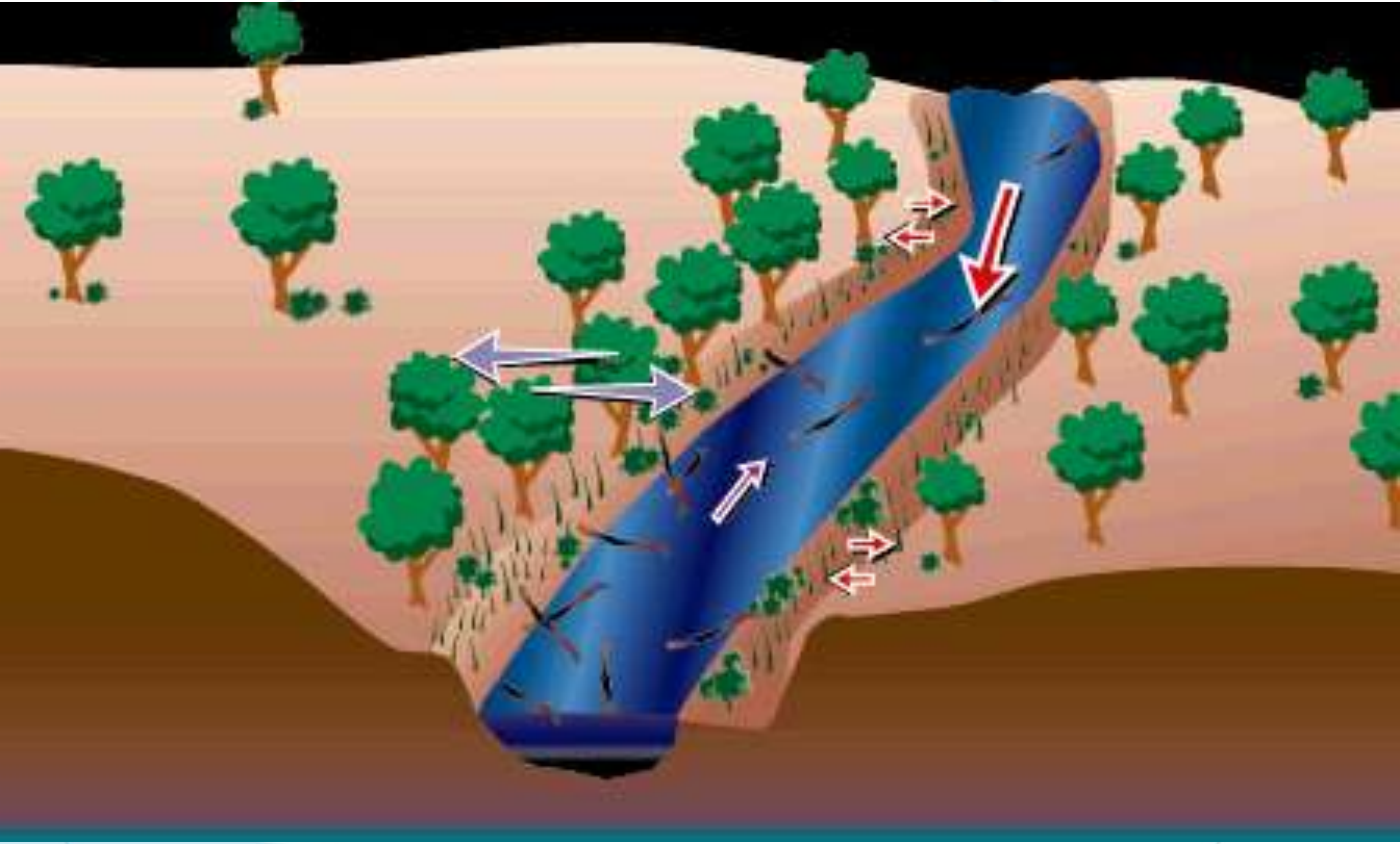
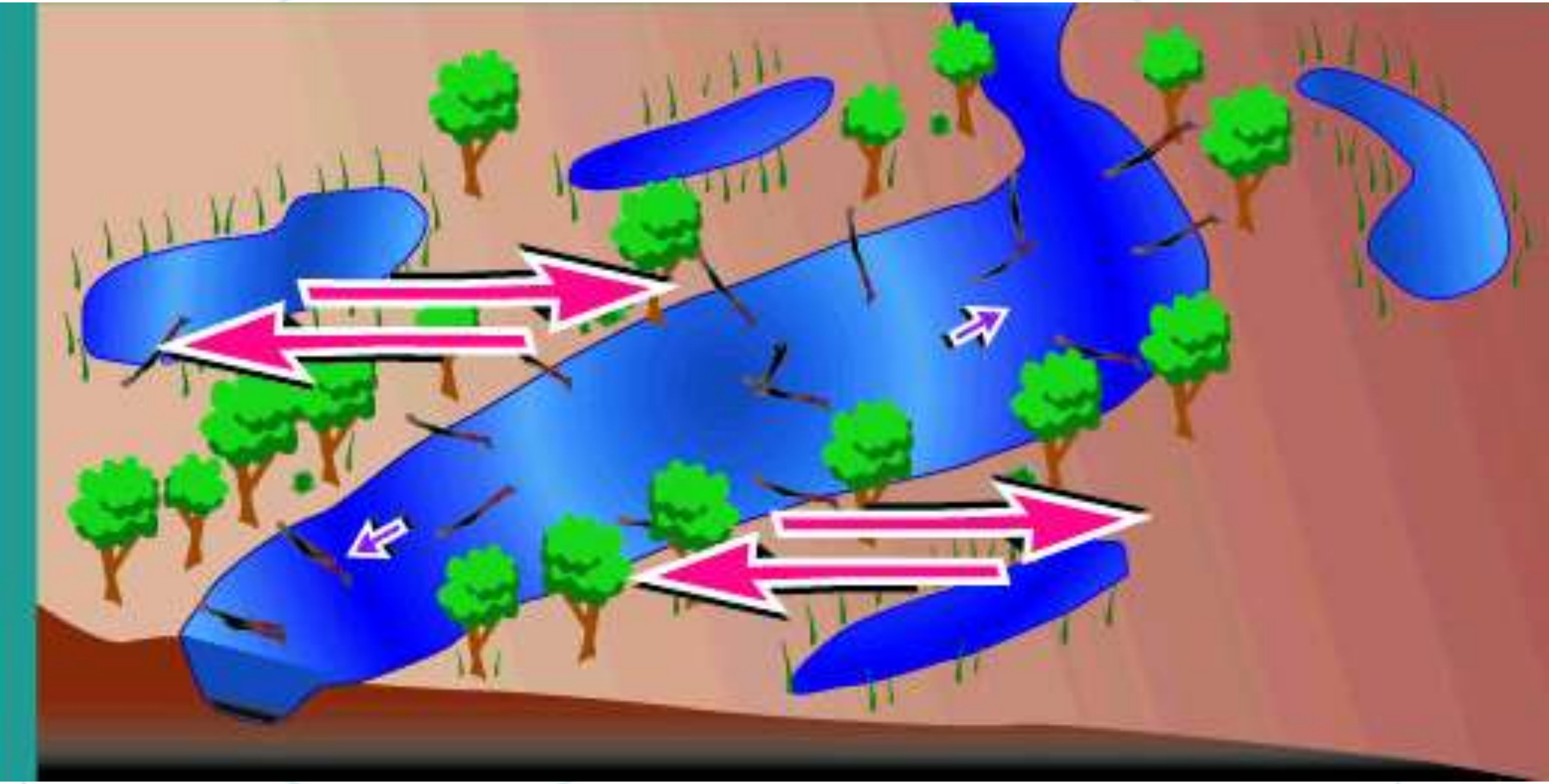






http://freshwater.canberra.edu.au/publications.nsf/6d4e4718a6b1a89aca256f1e0013cf af/cc439bb9f7eef13eca256f0b0023397b

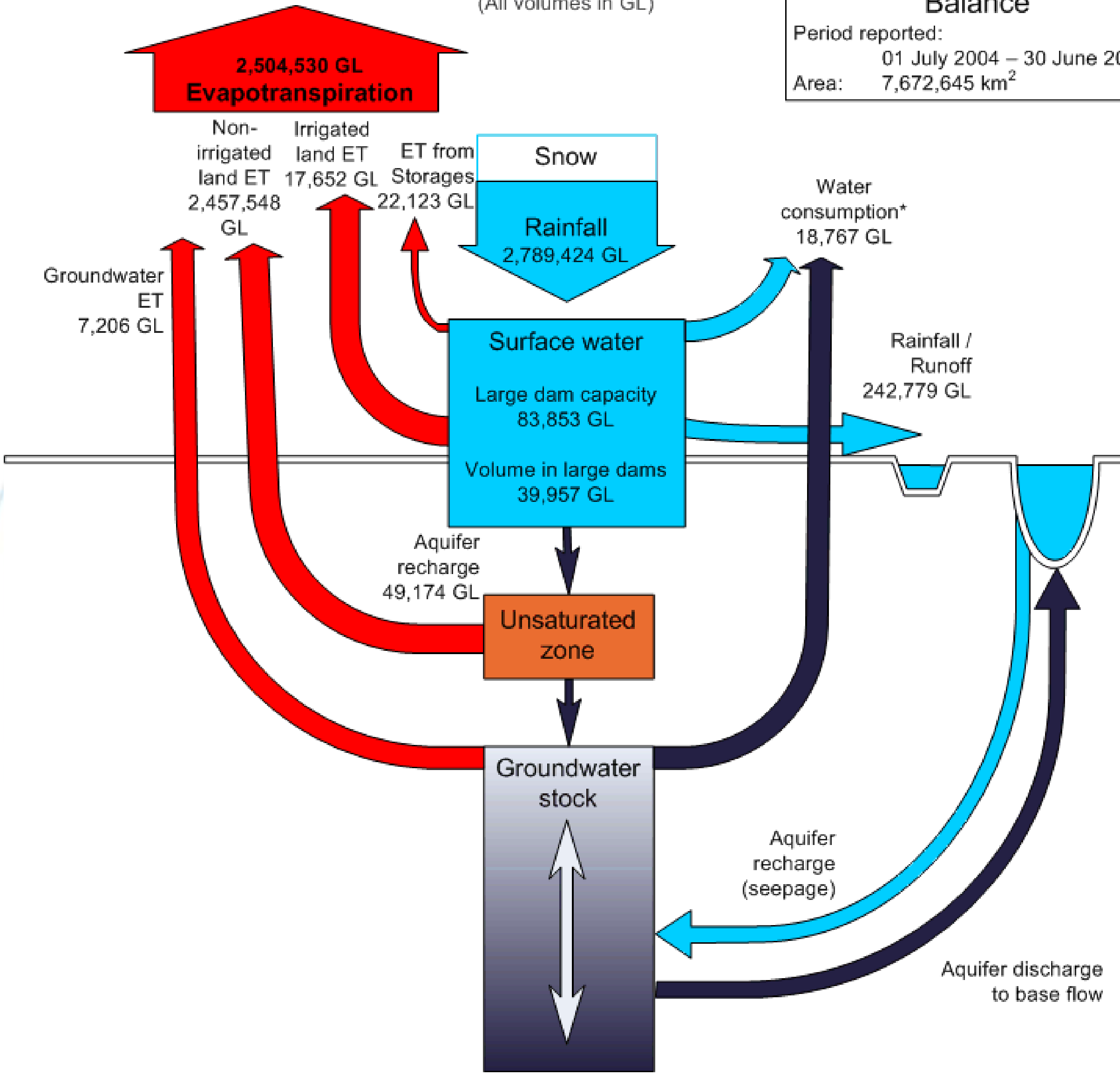
Water Cycle Report

(All volumes in GL)

Australia National Water Balance

Period reported: 01 July 2004 – 30 June 2005

Area: 7,672,645 km^2



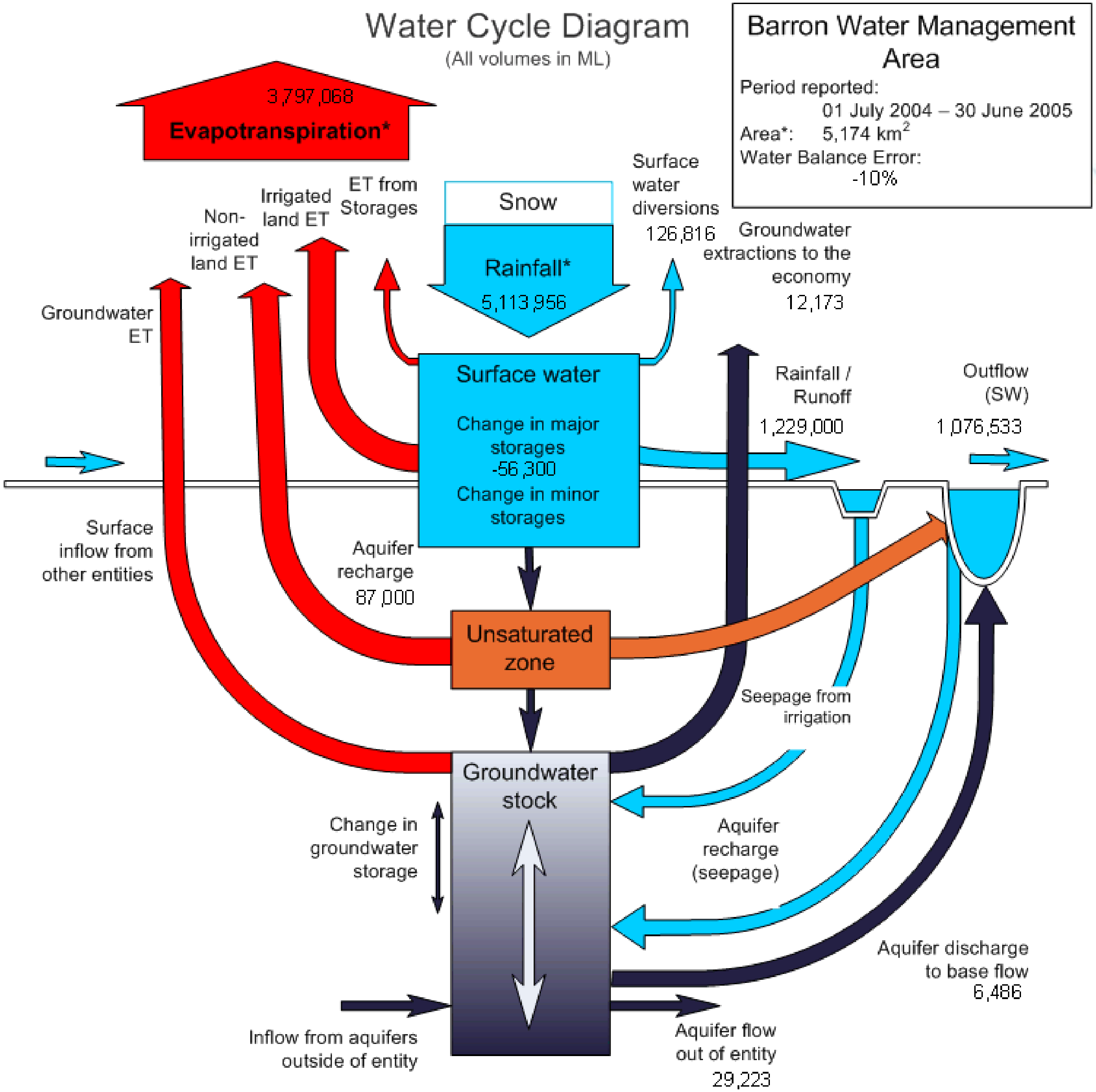
NB: Please note volumes for some items was not available.

Unless marked data sourced from Bureau of Rural Sciences, 2006, *Water 2010*

* Australian Bureau of Statistics, 2006, *Australian Water Account*

Source:

National Water Commission



Please note volumes for some items could not be provided. Other items are a combination of entries from the water balance. For further detail, see water balance report.

* Data source: Bureau of Rural Sciences (2006) *Water 2010*. All other items are sourced from the detailed water balance report.

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Source:

National Water Commission

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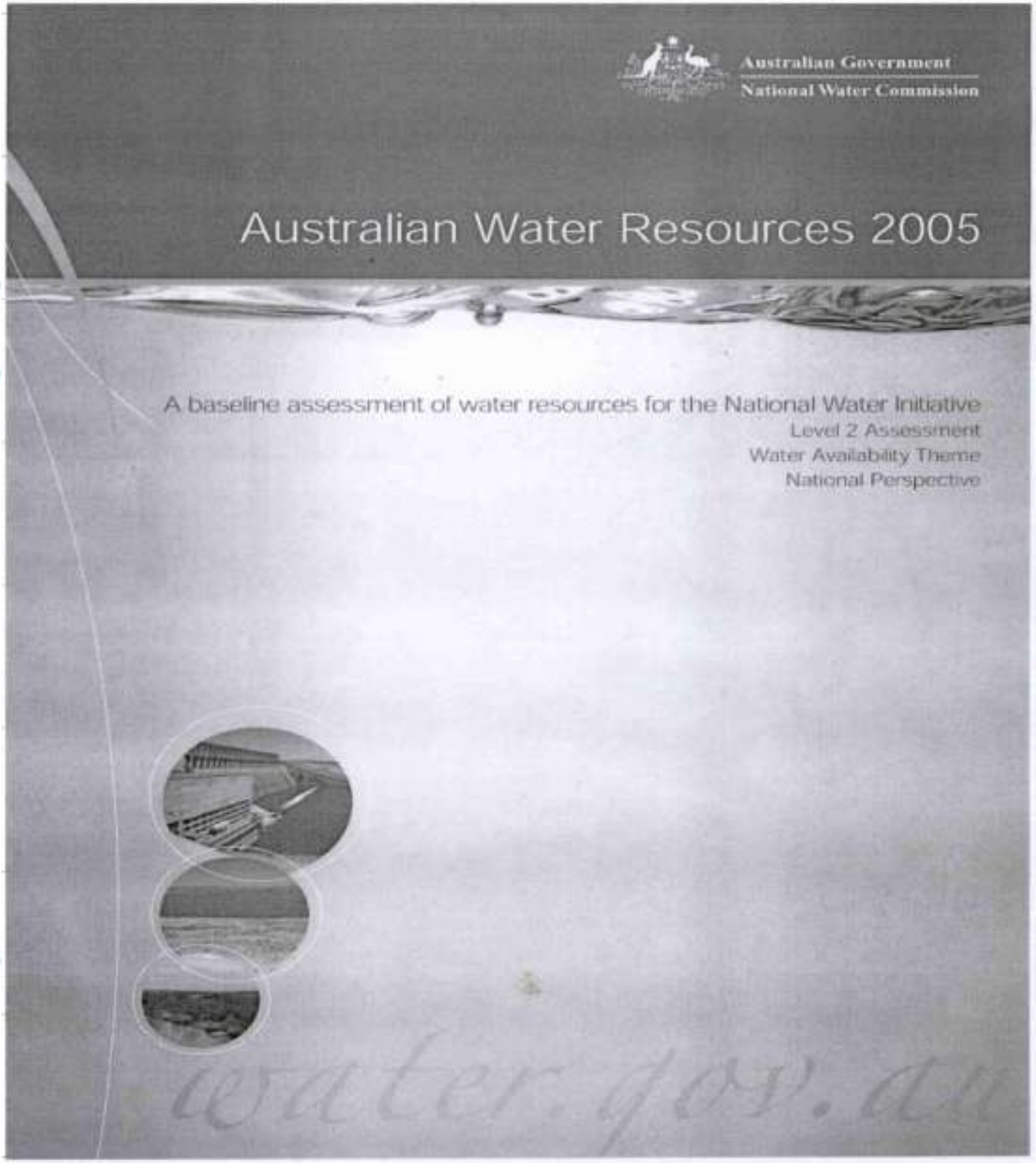
Australian Government
National Water Commission

Australian Water Resources 2005

A baseline assessment of water resources for the National Water Initiative
Level 2 Assessment
Water Availability Theme
National Perspective

water.gov.au

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SCIENTIFIC REVIEW

LOWER LACHLAN GROUNDWATER SHARING PLAN

November 2006

The following table shows the possible application of both ecologically sustainable development and risk management considerations to an annual average recharge estimate of 115GL per anum.

Risk tolerance	Uncertainty factor (%)	Rounded extraction limit (GL/y)	Degree of resource protection
Highly risk adverse	70*	35	Very high
Risk adverse	40	70	Moderate
Risk tolerant	20	90	Low
Ignores risk	0	115**	Nil

* Based on the CM Jewell uncertainty calculation referred to above.
** Based on the best available scientific estimate for average annual recharge as discussed above.
Note – This table depicts a risk evaluation and treatment matrix that is consistent with the risk management process outlined in AS/NZS 4360:2004 – Risk Management.

The allowance made for uncertainty is a matter for judgment and given the extent of

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Table 5. Surface water irrigation efficiency (personal communication Shahbaz Khan)

Key Indicators	Liuyuankou China	Rechna Doab Pakistan	MIA Australia
Area (ha)	40,724	2,970,000	156,605
Losses from Supply System (%)	35	41	12
Field Losses (%)	18	15	11
Net Surface Water available to crop (%)	46	32	77

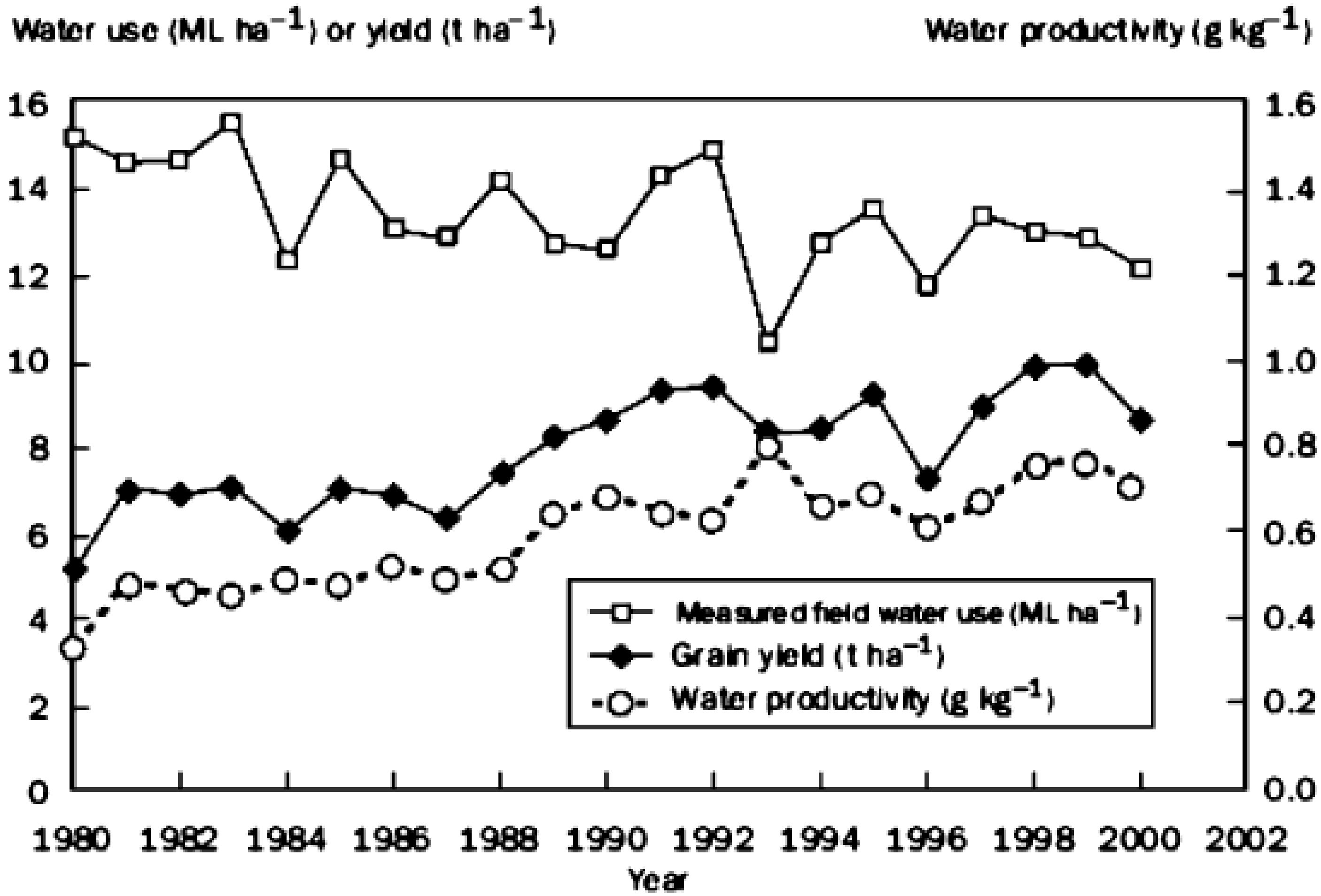


Fig. 8. Rice irrigation water use efficiency trend —Murrumbidgee Irrigation Area (MIA) (Source: CRC for Rice Production (Humphreys and Robinson, 2003).

Indicative costs of alternative water supply and demand management options (not including the cost of externalities)

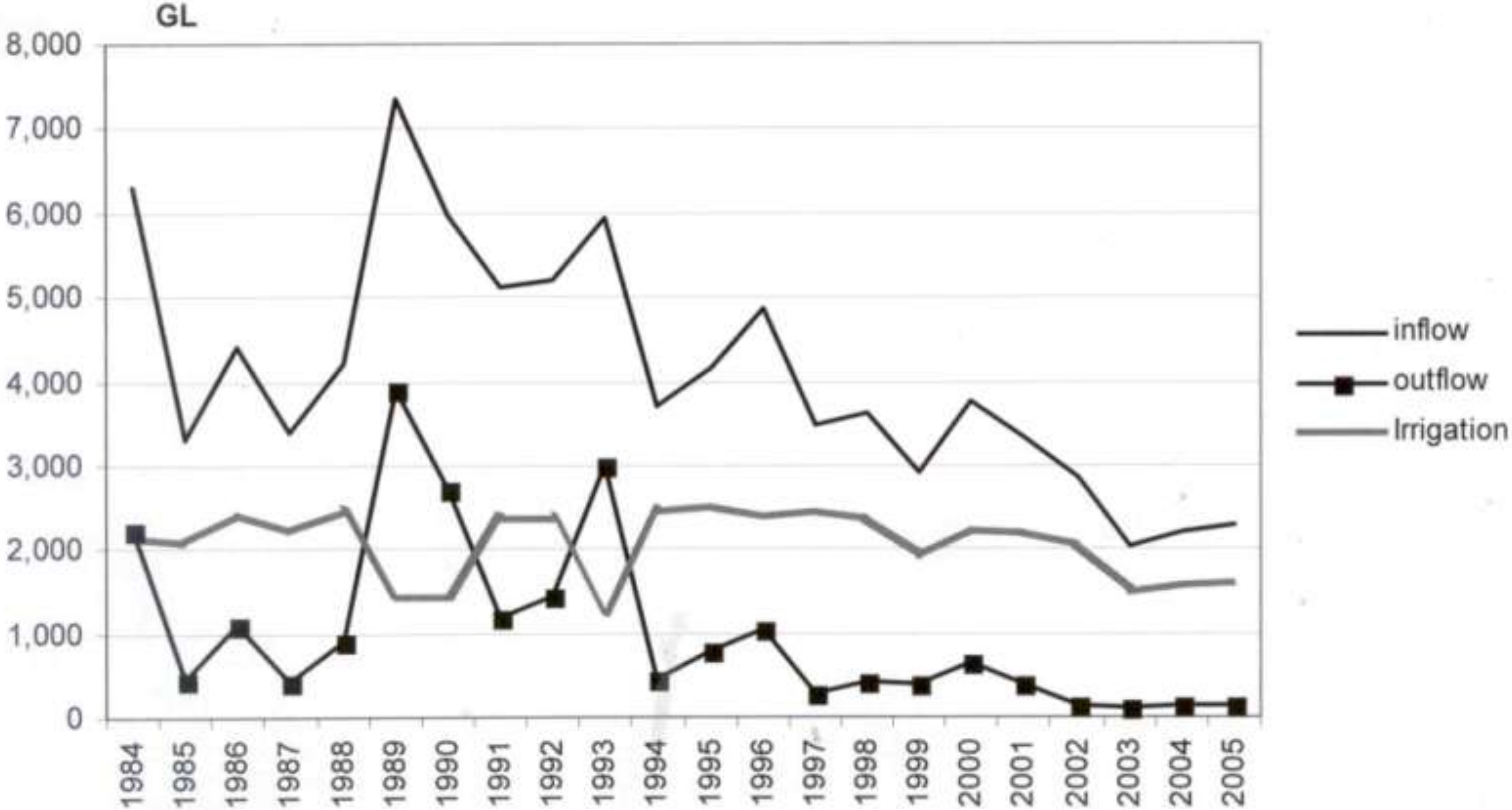
Option	Cost / Kilolitre ($/kL)
Buying a high security water from the River Murray	0.50
Appliance standards and labelling	$0.05
Leakage reduction	$0.20
Residential retrofits and rebates	$0.60
Desalination, Perth	$1.17
Desalination, Sydney	$1.95
Indirect Potable Recycling	$2.61
Rainwater tank rebates	$3.00
BASIX standards for water efficient buildings	$0.30 – $4.00

Source: Wentworth Group 2006

Managing the Water Balance between extraction and environment flows

- Requires actions to ensure that the environmental needs of river systems have first call on the water to keep them healthy, protecting both
  - **their environmental values and**
  - **ability to meet human needs into the future.**

Murrumbidgee River:
Inflow, outflow and water use for irrigation



Source: Water, Climate and Economic Loss in the Murrumbidgee River and Southern Murray Darling Basin
Professor Tom Kompas, Australian National University

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Tension between water extraction and water for river health

Irrigation Industr

Science knowledge
•Soil science
•plant breeding
•Agronomy
•Groundwater
•Pesticide chemistry

River Sciences Knowledge

•Aquatic ecology
•Fish ecology
•Riverine botany
•Riverine geomorphology

Sustainable Irrigation will then encompase river health

Managing the Water Balance between extraction and environment flows

- Fundamental to reform is the establishment of a nationally consistent water entitlement and trading system that provides security to both water users and the environment.

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Managing the Water Balance between extraction and environment flows

Critical to this is the clear definition of

- **water entitlements as a (perpetual in case of OZ) share of the available water resource.**
- **the regulation of this entitlement**
- **The trade of this entitlement**
- **volume allocations of water provided year by year from this entitlement**

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CSIRO

Water Availability in the Murrumbidgee

Summary of a report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project

www.csiro.au

June 2008

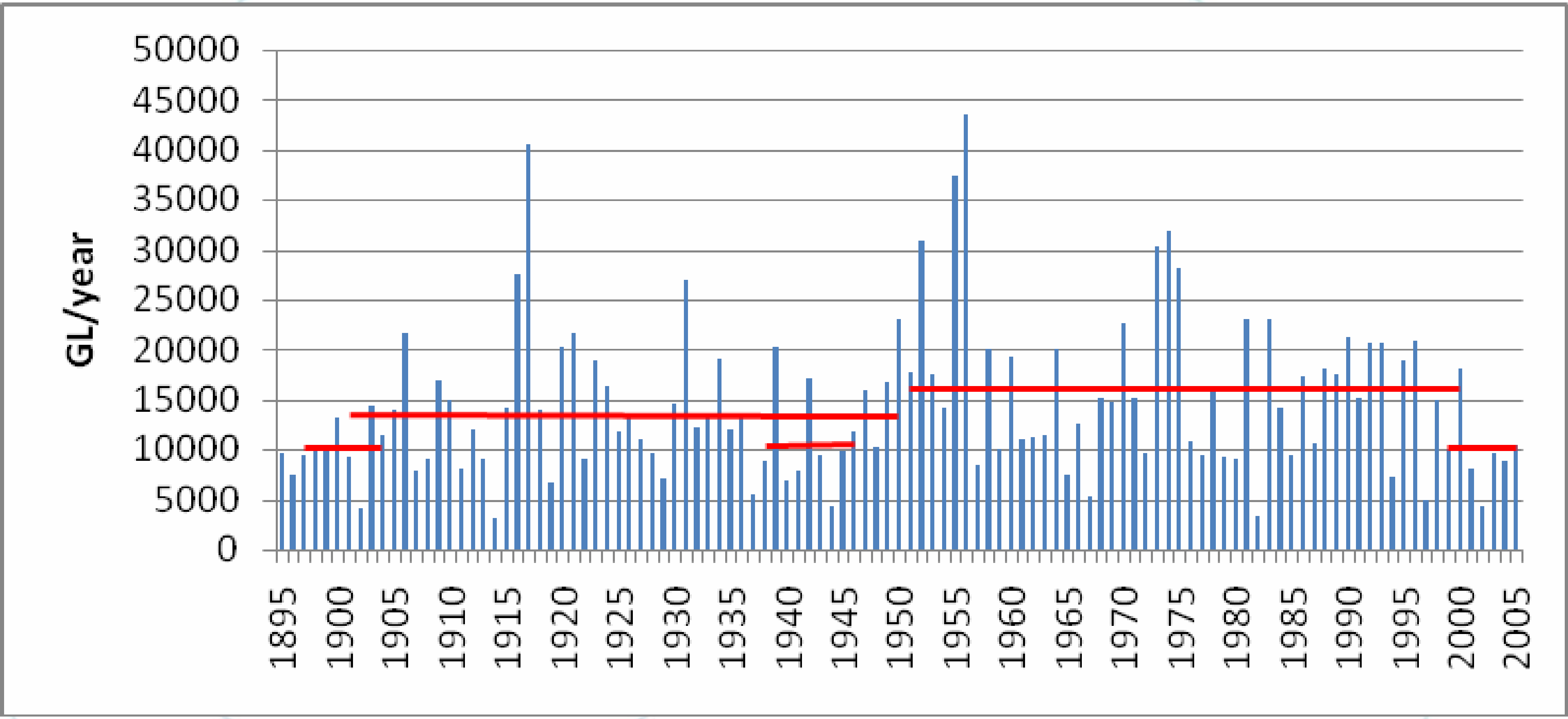
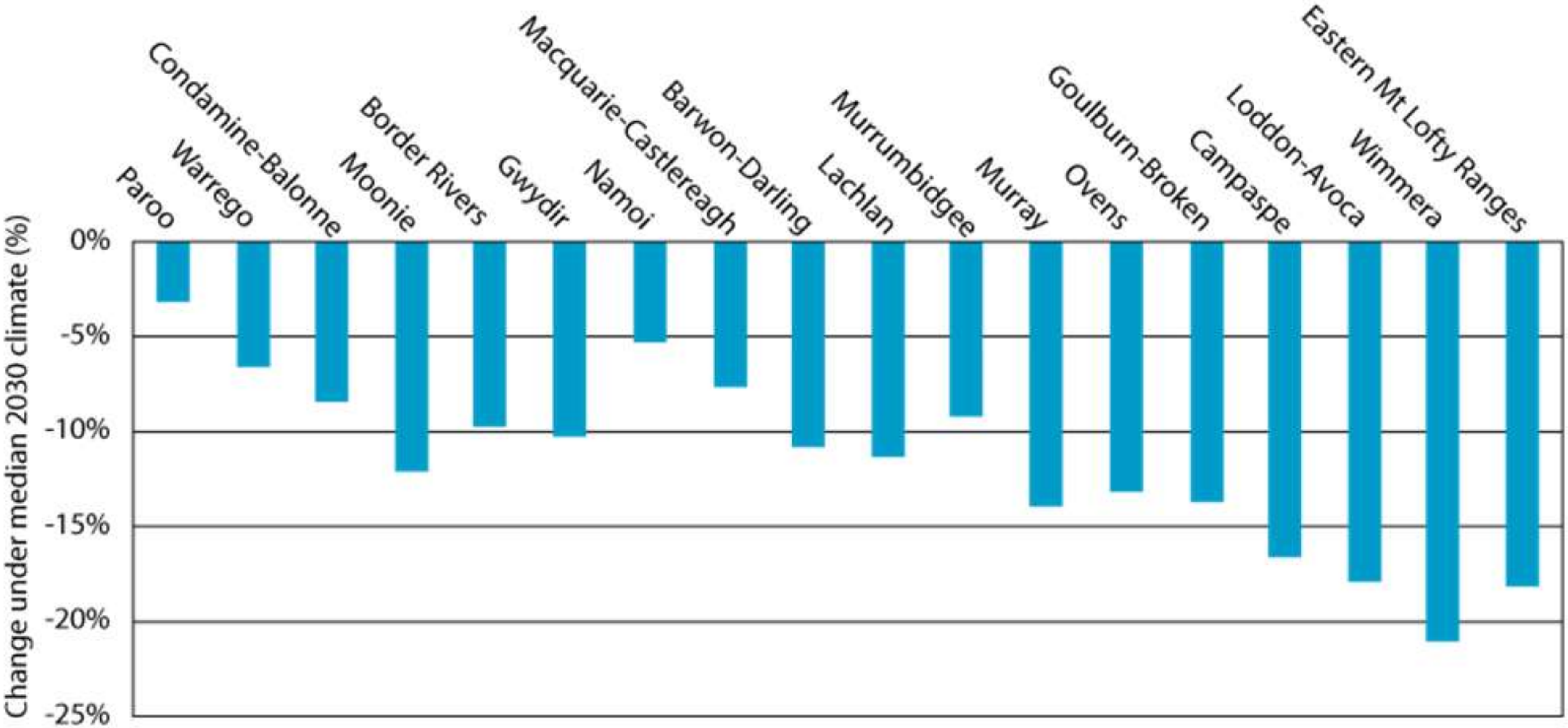

GL/year
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Table 3: Implications of river health flows on water allocation by 2030[31]

Period	Average surface water availability for diversion (GL/year)	Cap volume (GL/year)	Percent of Cap available for diversion	Percent below the current CAP
High probability of a healthy working river with no climate change impact				
1901 – 1950	7181	12,000	60%	40%
1951 – 2000	8796	12,000	73%	27%
High probability of a healthy working river with 'best estimate' reduction in runoff from climate change and development (11%)				
1901 – 1950	5667	12,000	47%	53%
1951 – 2000	6942	12,000	58%	42%
High probability of a healthy working river with 'worst case' reduction in runoff from climate change and development (38%)				
1901 – 1950	2016	12,000	17%	83%
1951 – 2000	2470	12,000	21%	79%

Impact of future climate on surface water availability



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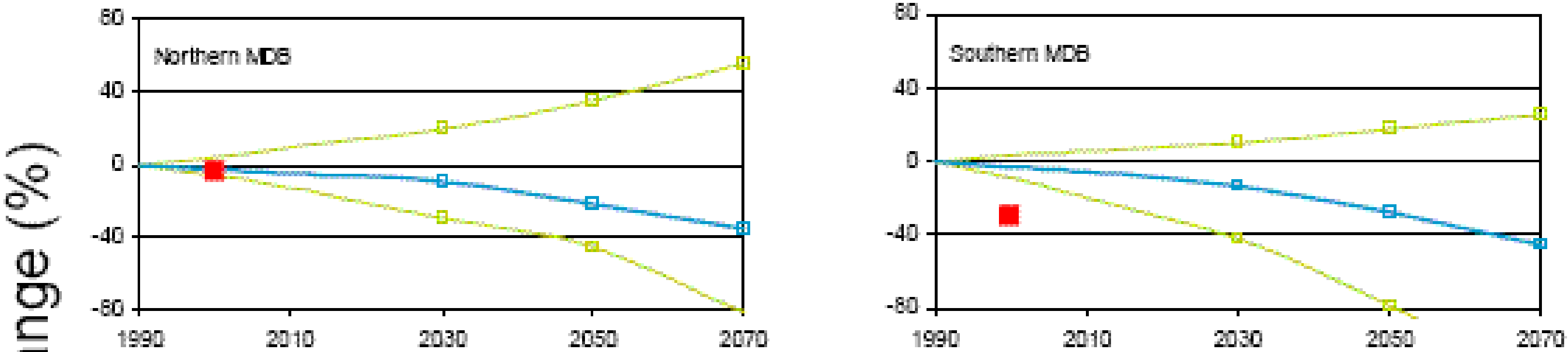
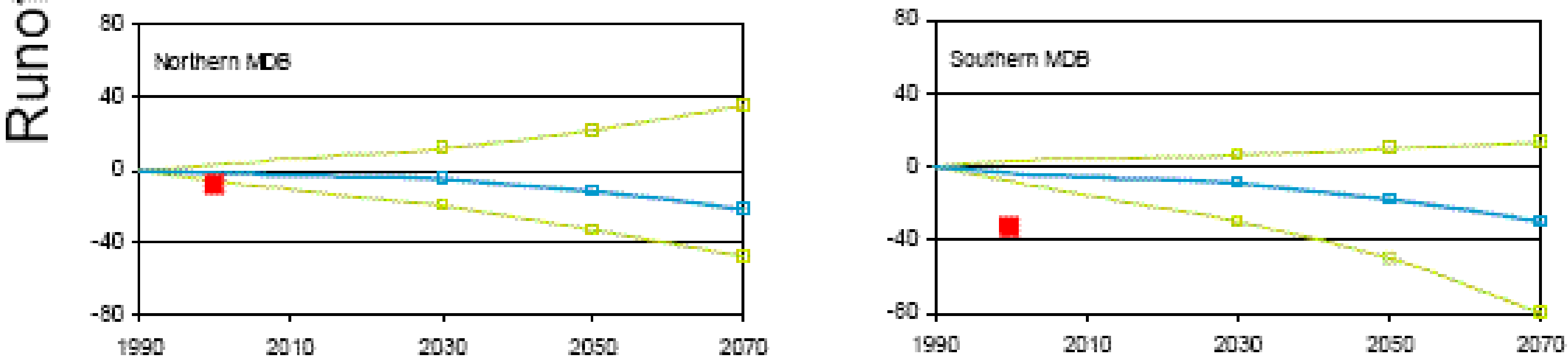
Raising National Water Standards Program

CSIRO

High global warming



Medium global warming



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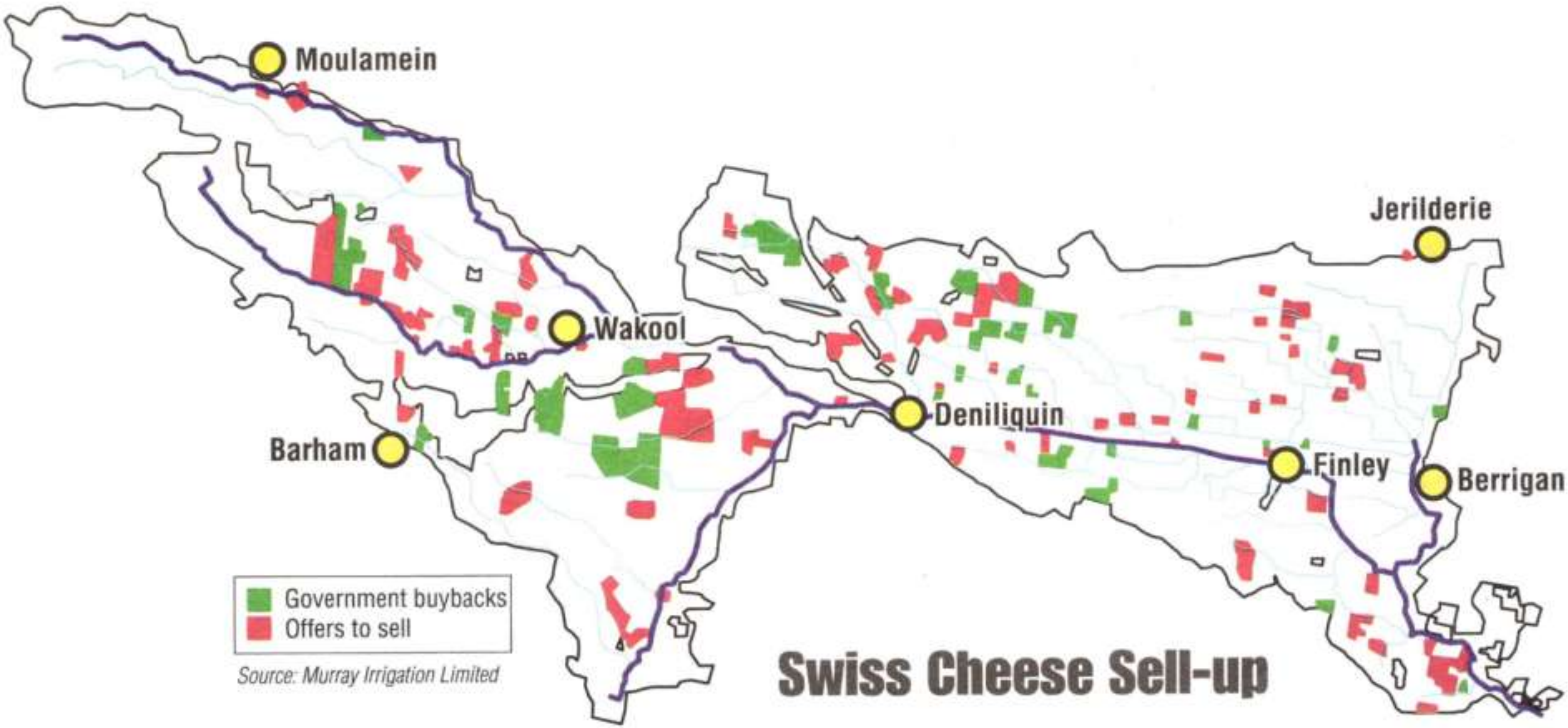

Immediate national priorities

1. Buy water for the environment to secure the health of over-allocated river systems from anyone willing to sell;

2. Regulate to offset further water losses caused by timber plantations, farm dams,groundwater use and water efficiency;

3. Build a National Water Account to find out where our water is, who is using it and what condition it's in;

Immediate national priorities

4. Apply the same environmental, market and price disciplines to everyone so that all users pay the full cost of water, including the cost of addressing environmental impacts; and

5. Accept that desalination, potable reuse, stormwater capture, recycling and urban-rural trade are all legitimate options for our coastal cities and often better options than building new dams and damaging more coastal rivers.

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Conclusions

Australia is at the crossroads in terms of its ability to cope with increasing water scarcity in that it has to choose between the more expensive capital and environmental downsides of options of:

- more storages and desalination,

or minimizes these via

- better water reuse strategies and increased water productivity.

Conclusions

A vigorous reform process is underway that is focusing on:

- governance, productivity and environmental issues.

This will oversee a major re-allocation of water:

- between irrigation activities,
- from irrigation to river and groundwater flow and
- some movement of water from irrigation to urban use.

Conclusions

If reforms allow third party access to urban sewage and effluents there will be incentives for:

- innovations in re-cycling and greatly increased water re-use.

Conclusions

If the reforms are able to establish a framework that allows efficient markets to work and thus water to trade and economic incentives develop that encourage and support innovation then we can expect to see:

- a significant increase in water productivity across industries while
- returning sufficient water to our stressed rivers, floodplains, wetlands and estuaries.
- Buying of water for the environment to secure the health of over-allocated river systems from anyone willing to sell

Conclusions

These reforms may also enable us to avoid mistakes made in the south as our northern rivers come under increasing developmental pressure