Part 1 - Summary Details

CRDC Project Number: UCW5208

Project Title: Preparing irrigated agriculture for statutory and climate change in the South West of Australia.

Project Commencement Date: 05/08/2011 **Project Completion Date:** 01/03/2012

CRDC Program: 3. Human Capacity

Part 2 – Contact Details

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Signature of Research Provider Representative: _____

Part 3

1. Background

In April 2006 the Western Australian government adopted the principles of the National Water Initiative (NWI) aligning the State's water management to the reforms agreed at the COAG meeting in 1994. As a result of this agreement a raft of changes to water management were examined by the Western Australian State Government agencies leading to the Government's publication in of "A Blueprint for Water Reform in Western Australia" a document that detailed the directions that were likely to be followed in the implementation of water management reform in Western Australia.

The Western Australia government agreed to a wide range of reform/change requirements, by WA at the COAG meeting. While to this time many of these agreed changes are not fully implemented, they indicate a real need to inform water users (farmers/irrigators/state and local governments) on how the changes will affect them. Furthermore, the South West of Western Australia has had a demonstrable decline in rainfall and run-off over the last 40 years. Climate change projections indicate that there will be further declines in rainfall and runoff which are likely to be exacerbated by an increase in temperature and evaporative demand. These changes will reduce water availability for irrigation (and competing uses) and increase demand.

1. Objectives

The project aimed to address the information deficit amongst irrigators, water resource managers and local government to ensure that irrigation in this region has a sustainable and productive future.

Objective 1. Increase the capacity of irrigators to respond to the pressures of statutory change and plan for future water requirements.

This objective was achieved by engaging the attendees to presentations in the topics including the proposed statutory changes to water law, the importance of understanding how climate changes is driving this, the environmental values that should be considered in a NWI and the opportunities available to growers etc. in adapting to the changes. All attendees were also given a resource CD ROM that included: copies of the presentations; background documents produced by both state and federal government agencies and useful factsheets, produced by DAFWA, to aid in better managing sustainable water use.

Objective 2. Increase the capacity of state and local government water resource managers to understand irrigator decision making and production constraints.

This objective was achieved by ensuring state and local government participation in the presentations and in the preparation of materials presented to the groups of participants.

2. *Methods*

To achieve a balanced view of the issues that should be included in the project, a steering committee of six was formed that included: Mark Gibberd – project supervisor; Mick Owens – Licencing Manager, W. A. Department of Water (DoW); Neil Delroy – Director Agribusiness, Research and Management; Geoff Calder – General Manager, Harvey Water, Glynn Ward - Viticulture Project Manager, Department of Agriculture and Food W. A. (DAFWA) and Rick Hoyle-Mills (project officer). Regular meetings with the steering committee guided the research directions taken and highlighted the areas that were deemed most relevant to address with the target audience.

With this guidance, the project was then focused on the following areas:

- Water Law reform in W. A. using the DoW document "A Blueprint for Water Reform in Western Australia" and a range of other documents from state and federal government agencies;

- The consideration of environmental flows and the role these play in the maintenance of healthy, sustainable water systems, using research/policy papers by state and federal government agencies and investigations by environmental researchers Dr. Andrew Storey – University of Western Australia and Genevieve Hanran-Smith – Cape to Cape Catchment Group;

- Climate change and the role that this is likely to play on future water availability using data sourced from CSIRO's Ozclim scenario generator and in particular research by Curtin University PhD graduate Nyamdorj Namjildorj, looking at climate change projections specific to the Southwest of Western Australia and the likely effects on wine grapes and other crops;

- "Using Water Wisely", with assistance from Department of Agriculture and Food, Western Australia, presentations were prepared to suit the different types of farming systems in various Western Australian regions that would be encountered throughout the delivery of the project. These presentations focused on the up-skilling of growers *etc.* in techniques to better monitor and apply water to their crops.

- Obtaining feedback from industry with respect to local and state issues via a participant survey.

3. Results

Details of presentations – the following are example presentations. The example used for the purposed of this report are the presentations given to the Manjimup audience. Presentations we modified to suit the local context of other audiences.

a. Observed and projected climate changes in Western Australia
b. Potential statutory changes to WA's water laws
c. Environmental Flows and GDE's
d. How to irrigate for WUE

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Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change Workshop
Manjimup. 10 February 2012

Observed and Projected Climate Changes in Western Australia

Dorj Namjildorj
Rick Hoyle-Mills

Department of Environment and Agriculture
Curtin University

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Presentation outline

- Greenhouse effect
- To date climate change in Western Australia
- Observed impacts of recent climate change on water supply/streamflow
- Projected climate in the future
- Projected changes in some key attributes of grapevines (some results of recent study)

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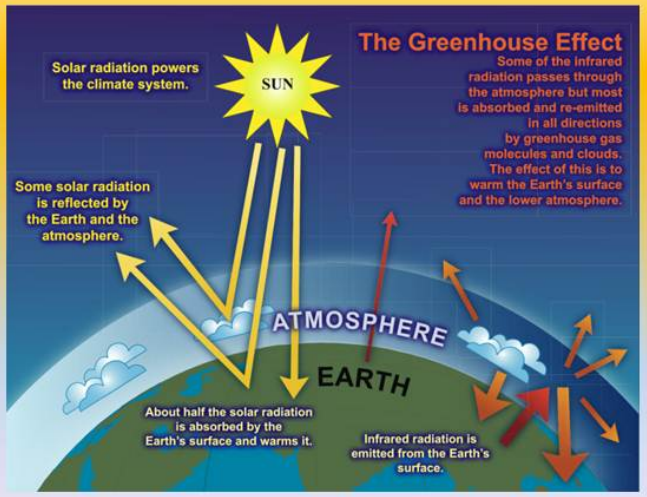
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Green-house effect



-Increased concentration of long-lived greenhouse gas in the atmosphere
- Re- emission of infra-red radiation by the atmospheric greenhouse gases
-Changes in net radiation balance due to the infra-red radiation
-Additional heat accumulation due to the trapped heat radiation
- Greenhouse gas emissions from human activities are 90 per cent likely to have caused most of the global warming since the mid-20th century (IPCC 2007)

Source: IPCC 2007: WG1-AR4

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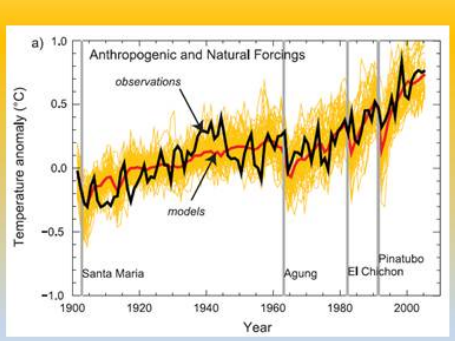
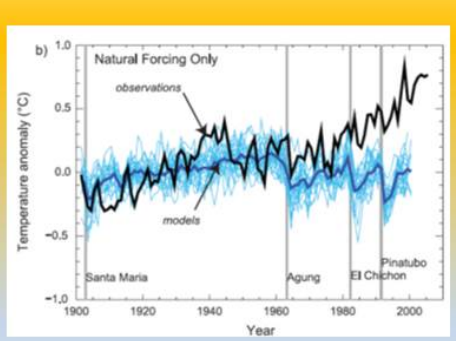
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Greenhouse gas effect modelling

Global mean surface temperature anomalies relative to 1901-1950 period





Inclusion of greenhouse effect into global climate modelling results better fit than models without the greenhouse gas effect inclusion.

Source: IPCC 2007: WG1-AR4

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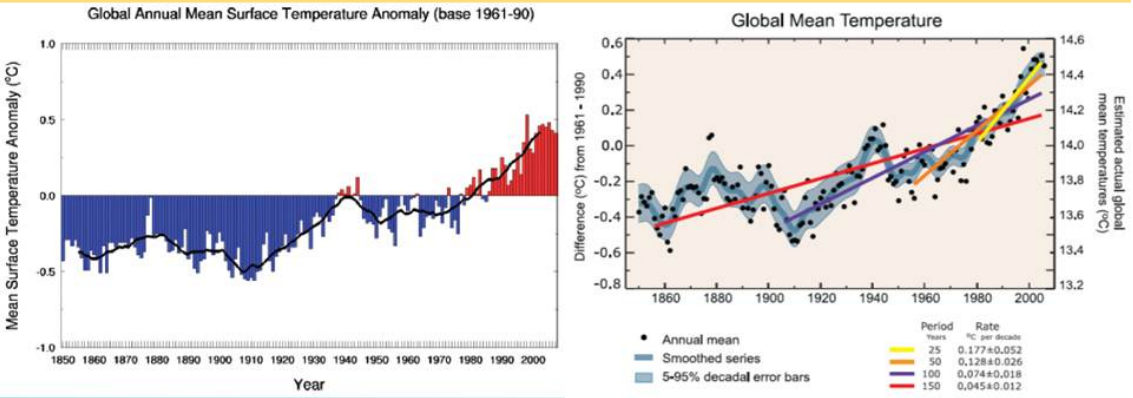
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Observed changes in global mean temperature



- **The global mean temperature increased by 0.7 °C over the last century**
- **Most of the changes (0.4 °C) has occurred since 1979**
- **The rate of the global temperature change over the last 25 years is 0.18 °C/decade and this is 2.4 times faster compared to the changes during the last 100 years**

Source: IPCC 2007

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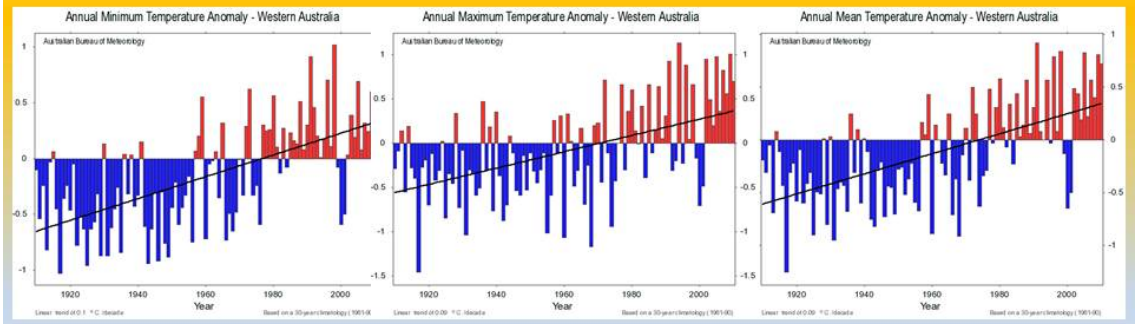
Observed annual temperature anomaly in WA (compared with 1961-1990 average)



- **Rate of minimum temperature increase is slightly (0.01 °C /decade) higher than the rate of maximum temperature increase**
- **Mean temperature increased by 0.09 °C per decade over the last century in Western Australia**

Source: Australian Bureau of Meteorology

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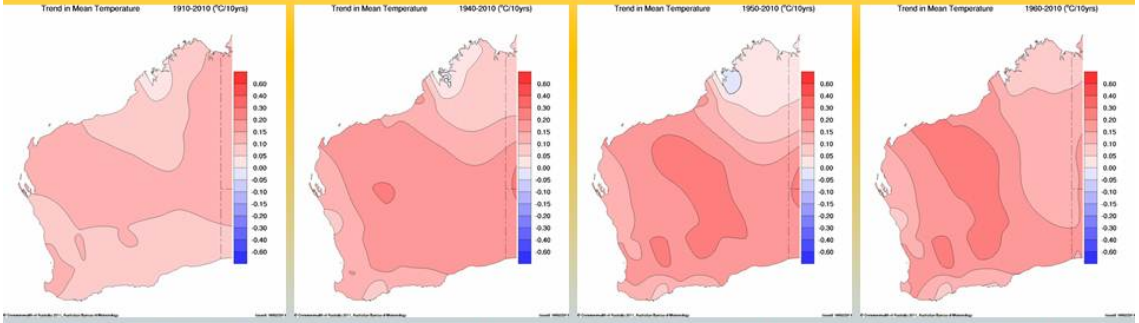
Rate and distribution of the warming in the last 100 years in WA



Between 1910 and 2010 | Between 1940 and 2010 | Between 1950 and 2010 | Between 1960 and 2010

- **Rate of the warming is higher in inland areas**
- **The warming trend is more intense since the middle of last century**

Source: Australian Bureau of Meteorology

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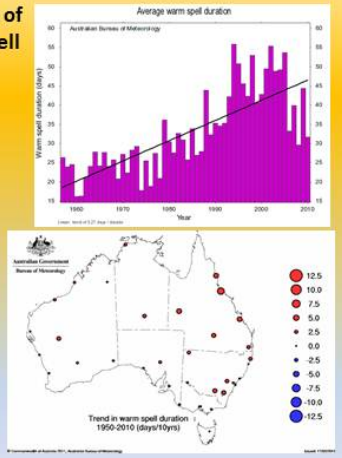
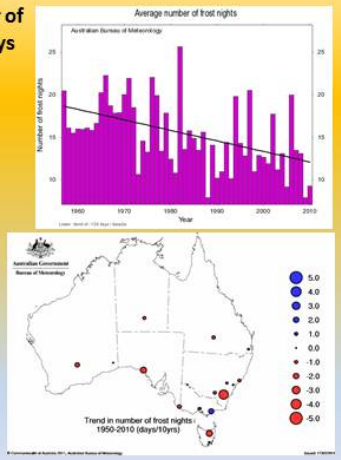
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Changes in warm spell and frost nights

Duration of warm spell



Number of frost days



Since the middle of last century;

- **Duration of warm spell is increased by 5.3 days per decade**
- **Number of frost nights is decreased by 1.24 nights per decade**

Source: Australian Bureau of Meteorology

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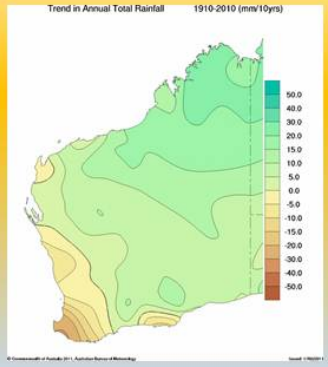
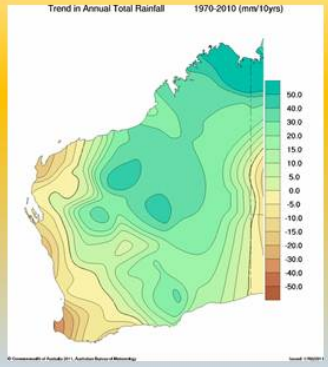
Changes in total annual rainfall in WA



Between 1910 and 2010



Between 1970 and 2010

- **Both increasing and decreasing rainfall trends are observed**
- **Drying trend is observed for the south-west and the north-west parts, especially since 1970s**

Source: Australian Bureau of Meteorology

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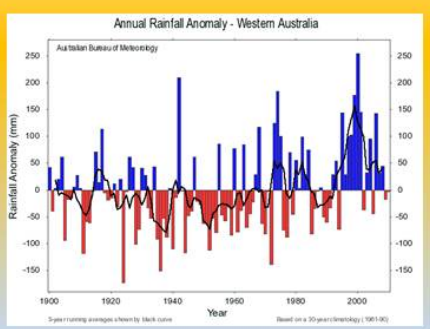
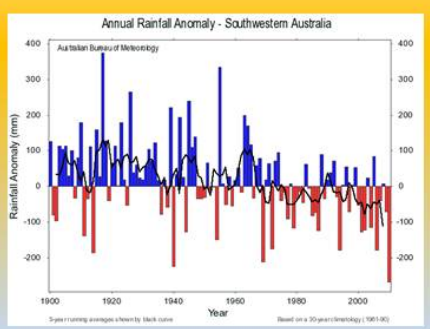
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Observed annual rainfall anomaly in WA





- **Changes in rainfall are spatially and temporally different**
- **10% decline for annual and 15% decline for winter rainfall for the south-west corner of the state since 1975 compared to 1961-1990 average**

Source: Bureau of Meteorology

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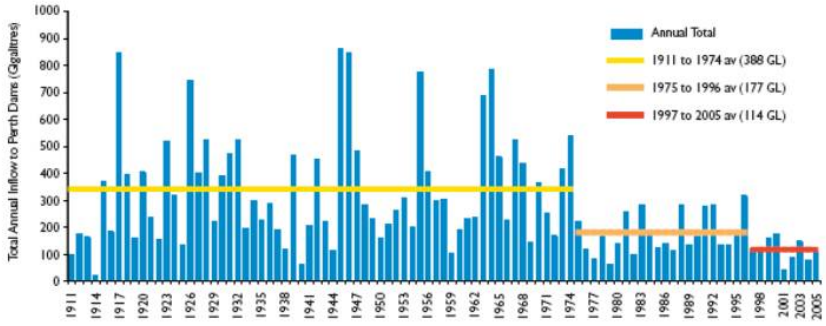
Changes in Streamflow



Streamflow to Perth's public water dams to 2005

- **54 % decreases in Perth's public dam streamflow during 1975-1996 compared to 1911-1974 period**
- **Streamflow to Perth's public dams during 1997-2006 was only one third of last century average**

Source: IPCC 2007

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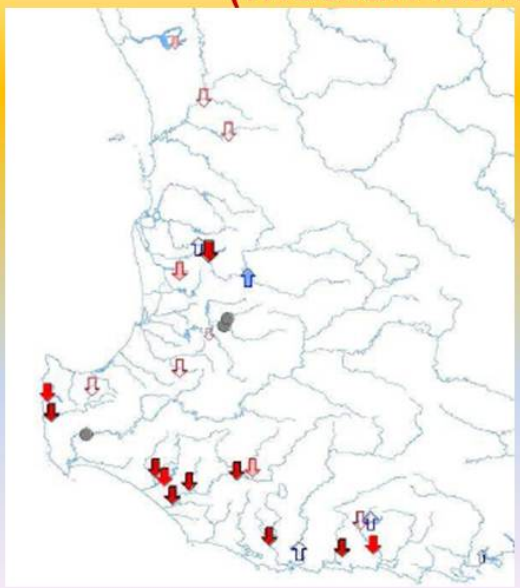
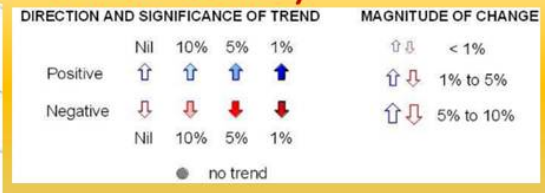
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Streamflow trends in South-West WA (Median flow- since 1975)





-Annual median streamflow is largely decreasing (20 stations show a decrease)

- There is a clear dominance of significant trends (14 of the 20 are statistically significant)

Source: Department of Water 2009

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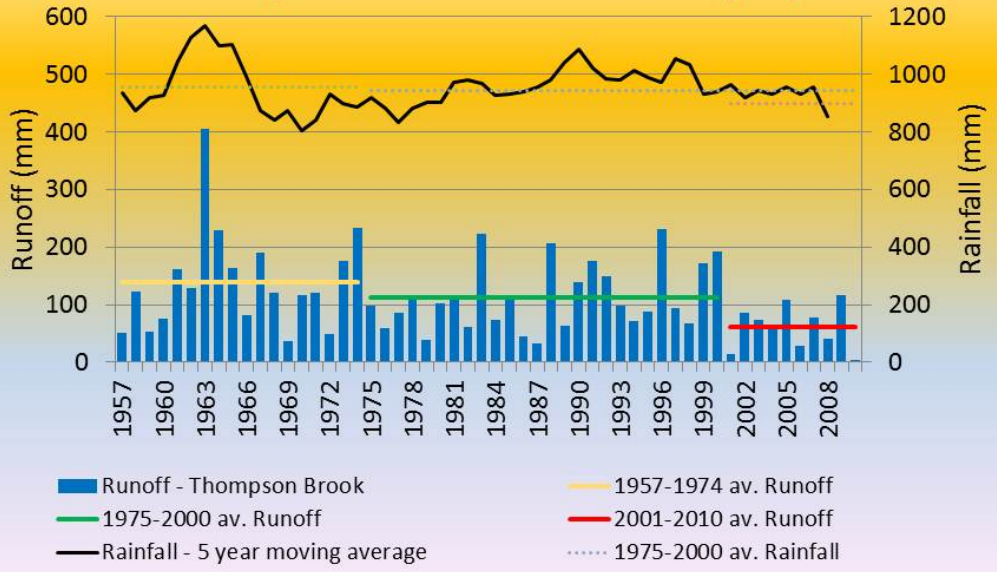
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Changes in Rainfall and Runoff in South West WA (Thomson Brook example)



Source: Department of Water 2011

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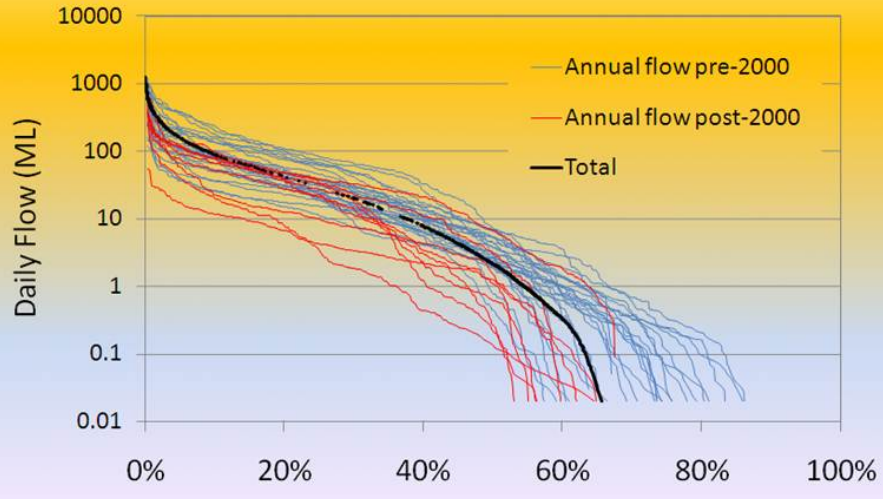
Changes in Streamflow (post 1975 flow regime -Thomson Brook example)



Source: Department of Water 2011

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Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Future climate projections

Uncertainties;

- **Scenarios – series of events that could lead from present to possible but not assured future situation**
- **Climate sensitivity in response to increasing greenhouse gas concentration**
- **Global climate models**

Projected global warming value is determined by above factors

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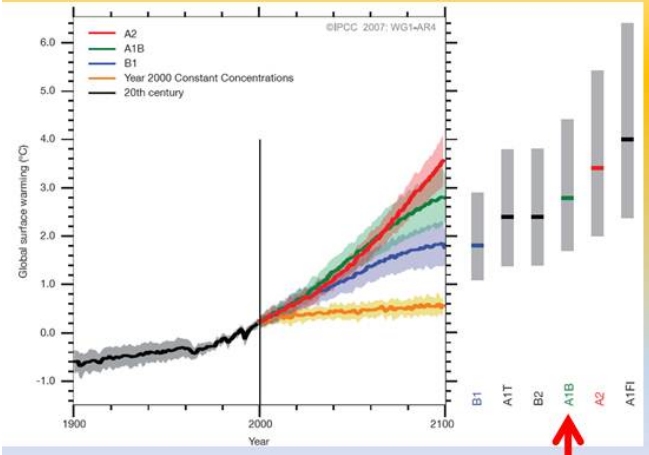
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Climate change scenarios



This presentation used A1B scenario for future climate projections

For example, Global average warming estimation ranges between 1.1 °C to 1.8 °C by 2050 with B1 and A1F1 scenarios, respectively, relative to 1990

Source: IPCC 2007

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Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Climate sensitivity and Global Climate models

Climate sensitivity –
assumption of future climate warming when current levels of atmospheric CO_2 doubles

- **Low** **1.7 °C**
- **Moderate** **2.6 °C** - for this presentation
- **High** **4.2 °C**

When the CO_2 increases from 280 ppm to 560 ppm

Climate Model difference –
Below models project **low** and **high** warming ranges for WA out of 23 IPCC AR4 GCMs examined.

IAP FGOALSG1.0	CSIRO Mk3.5
0.86 °C (2030)	1.37 °C (2030)
1.46 °C (2050)	2.33 °C (2050)

Outputs of above models are presented for this presentation to illustrate potential range of climate change across WA

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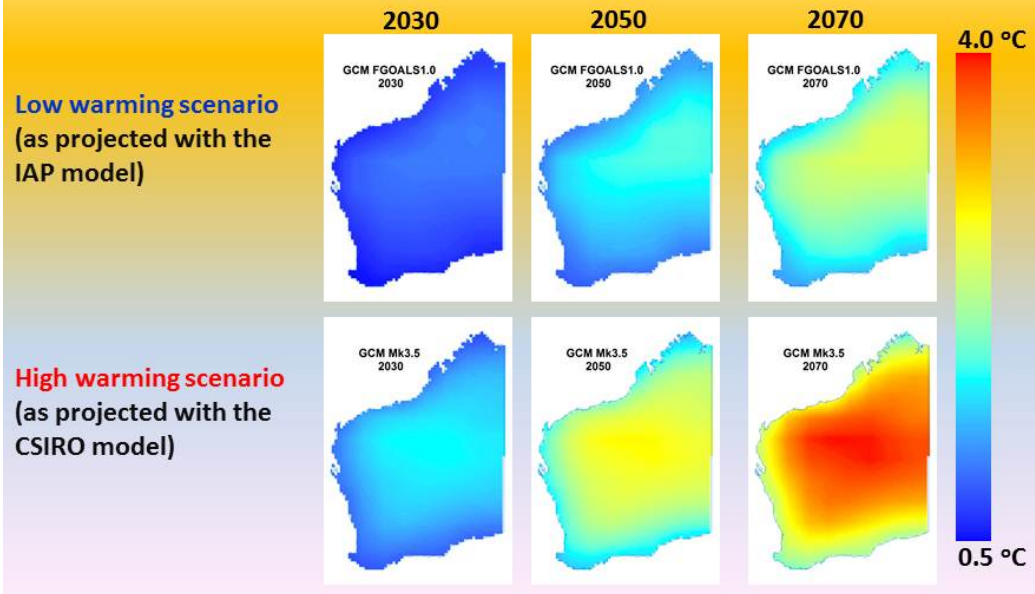
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Changes in annual mean temperature compared to 1974-2004 average



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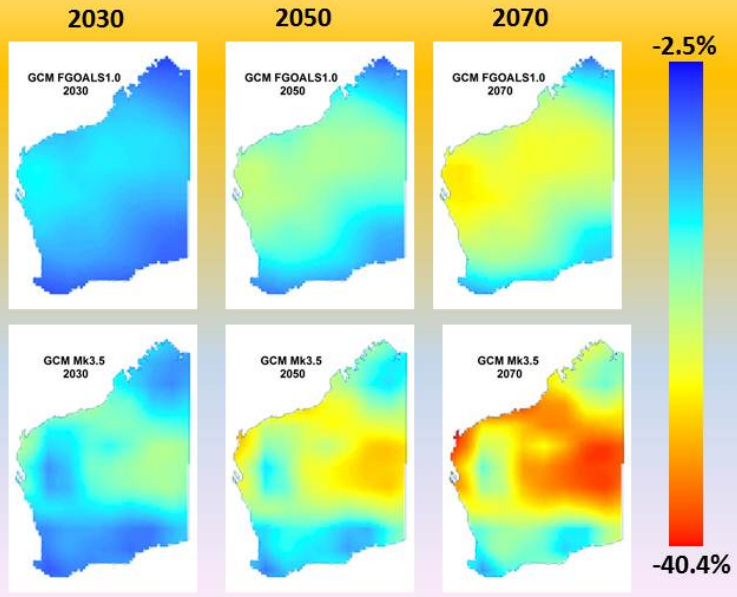
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Projected Annual Rainfall change in WA compared to 1974-2004 average



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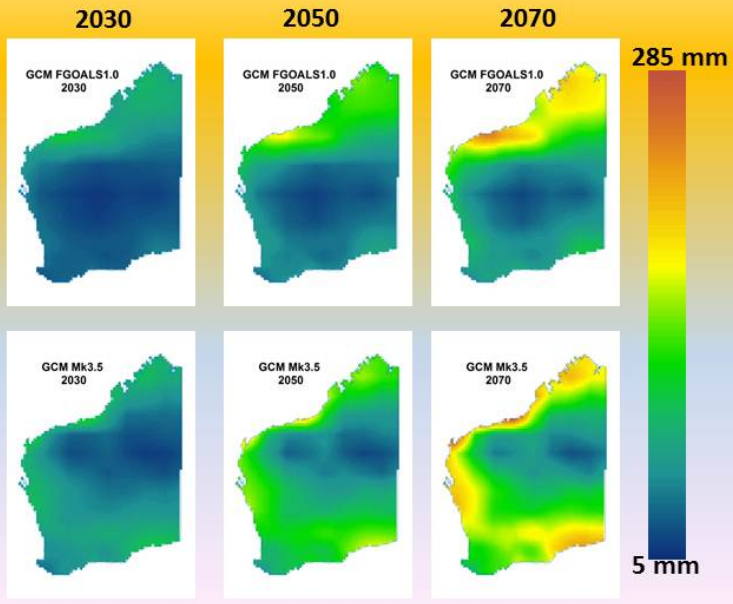
Changes in annual Potential Evapotranspiration compared to 1974-2004 average



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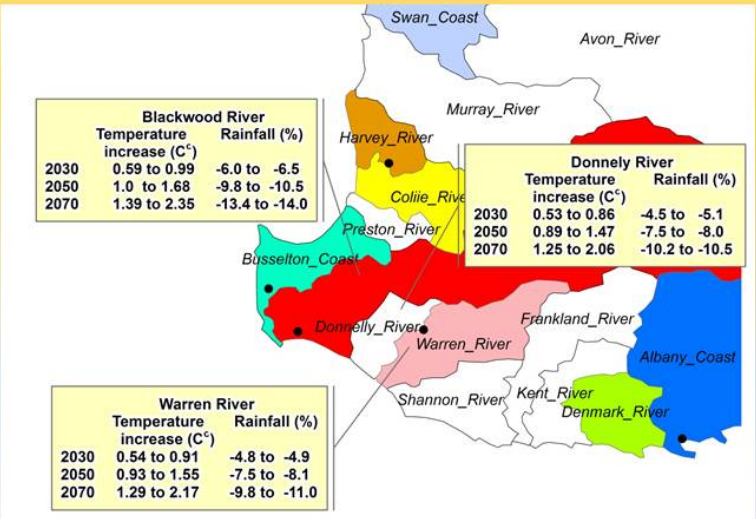
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Changes in annual mean rainfall and temperature in South-West of WA



Compared to current climate, (1974-2004) the annual mean rainfall and temperature across river basins in South-West WA will likely decrease, while the mean temperature increases

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Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Summary

- **The climate is changing and the rate of change is getting more intense**
- **Magnitude of the projected climate change is greater than the recent changes in climate**
- **This will likely impact existing agricultural systems in various ways (water shortage/increased irrigation demand etc)**
- **Adapting to the changing climate will be necessary to avoid negative impacts of the change**

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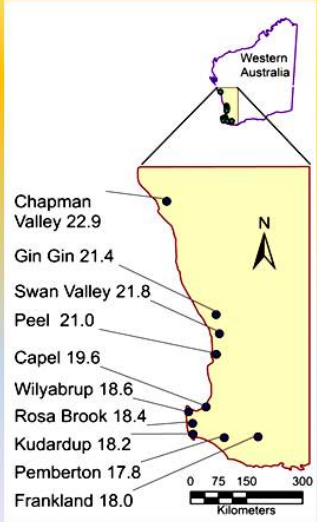
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Modelling of Climate change impacts on grape quality
(data source - for model development)



- Sampling transect set up along natural climate-gradient covering all WA GIs,
- About 5 °C GST range along the transect,
- Weekly sampling of fruit during 08/09 & 09/10,
- Anthocyanins and titratable acidity at 22 °Brix TSS,
- Measured climate & berry quality data for model development

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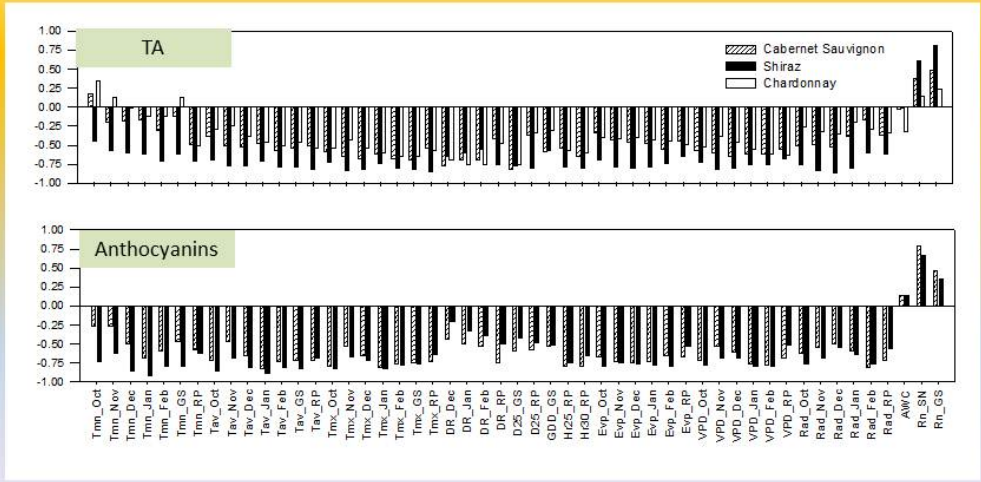
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Correlations between the grape quality attributes and climate variables



Despite differences in plant material and soil properties, levels of TA and anthocyanins show consistent correlations with site climate variables

Results: Grape quality models

Anthocyanins concentration at 22 °Brix TSS:

Cab. Sauv. = 3.63 - 0.094 MJT Adj_r^2 = 0.65

Shiraz = 2.59 - 0.051 MJT Adj_r^2 = 0.77

Titratable Acidity at 22 °Brix TSS:

Cab. Sauv. = 19.20 - 0.003 DR_GS - 0.389 Tmn_RP Adj_r^2 = 0.77

Shiraz = 13.34 - 0.0034 DR_OF + 0.0086 Rn_GS Adj_r^2 = 0.82

Chard. = 16.11 - 0.0305 DR_Feb - 0.935 Tmn_RP + 0.942 Rad_Oct Adj_r^2 = 0.82

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Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Grape maturity date modelling

Data: Observed climate and grape maturity data

Two methods were compared and used:

Method 1: BEDD accumulation starting from 1st of October:

- 1300 for Cabernet Sauvignon
- 1250 for Shiraz
- 1150 for Chardonnay

Method 2: Regression approach at 22 °Brix TSS:

$Mat\_Date_{Cabernet\ Sauvignon} = 62.55 * T_{av\_OF}^{-2.49}$ Adj_r^2 = 0.94

$Mat\_Date_{Shiraz} = 79.58 * T_{av\_Oct\_Feb}^{-2.721}$ Adj_r^2 = 0.92

$Mat\_Date_{Chardonnay} = -5.39 * T_{av\_Oct\_Feb} + 19.85$ Adj_r^2 = 0.88

Both Mat_Date and T_{av}_OF in natural Log scale

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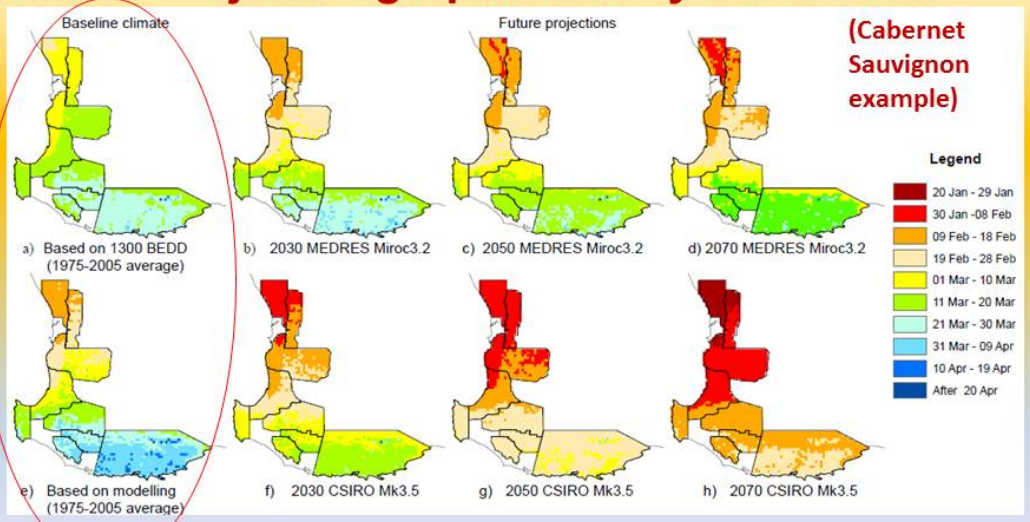
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Projected grape maturity at 22 °Brix



Average temperature during October to February was better predictor for maturity dates (at 22 °Brix) than the BEDD for this study

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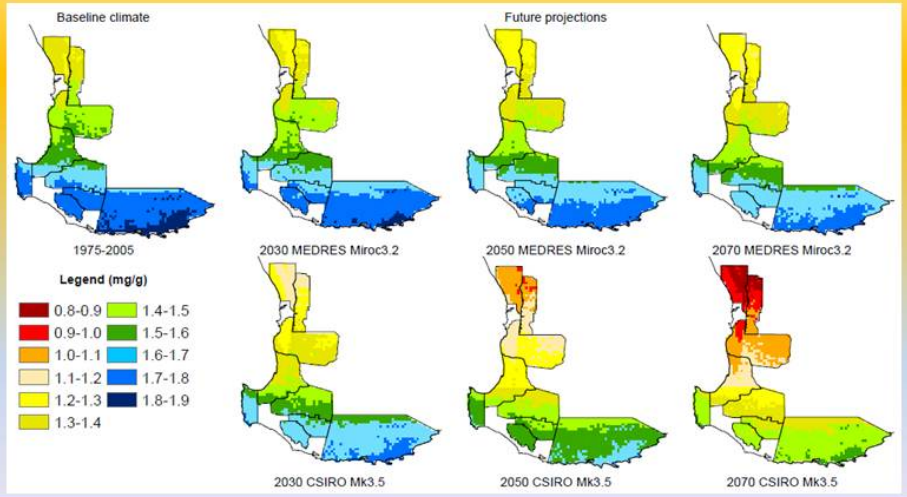
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Projected anthocyanin concentrations (mg/g) at 22 °Brix TSS (Cabernet Sauvignon)



Changes in anthocyanins levels were not uniform across regions: Current median anthocyanin levels will drop by 18% for cooler southern regions and 33% for warmer northern regions under the most warming projection by 2070.

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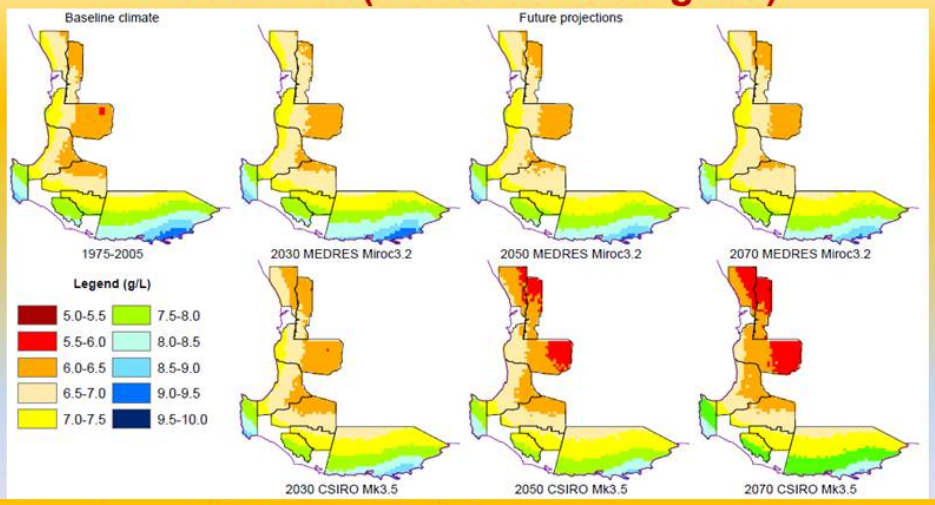
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Projected titratable acidity (g/L) at 22 °Brix TSS (Cabernet Sauvignon)



The maximum change will be less than 0.5 g/L at any given area.

The current median Caberner Sauvignon TA will decline by 6 to 12%, depending on the region, by 2070 under higher warming range (as projected by the CSIRO Mk3.5 model)

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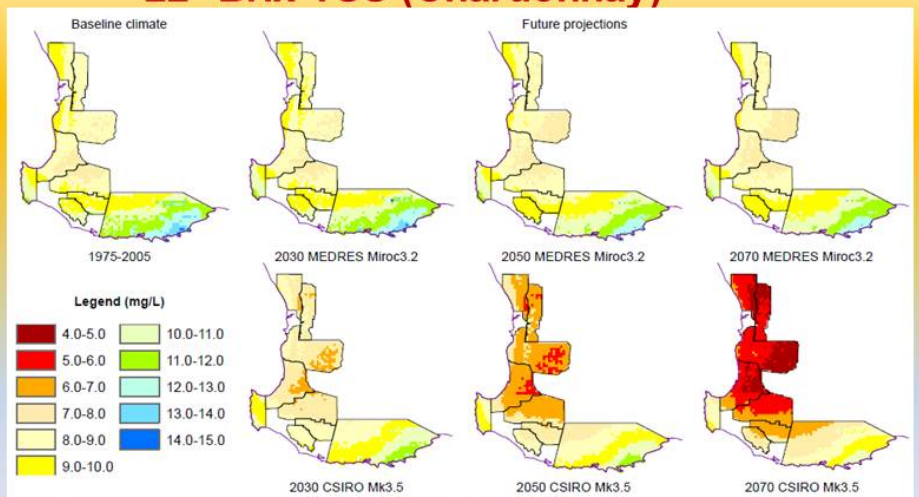
Anticipated Changes in Water Supply and Irrigation Requirements Associated with Climate Change

Results: Projected titratable acidity (g/L) at 22 °Brix TSS (Chardonnay)



Current Chardonnay median TA will drop by 40 to 42% for the warmer northern regions by 2070, under the most warming scenario.
The southern cooler regions will experience up to 30% less TA levels by 2070 under the most warming scenario.

Conclusions

- Primary characteristics of grape quality will be negatively affected by warming climate
- However, the magnitude of the impacts will be different across the established wine regions for different varieties.

Preparing Irrigated Agriculture for Statutory and Climate Change Manjimup Presentation

A Collaborative Project Between Curtin University and The Department of Agriculture and Food W. A.
Supported by:
The National Program for Sustainable Irrigation

Department of Environment and Agriculture

Potential Statutory Changes to W. A.'s Water Laws

Presenter:
Rick Hoyle-Mills
Curtin University
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Department of Environment and Agriculture

Outline for Presentation

- History and current situation of water legislation in W. A.
- National Water Initiative;
- Water Trading;
- Security of water entitlements;
- Key policies for new legislation;
- Compensation.

Introduction

- Western Australia's water resources law and management processes have developed over more than 100 years;

- They no longer meet the state's need to manage water sustainably for future generations at a time of a drying climate and increasing demand.

RIGHTS IN WATER & IRRIGATION ACT 1914 (RiWI)

- Abolishment of common law;
- Redefine riparian rights;
- Authorise water use through licensing;
- Plus six other acts…

Background to Current Legislation

- The principal Act under which water resources are managed, *The Rights in Water and Irrigation Act* was enacted in 1914 and provided for the damming of the Harvey River to establish irrigated agriculture;
- The act is inconsistent, has outdated provisions and is heavily amended making it difficult to understand.

Outline

- History and current situation of water legislation in W. A.
- National Water Initiative;
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- Compensation

National Water Initiative

- In 1994, the Council of Australian Governments (COAG) agreed on a set of national reforms to improve water supply and water management;

- Western Australia adopted the National Water Initiative (NWI) on 6 April 2006, after carefully considering whether the NWI principles could be adapted to WA.

National Water Initiative

- The overall objective of the NWI is to achieve a nationally compatible market and a regulatory and planning-based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes.

Changes to Proclaimed Areas

- A key task of water resource management is to manage the abstraction of water from water resources. This is necessary to:
  - Give water users the certainty and confidence to make an investment;
  - Ensure sustainable outcomes;
  - Manage cumulative impacts that can jeopardise either of the above;
  - An administrative system that has the flexibility to manage water without proclamation is needed.

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Drilling Down – The Challenges

- Over the past 35 years, annual rainfall in the south-west has declined by 15% and run-off of surface water has fallen by up to 40%;
- The amount of water taken from streams/aquifers has more than doubled;
- These challenges must be addressed in the context of providing greater security and certainty of water access entitlements for all water users, while also protecting the environment.

Drilling Down – Preventing Over-Allocation

- For parts of Western Australia, further increases in the volume of water taken will:
  - erode the water security of other water users and/or
  - increase the risk of environmental impacts;
- This could be addressed by setting caps to prevent both the erosion of existing water rights and damage to the environment.

Outline

- History and current situation of water legislation in W. A.
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- Compensation

Water Trading to Manage Water Scarcity

- Previously the government has taken water from some water users and reallocated it to anticipated higher value uses;

- An appropriately regulated market that allows water users to manage their own water needs is widely recognised as being preferable.

Water Trading

- Allowing better management of water rights;
- Selling and trading water access entitlements will be encouraged;
- Land and water title may be traded separately;
- An improved water registry – similar to that currently used for land ownership (based on the Land Title Register model).

The benefits of transacting water entitlements include:

- Encouraging the efficient use of water resources (within allocation limits) by providing the opportunity to capitalise on water savings
- Enabling the migration of water, on a permanent or temporary basis, to uses of higher economic value
- Allowing the water users to respond to changing conditions
- Enabling the re-allocation of water resources in fully allocated systems, including opportunities for new water users to access the water resources.

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Unbundling

- Unbundled right - An unbundled right is the separation of a 'bundled' right into its individual elements. At its most basic level, unbundling separates water rights from a land property title, allowing the trade of the water rights independently of land.

- Additional degrees of unbundling involve the separation of a water right into its individual elements. These might include, but are not limited to, water access entitlements, water allocations, water use rights, delivery rights and works approvals.

Current Water Trading in Victoria

Temporary Market				Permanent Market			
Avg Price	Total Sell Vol	Total Buy Vol	Last Trade	Avg Price	Total Sell Vol	Total Buy Vol	Last Trade
$19.03 v	12297.6 ML	12155 ML	350ML @ $12	$1,688.62 v	17535.2 ML	2668.7 ML	50ML @ $800
Lowest Sell Order				Lowest Sell Order			
500ML @ $12/ML MURRUMBIDGEE (SUPPLEMENTARY) - ZONE 4: DOWNSTREAM OF GOGOLDERIR WEIR				38ML @ $100/ML 6 VIC MURRAY (DARTMOUTH TO BARMAH) GMW - LOWR			
Highest Buy Order				Highest Buy Order			
500ML @ $250/ML GWYDIR 1 VALLEY - GENERAL S				3ML @ $8000/ML MCLAREN VALE - WEST OF WILLUNGA FAULT LINE			

Source: Waterfind Weekly Newsletter, (26-Sep-11 - 03-Oct-11)

Outline

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Security of Water Users Entitlements

- Water users rely for their livelihood on their rights to take and use water - They want secure, long-lived rights;
- WAE's will be seen as a right to water in perpetuity;
- In providing secure entitlements for water users, it is critical that the allocation system can manage the sustainability of the water resource.

Security of Water Users Entitlements

- Weaknesses in existing legislation include:
  - a poor ability to manage water systems in a way that is adapted to match rainfall/run-off;
  - an inability to deal effectively with water use by plantations and other activities that intercept water (more on this soon);
- This could be addressed by a system that can adjust to changes in water availability, allowing for secure, perpetual water access entitlements to a share of available water.

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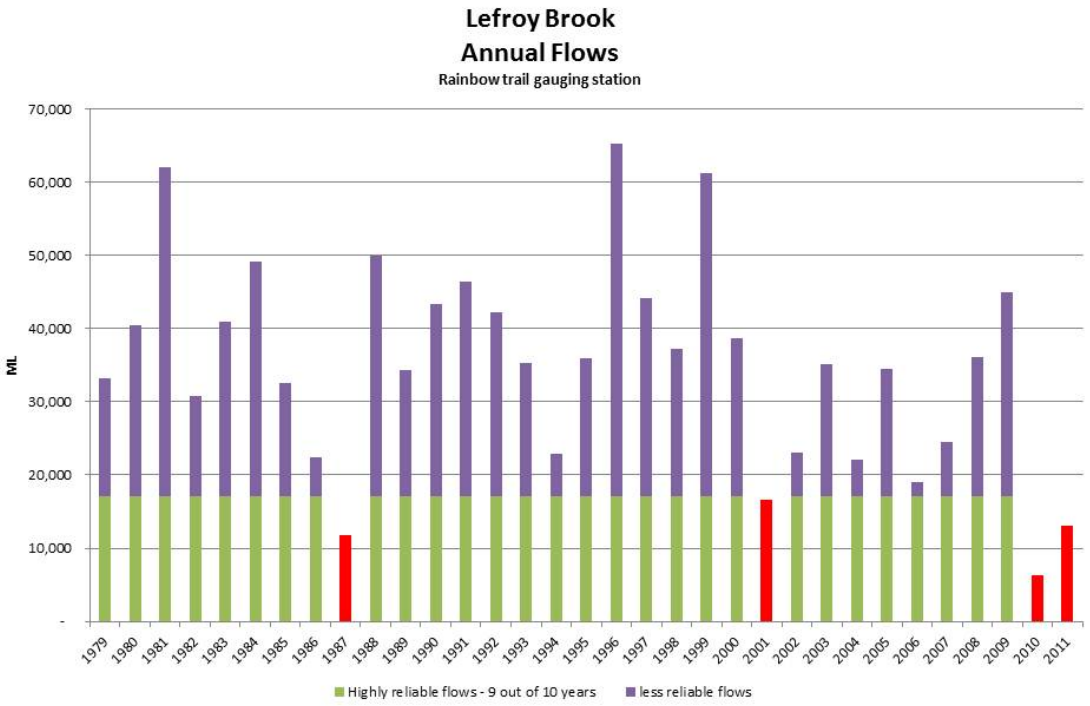

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Water Allocation to Ensure Sustainable Outcomes

- Current legislation (RiWI Act) lacks transparency and is poorly defined when it comes to decreasing the volume of water taken during periods of water scarcity;
- Hence the development of Water Management Plans at a local, sub-regional and regional level.

Plantations and Other Water Inception Activities

- Activities that intercept water (such as plantation forestry and overland flow) are not recognised under the Act;
- This could be addressed by including such activities under the definition of 'taking water' and offering these users WAE's.

Outline

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Key policies for new legislation

- Stronger and more transparent allocation plans;
  - Make water allocation plans binding on all water users and on the government. This will give greater certainty and security of title for all water users – critical to establishing an efficient water market.

Key policies for new legislation

- Environmental water management;
  - Protect water resource ecosystems and their environments – stream/river banks and environmental flows necessary for ecosystems.
- Important considerations in the development of water allocation plans would be:
  - Setting water resource objectives for the area;
  - Setting water-related environmental outcomes for the area;
  - Defining the water regime required to meet those outcomes.

One Size Does Not Fit All

- Two options identified:

1. Establishment of 'Consumptive Pools' – new legislation required;
2. Licences - The existing system of licences for the taking of water could be retained in areas where there is little competition between users and in areas where a consumptive pool had not been established by a water allocation plan.

Basic Water Rights

- Currently 'Riparian Rights' – the right to use water for domestic use, stock/garden watering and fire fighting;
- NWI – no real change:
  - The landowner or occupier would have the right to construct the necessary works to take that water without a permit, except for bores that accessed confined aquifers, or in-stream dams. A permit would be required in both of these circumstances – a continuation of the current arrangements.

New Perpetual Water Access Entitlements

- Secure and well-specified water entitlements to a share of available water are necessary to:
  - Provide certainty for water users;
  - Promote investment;
  - Encourage the efficient use of water through water trading.
- This could be addressed by creating a system of secure and fully tradable Water Access Entitlements (WAE).

Allocation Entitlements

- Size of consumptive pool would be announced periodically by the DoW;
- To reflect the realties of changes in the water cycle - holders of WAE's would be aware that their allocations can be reduced;
- Gives necessary flexibility to match extraction with availability;
- Protect resource from over extraction and times of climatic stress.

Licences to Take and Use Water

- The existing system of licences for the taking of water could be retained;
- Improvements needed:
  - Simplify and consolidate applications;
  - On the death of a licence holder the executor may become the holder of the licence;
  - Establish a moratorium on new applications when a resource is fully allocated. NOTE: This is now being reviewed…

Construction of Dams and Wells

- Under a new consumptive pool regime, separate approval (in the form of a permit) would be required to operate the works to take water and to use that water;
- Where the existing licensing scheme remains, approval to operate works and use water would remain as part of the licence.
- Current licensing arrangements for farm dams would continue.

Scope of Management of Water Resources Increased

- Currently sources such as springs and wetlands within a property boundary are exempt from RiWI Act;
- Under new legislation these would be managed by the issuing of a WAE for water taken over and above that used for basic rights.

Water Metering

- Not possible to manage water effectively if usage is unknown:
- All usage above 50 ML/year – metered;
- Metering of existing water licences below 50 ML/year would be required where circumstances warrant this;
- User pays – however proposed that Government pays up-front and recovers through annual metering charge

Native Title

- Under current legislation, there is no specific provision for Native title holders' rights to water. While it would appear that Native title holders do not require a licence under the RiWI Act 1914, the situation is not entirely clear;
- Native title holders' rights to take and use water in accordance with traditional laws must be recognised. This would not include water for commercial purposes.

Outline

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Compensation Arrangements

- The requirement for compensation to be paid, should continue when there is a need to reduce the licensed water use on a permanent basis and the reductions are not fair and reasonable;

- The NWI sets out a risk assignment framework that specifies how water access entitlement holders may bear the cost of reductions in water allocation according to the cause of the reduction.

Reason for Reduction in Allocations	Who Would Bear the Risk?
Uncontrolled events (e.g. drought).	WAE holders.
Changes in government policy (e.g. new uses for the water or environmental objectives).	Government (changes suffered by entitlement holders are paid for).
Improvements in knowledge that require more water to be provided for the environment.	Shared between WAE holders and the government. WAE holders bear up to three per cent reduction in 10 years; government would bear the rest (shared between the state and Commonwealth governments as specified in the NWI agreement). Would apply only where there was a consumptive pool under a statutory water allocation plan and only from 1 January 2015.

Break

- Next topic – Climate Variability

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Environmental Flows and GDE's

Presenter:
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Groundwater Dependant Ecosystems

- Dependency of ecosystems is based on:
  - Flux or flow of water, the volume and rate of water into the system;
  - The level of water in unconfined aquifers;
  - Pressure, the potentiometric head in confined aquifers and
  - The chemical quality of the groundwater *e.g.* pH, salinity, nutrients, and contaminants.

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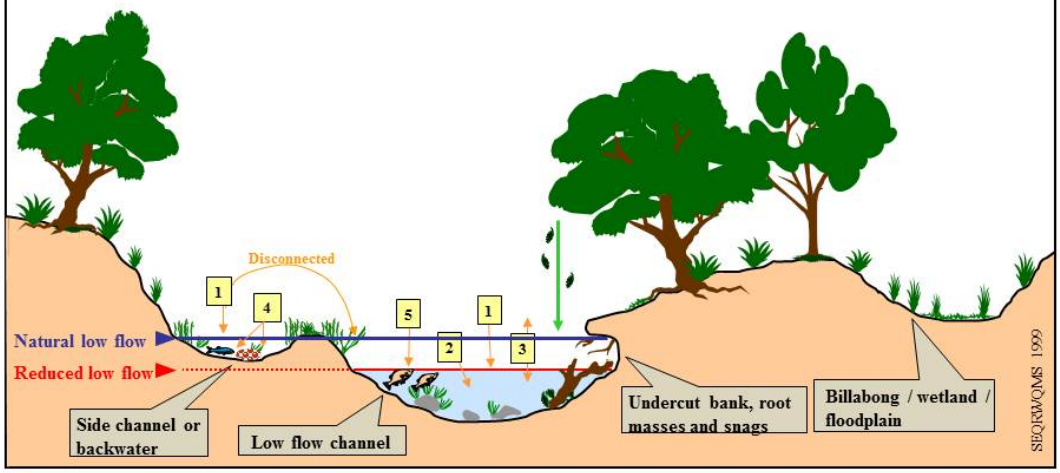
Types of GDE's

- Terrestrial vegetation – may be dependant on shallow groundwater;
- Wetlands – a wide range of these across W.A. and their diversity means that all four of the previous attributes play a role;
- River base flow systems – stream flows often have a groundwater component in many rivers in W.A.;
- Aquifer and cave ecosystems;
- Terrestrial fauna – sources of drinking water and
- Estuarine and near shore marine systems - crocodiles, turtles, fish and macro-invertebrates

Figure 12. Effects of flow regulation (reduced low flows, increased variability) on fish communities.



1 Reduced low flows and increased variability reduce overall aquatic habitat availability. Side channels and backwaters may also be disconnected from low flow channel and may dry out, reducing access to and availability of lateral aquatic habitat. 2 Reduced low flows may lead to degraded water quality in aquatic habitats (e.g. increased temperature, decreased D.O.), affecting fish survival and recruitment. 3 Reduced low flows in riffles and runs cause a reduction in the frequency and duration of longitudinal connectivity within channel network, causing barriers to fish movement. 4 Reduced flows and increased variability may cause stranding/desiccation of fish eggs, larvae and adults. 5 Change in temporal pattern of flow may cause loss of appropriate stimuli for fish movements, migrations and reproduction.

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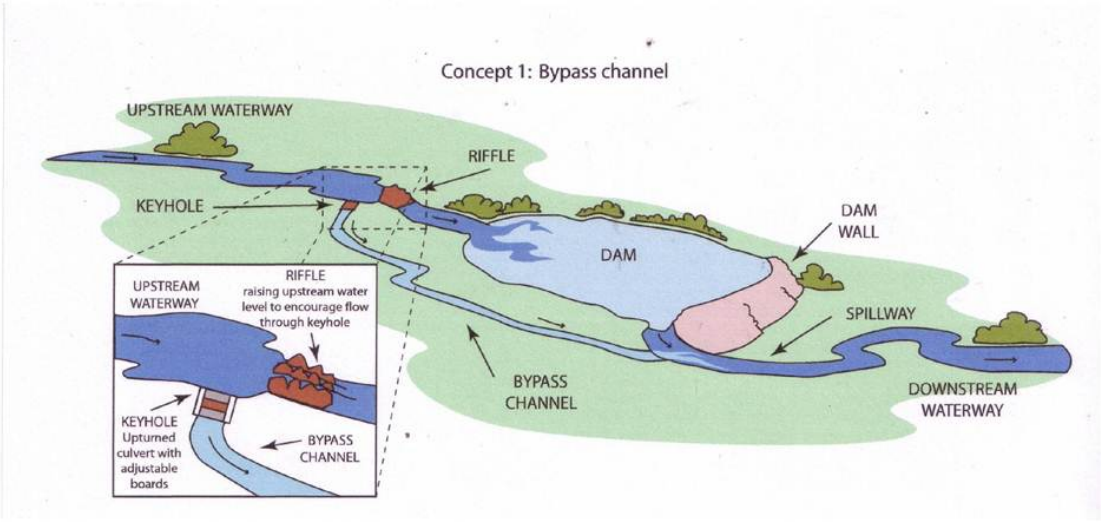
Low Flow By-Pass Channel



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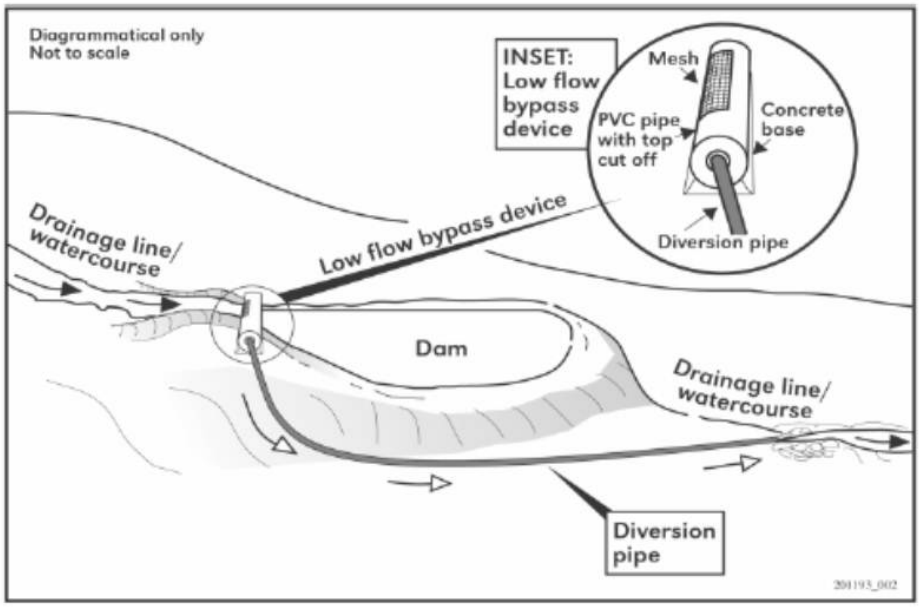
Low Flow By-Pass Device



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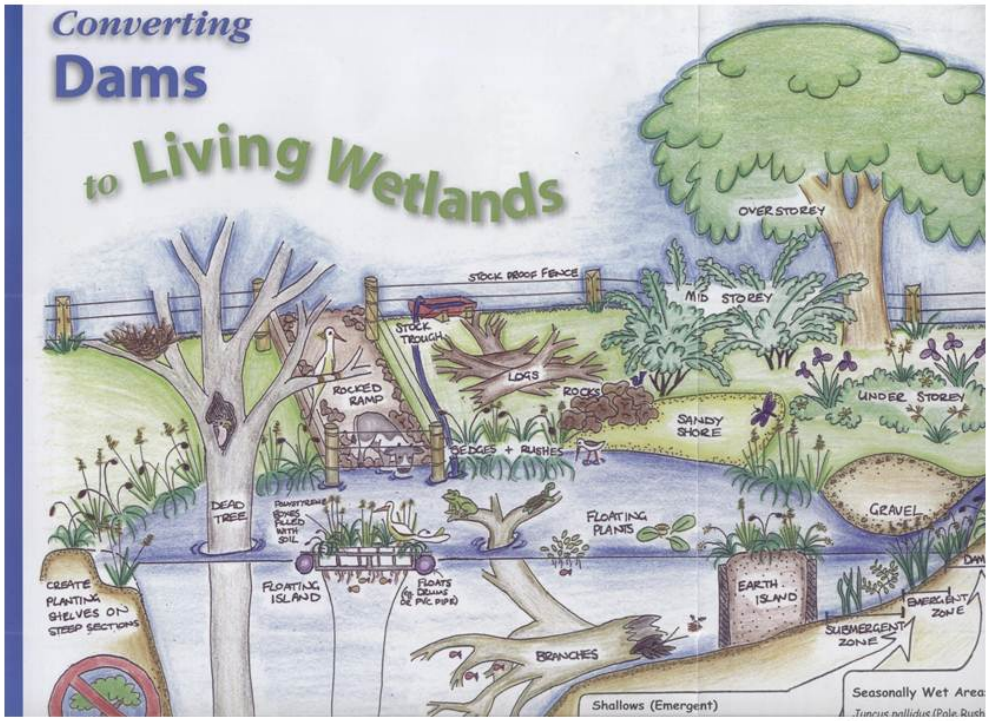
Biodiversity and ecosystem services

- Increased ecosystem resilience
- Attracting beneficial species for natural pest control (invertebrates, insect eating and predatory birds, bats)
- Pollination
- Wind management - windbreaks, control of spray drift
- Flood and erosion control
- Water quality protection
- Soil health and fertility
- Enhanced water penetration and retention



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Acknowledgements

- Dr Andrew Storey - School of Animal Biology, The University of Western Australia;
- Genevieve Hanran-Smith; Winewatch Project Officer, Curtin University;
- Department of Water, Land and Biodiversity Conservation.
- Cape to Cape Catchments Group

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Using Water Wisely

HOW?

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Crop Water Use

- Crop water use is driven by the weather conditions of the environment the crop grows in
- Weather conditions include
  - Solar radiation
  - Humidity
  - Wind speed
  - Temperature

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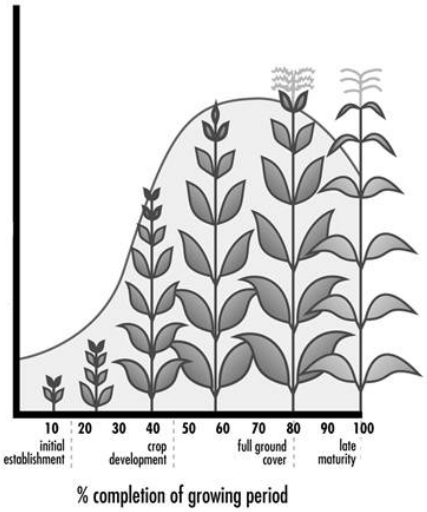
Crop Water Use

- Crop water use will also vary with the stage of crop development
- Evapotranspiration (ET) will tell us how much water is being used by the crop (CWU)



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Understanding your Soil

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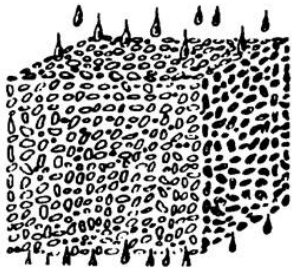
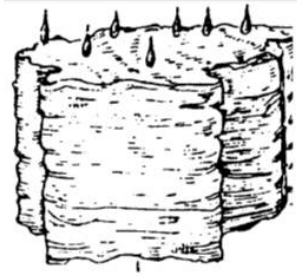
Single Grain Structureless Sand

Massive Structureless Clay

Crumb





Prismatic

Blocky

Platey

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Measuring your output…

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When/how much should I water?

- Crop water use can be monitored in three different ways
  - Plant based methods
    - direct observation – NOT recommended!
  - Weather based methods
  - Soil water based methods

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Weather based method

- To calculate the crop water use, you will need
  - Evaporation figures
  - Crop factor (K_f)

$$E \times K_f = \text{Daily Crop Water Use (CWU)}$$

By monitoring the crop water use, we may predict when we are likely to run out of water

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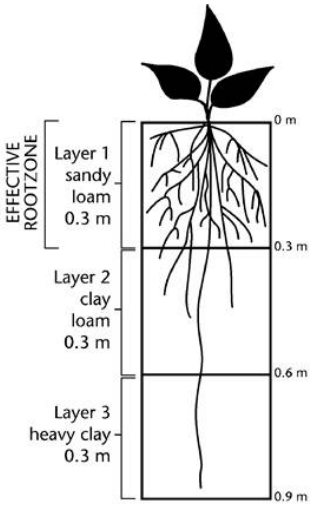
Key terminology

RAW – readily available water

- the amount of water held by the soil (within the effective rootzone) that is readily (or easily) accessible to the plant



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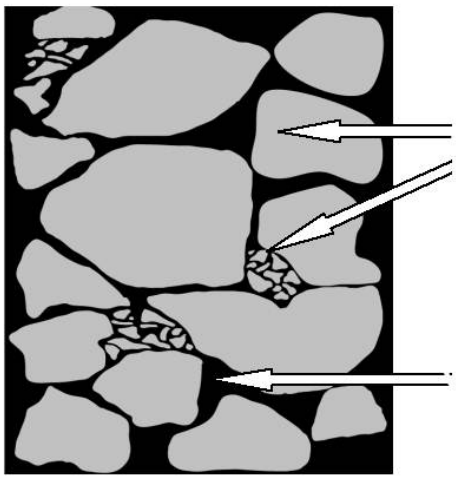
Saturation point

- After heavy rain or over-irrigation
- Even the largest pores are filled with water
- Applying more water causes ponding, run-off or deep drainage.
- No air for the plant roots. This will stress many plants.



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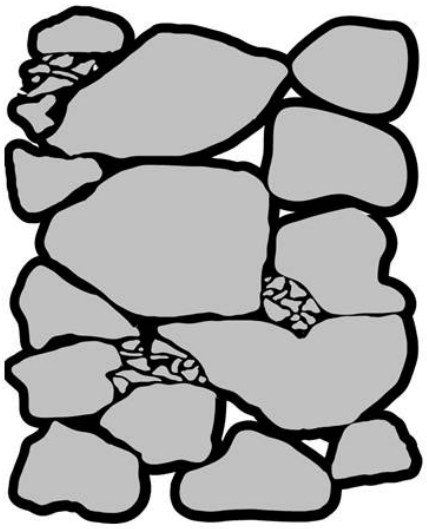
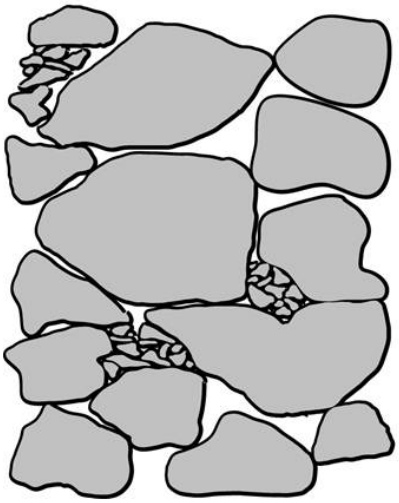
Field capacity

- Once rain or irrigation stops, large soil pores drain due to gravity
- Small pores resist gravity and hold onto their water through capillary force
- The soil is still wet, but not saturated



Permanent wilting point

- Soil water reaches a point when the plant can no longer extract any water
- Water is held by the soil so tightly that the plant will start to die from lack of water.



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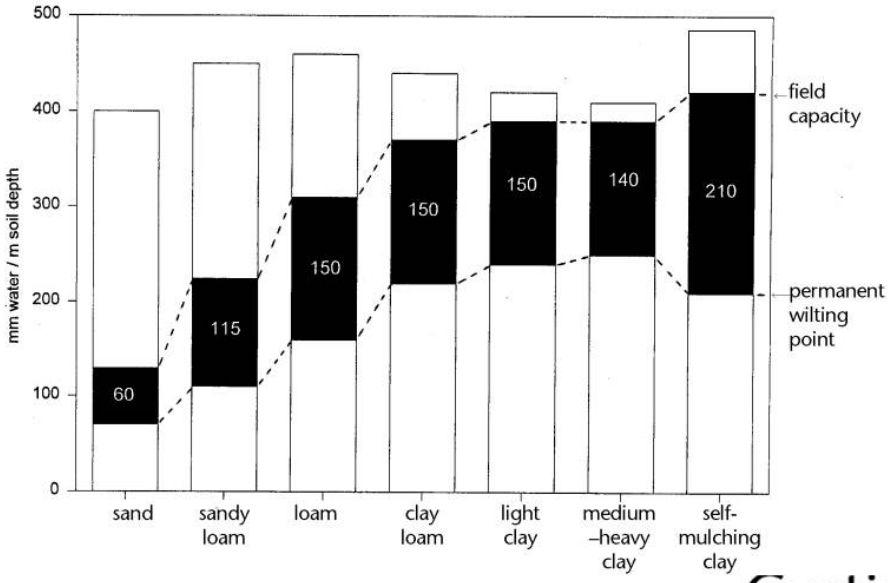
Total Water Holding Capacity of soil



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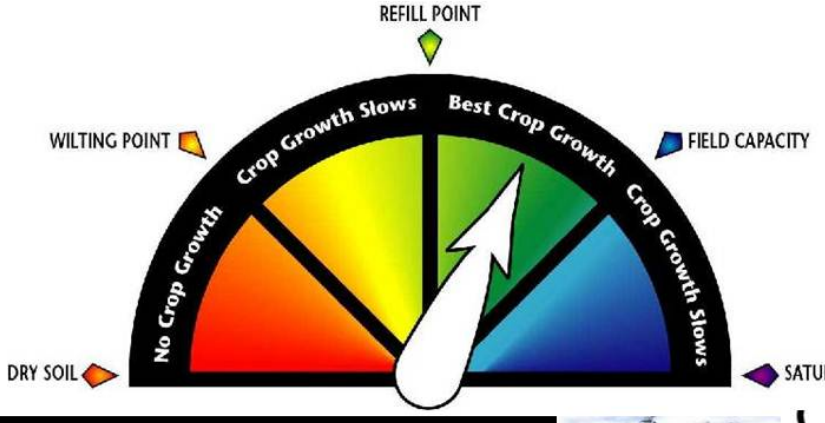
Soil Water Based Methods

Directly determine the crop water use by estimating how much water is lost from the soil



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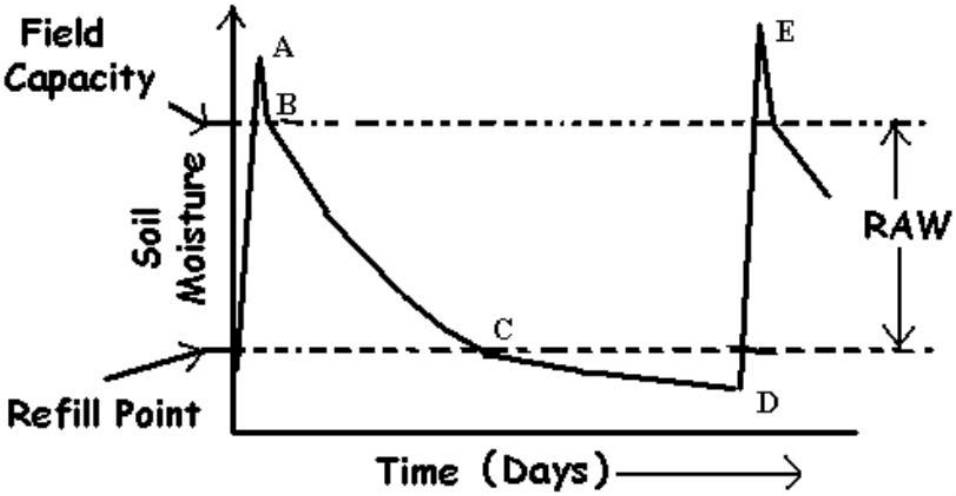
GOVERNMENT OF WESTERN AUSTRALIA

Monitoring crop water use



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Calculating water requirements

- Scheduling
  - Applying the right amount of water at the right time

Month	January		Crop	perennial pasture		
Block			RAW	27	mm	
Irrigation MAR		8.2				
	A	B	C	D	E	
Date	ET_o	K_c	ET crop (A x B)	Effective rain or irrigation	Remaining RAW (E from previous Day - C + D)	Lost to runoff
1	6.7	0.75	5.025		21.98	
2	6.7	0.75	5.025		16.95	
3	8.5	0.75	6.375		10.58	
4	7.7	0.75	5.775	20.5	25.30	
5	7.2	0.75	5.4		19.90	
6	8	0.75	6		13.90	
7	7.5	0.75	5.625		8.28	
8	4.5	0.75	3.375	20.5	26.40	
9	8	0.75	6		19.40	
10	7.3	0.75	5.475		13.93	
11	5.4	0.75	4.05		9.88	
12	5.1	0.75	3.825		6.05	
13	7.9	0.75	5.925	20.5	20.63	
14	7.9	0.75	5.925		14.70	
15	7.6	0.75	5.7		9.00	
16	7.9	0.75	5.925		3.08	
17	9.3	0.75	6.975		-3.90	
18	9.8	0.75	7.35		-11.25	
19		0.75			-11.25	
20		0.75			-11.25	
21		0.75			-11.25	
22		0.75			-11.25	
23		0.75			-11.25	
24		0.75			-11.25	

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- Water budgeting

	Rainfall					Crop Water Use			Irrigation	
Month	Decile 5 Rainfall mm	Decile 1 Rainfall mm	Effective Rainfall factor	Effective rain Decile 5 mm	Effective rain Decile 1 mm	Evap mm	Kc	ETcrop mm	Irrigation requirement Decile 5 mm/ha	Irrigation requirement Decile 1 mm/ha
Data Source	Table 4	Table 4		A x C	B x C	Table 4	Table 7	F x G	H - D	H - E
	A	B	C	D	E	F	G	H	K	L
July	205.0	144.8	0.6	123.0	86.9	42.2	0.75	31.6		
August	170.5	100.1	0.7	119.4	70.1	50.1	0.75	37.5		
September	119.0	75.2	0.8	89.3	56.4	61.2	0.75	45.9		
October	84.9	43.6	0.8	63.7	32.7	79.1	0.75	59.3		26.6
November	54.4	17.4	0.8	43.5	13.9	102.0	0.75	76.5	33.0	62.6
December	25.4	9.3				126.5	0.75	94.9	94.9	94.9
January	15.9	3.8				142.3	0.75	106.7	106.7	106.7
February	12.3	3.8				125.7	0.75	94.3	94.3	94.3
March	25.5	9.5				102.8	0.75	77.1	77.1	77.1
April	64.6	27.6	0.8	51.7	22.1	66.3	0.75	49.7		27.6
May	149.3	82.3	0.8	119.4	65.8	50.1	0.75	37.5		
June	187.9	123.7	0.7	131.5	86.6	38.3	0.75	28.7		
								Total (mm/ha)	406	490

- Annual requirement of: 4ML/ha or 4.9ML/ha
  - Over 85 ha, need 340ML or 416.5ML in a dry year

Water storage options

- Tanks – most efficient storage
- Dams
  - Leakage
  - Evaporation

1. Licensing
2. Landscape
3. Dam site

Managing Dam Evaporation

- If you have multiple partially filled dams, bulk up.
- Dam shape can reduce evaporation by around 14%.
- Other techniques: expensive, and long term, but worth thinking about for future years.

Shade cloth spanned over dam (69-71%)
Floating cover (83-100%)
Chemical monolayer (0-40%) (Craig et al 2005)

Improving & Monitoring WUE

- Water use efficiency - "the comparison of the yield of product, to the units of water applied to produce that product"
- Benchmarking
  - Yield (kg) per ML water applied
  - Value ($) per ML water applied

Department of Agriculture and Food

Monitoring water use efficiency to identify improvements

- The amount of water that reaches the crop is determined by the **crop water requirements**, **irrigation system efficiency**, and the **availability of water**.
- Records of field application efficiency and distribution efficiency should also be made. This will allow comparison within your own enterprise.

Department of Environment and Agriculture

Curtin University of Technology

Department of Agriculture and Food

Key points…

- **Understand how much water you need**
  - consider both average and dry years
  - what will you do in a dry year?
- **Test your irrigation system**
  - measure the output and operating pressure
  - Check for leaks, sprinkler blockages etc
- **Get your scheduling right**
  - get the water on **when** you need it
  - only apply as much as needed for the **plant**

Department of Environment and Agriculture

Curtin University of Technology

Improving your water use efficiency can lead to

"more crop *per* drop"

WUE Future Directions

- Industry Development
- Helping farmers assess WUE on Farms
- Develop new irrigation scheduling tools
- Demonstration of WUE best management pracitces

Outcomes

4. Details of workshops and presentations:

Workshop Date	Workshop Location	Number Attending	Outcomes
Tuesday 29 November 2011	Carnarvon	~ 60	Presentation was delivered to the members of the Gascoyne Water Co-Op following their AGM All attendees received the CD of resources and the survey questionnaire.
Friday 2 December 2011	Swan Valley	10	Attendees to this presentation included both surface and ground water irrigators. Main concerns were the abstraction from the Gnangara mound and associated aquifers by W. A. Water Corporation for public supply and various issues affecting agriculture/horticulture/water security as a result of the Swan Valley Planning Act. All attendees completed the survey questionnaire and received a copy of the resource CD.
Friday 9 December 2011	Harvey	11	All attendees were members of the Harvey Water Co-Op many of whom are still using flood irrigation to grow pasture (mainly) for dairy cows. Considerable interest was shown in the Climate Change presentation and one grower brought with him BOM rainfall records he had collected from 1942 that dramatically showed the decline in rainfall since the mid 1970's. All attendees completed the survey questionnaire and were given a copy of the resource CD.
Tuesday 13 December 2011	Albany	6	A mixture of surface and ground water users all self-supply along with a representative from Denmark and Albany Shires. DAFWA was represented by Miriam Lang who is involved in the local water advisory group currently working on the Lower Great Southern Regional Water Plan. A main area of concern with the growers was the management of the unproclaimed water areas impacting on self-supplier's water availability. All attendees completed the survey questionnaire and were given a copy of the resource CD.
Friday 16 December 2011	Scott River	5	As a result of the recent fires in this area some members of the irrigating community were unable to attend due to increased work repairing fences etc. All attendees are self-supply ground water users. Interest shown in the unbundling of water and land rights and the potential flexibility offered to irrigators to a) generate a new income stream and b) to better manage times of reduced water

			availability. All attendees completed the survey questionnaire and were given a copy of the resource CD.
Friday 13 January 2012	Margaret River	11	A mix of surface and ground water users attended this workshop. Much interest was shown in the climate change presentation especially the section to predicted changes in grape quality in this region in a warming and drying climate scenario. All attendees were given a copy of the resource CD.
Friday 10th February 2012	Manjimup	17	A well-attended presentation with representatives from the DoW, DAFWA, Avocado growers, orchardists, local water user group, Warren Catchment council and the Warren Blackwood Strategic Alliance. The significance of the topics presented was highlighted as the Warren/Blackwood region has recently signed off on the final draft of a new Water Management plan with the DoW. Much interest was shown in the proposed changes to W. A.'s water laws by growers in attendance with a surprisingly high level of agreement in water metering as the fairest, most efficient method of water management. The climate change presentation in particular created a lively discussion from the attendees who were keen to ask questions to Nyamdorj especially regarding the data he presented that related directly to the Manjimup region.
Wednesday 15th February 2012	Myalup	5	A disappointing result in terms of attendance from the growers in this region. The initial date for Myalup was changed due to a lack of RSVP's from a mail invite sent to 55 licence holders. The second date was set as a couple of the growers, who did make contact with me, insisted that they believed the content of the presentations was of benefit to growers in the region. 8 respondents to the second round of invites registered to attend however, only 5 attended. Of those who attended all were vegetable growers who source water from superficial aquifers. Interest in the presentation on climate change was keen and attendees asked a range of questions pertinent to the crops they grow in that region and the impact on these of a changing climate. All were concerned about delays in the release of alternative sources of water for crop irrigation.

5. Survey Questionnaire Findings

Introduction

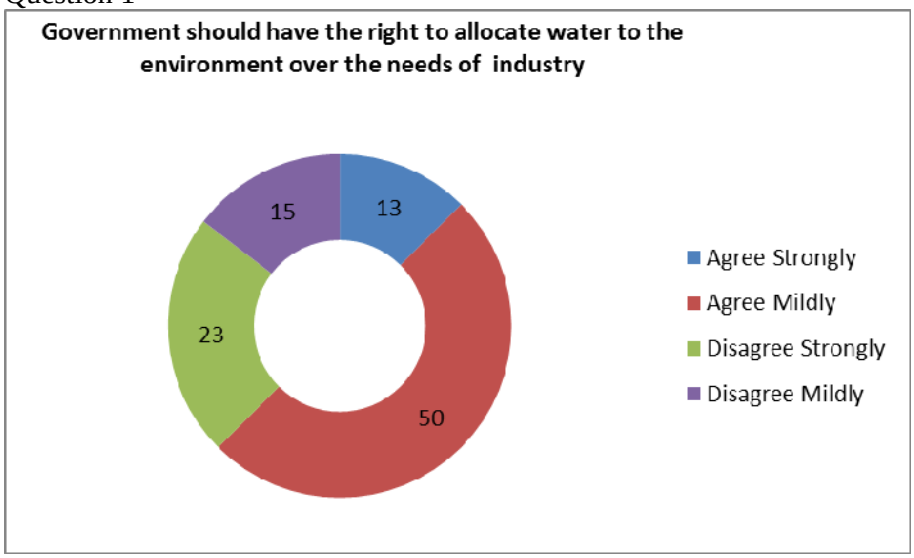
A survey questionnaire comprising a set of 17 questions, derived from input by the project steering committee members, was presented at each of the workshops to attendees to gauge responses to changes in Western Australia's water legislation.

Participants were asked to indicate the source of water used for irrigation as either surface or ground water.

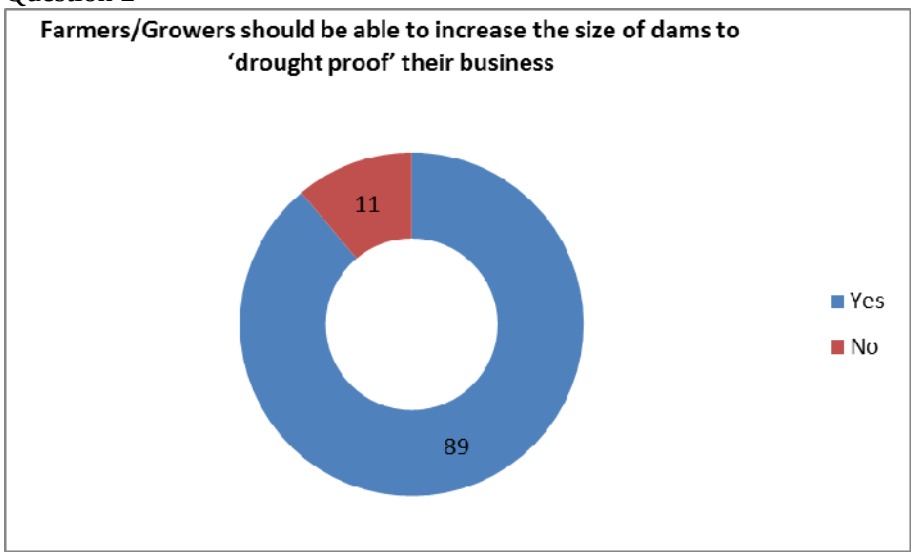
Due to the low sample sizes at each of the workshops the data collected has been analysed as a 'whole of state' rather than by individual regions.

Results

Question 1



Question 2



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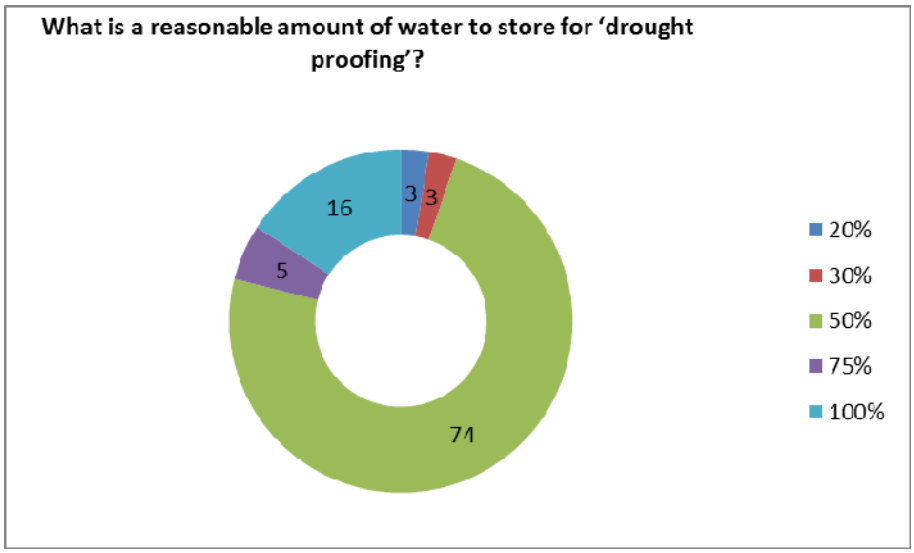
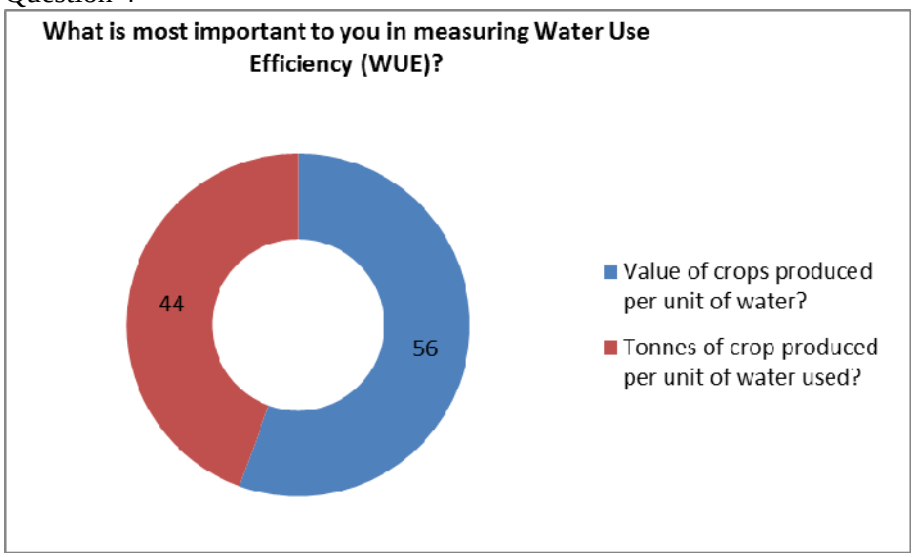
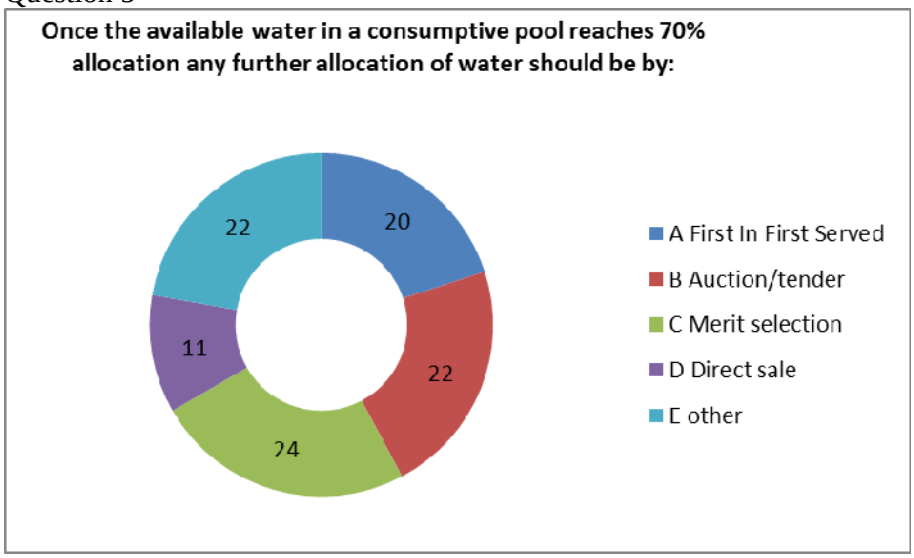


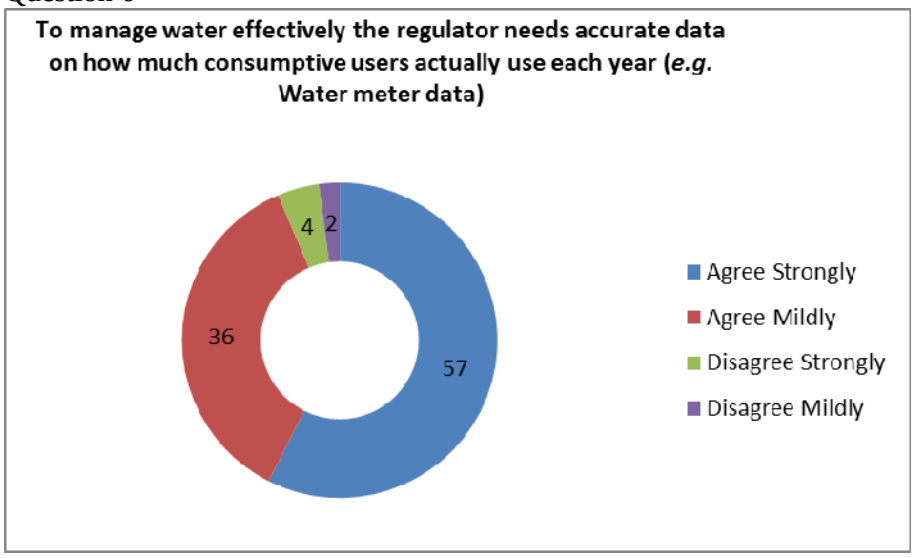
Question 4



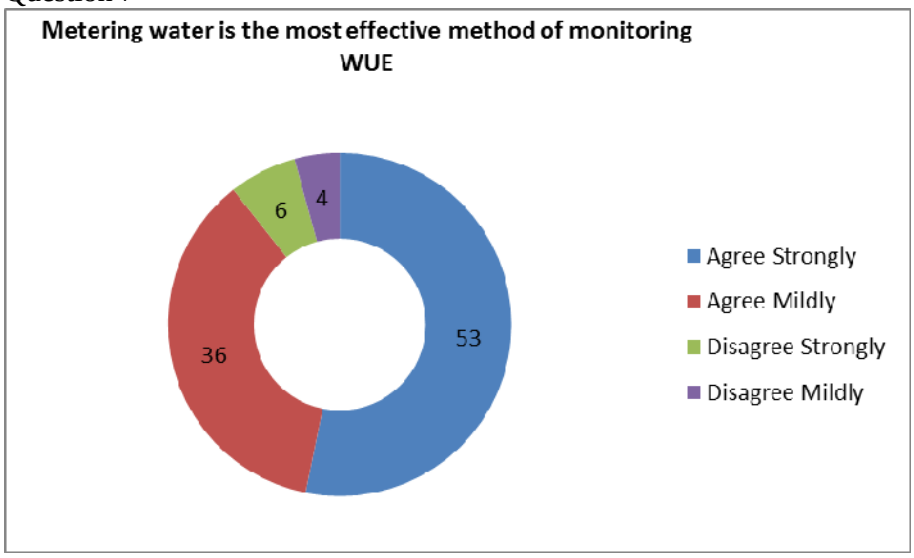
Question 5



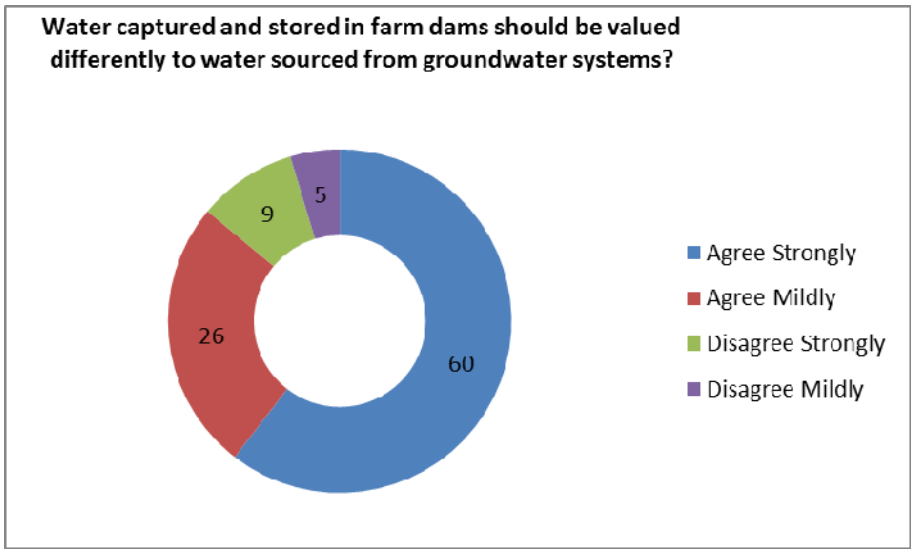
Question 6



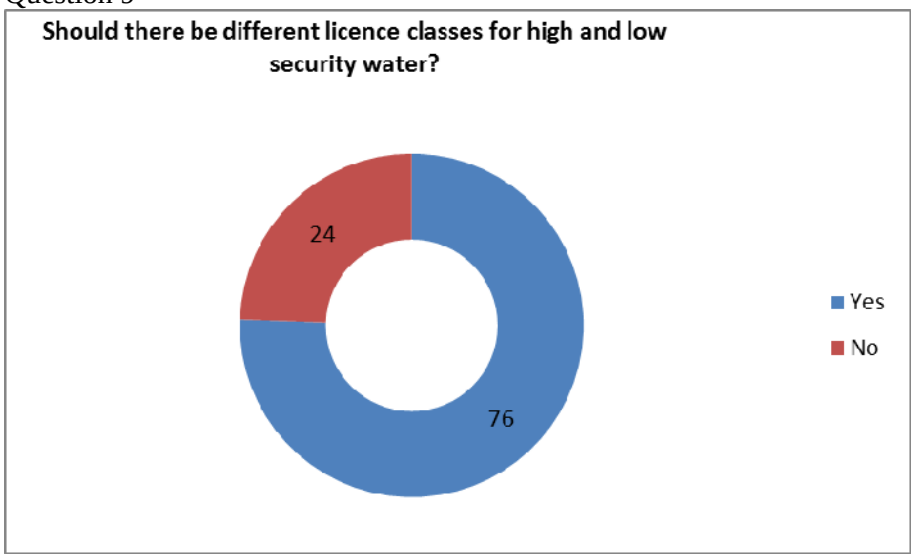
Question 7



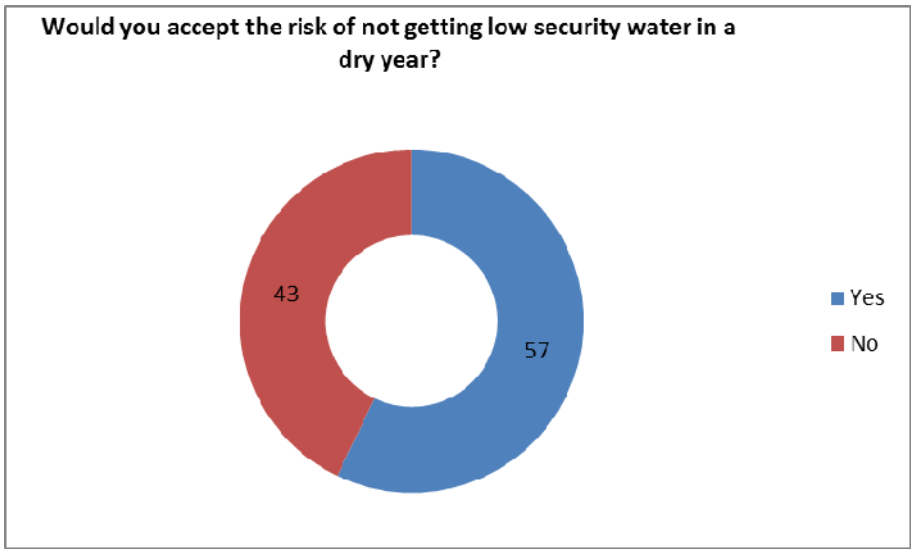
Question 8



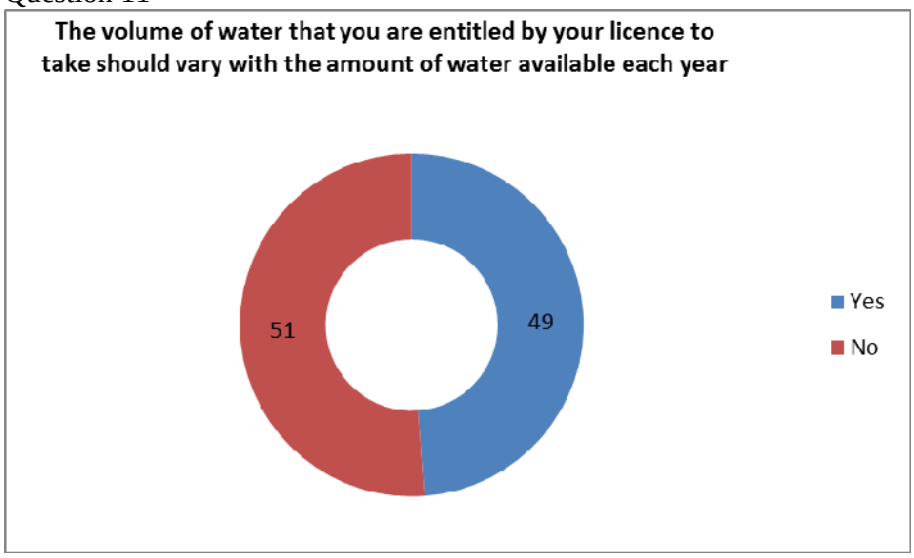
Question 9



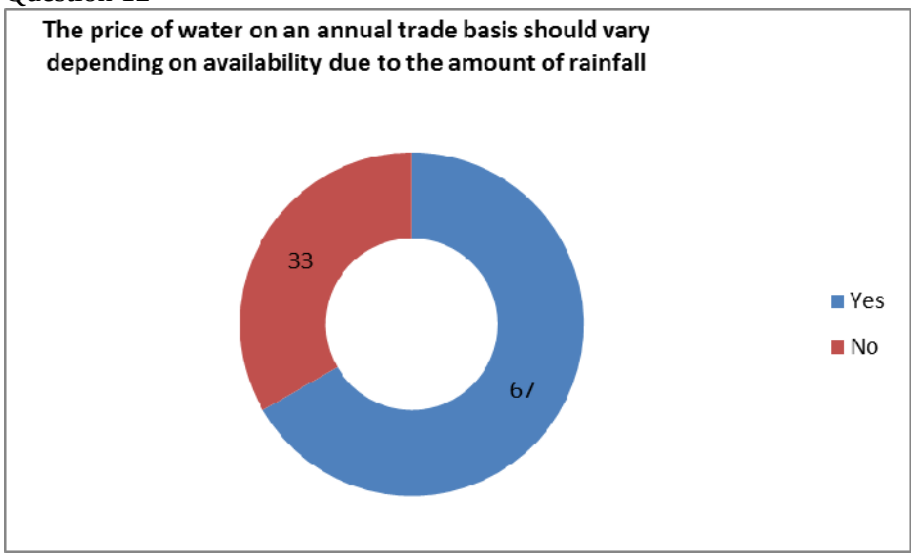
Question 10


Would you accept the risk of not getting low security water in a dry year?
43
57
Yes
No

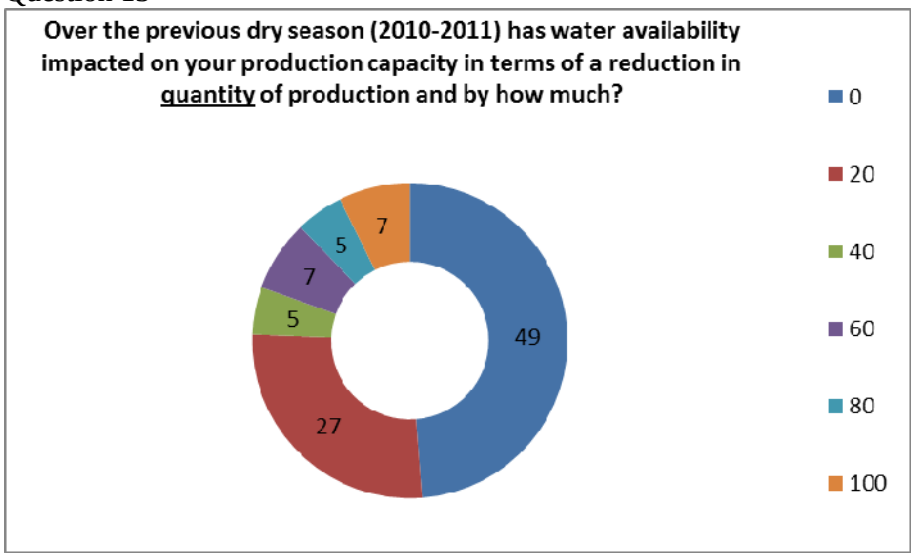
Question 11


The volume of water that you are entitled by your licence to take should vary with the amount of water available each year
51
49
Yes
No

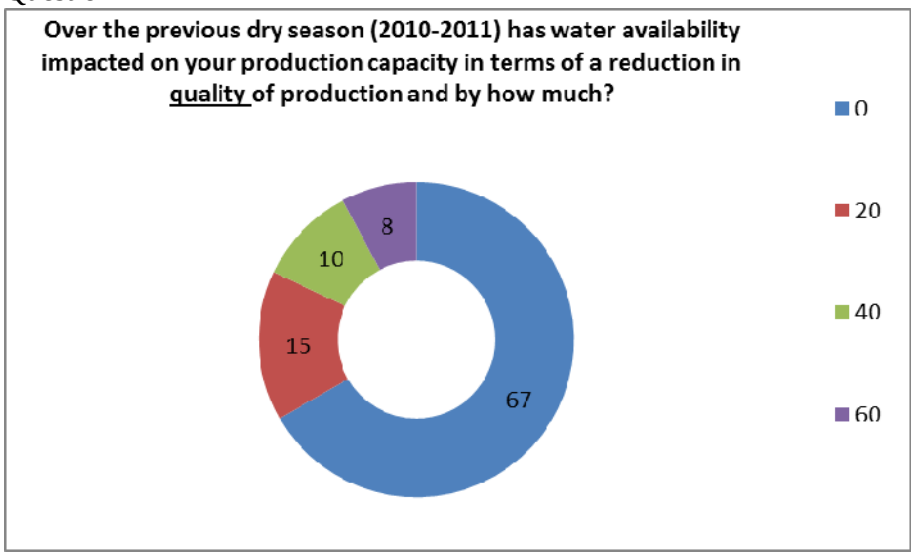
Question 12



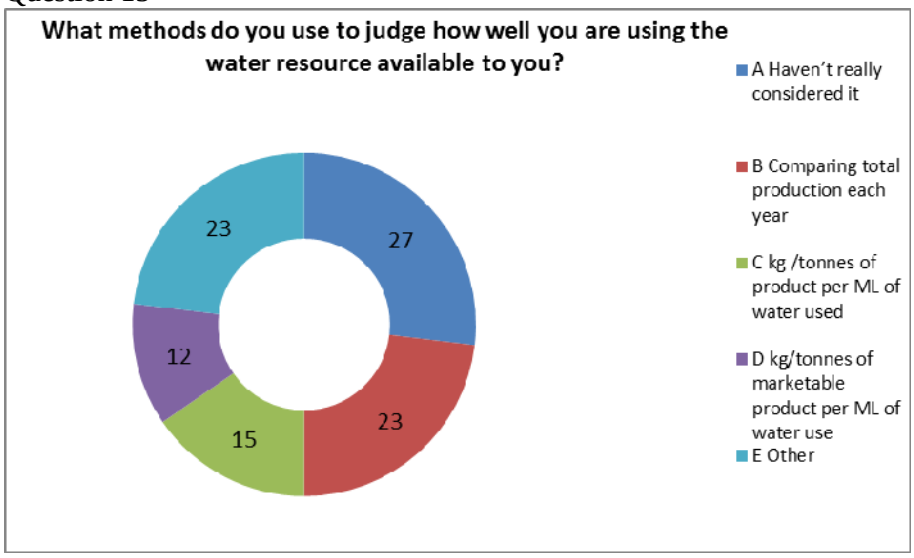
Question 13



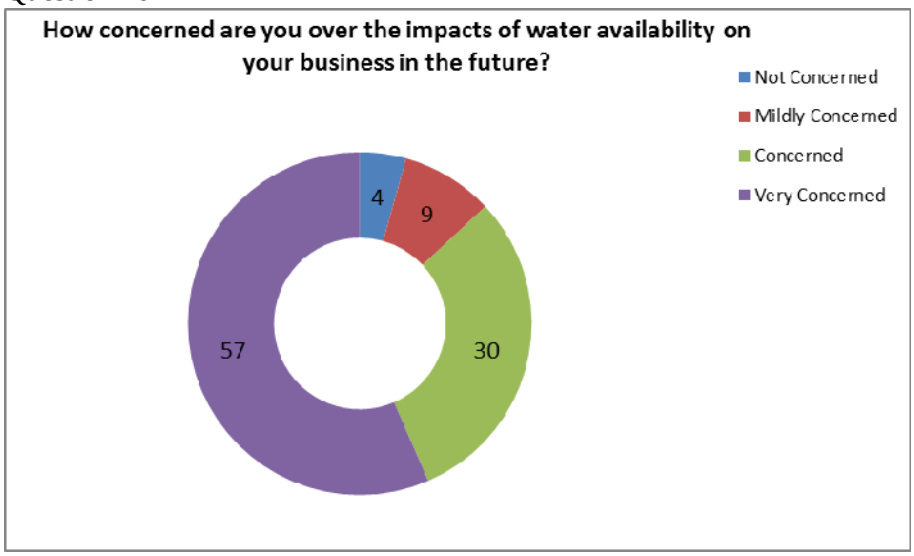
Question 14



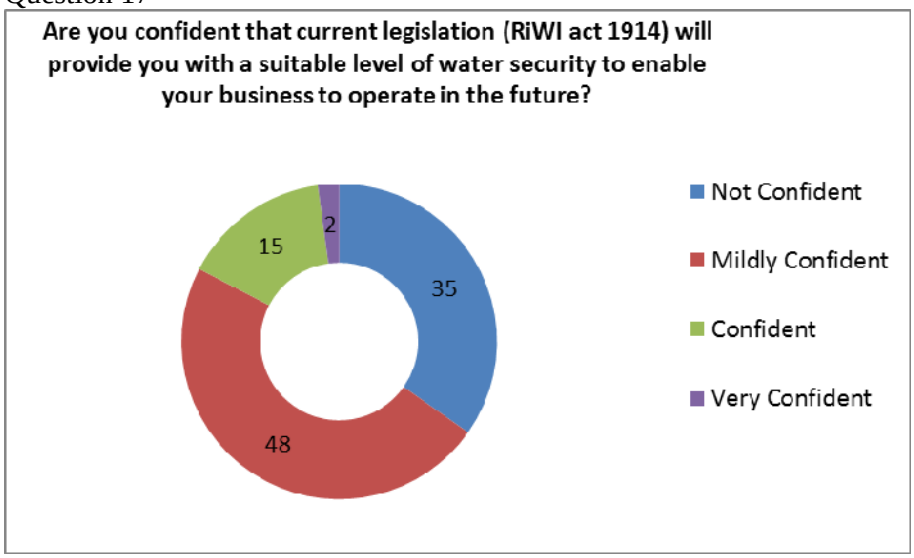
Question 15



Question 16



Question 17



Discussion

A significant percentage of those surveyed believed that the government did have the right to consider the needs of the environment when making water allocation provisions with 83% of respondents in favour. However, at each location, that the question was asked, at least one or two participants disagreed.

The issue of water security was clear cut in terms of the responses given with 89% agreeing that growers should be able to 'drought proof' by increasing the size of their water storage to allow for years of poor rainfall. The amount by which this could be achieved varied with 74% of respondents opting for a 50% increase in storage capacity and surprisingly only 16% for a 100% storage buffer.

The response to the question of measuring water use efficiency was effectively split with 56% believing that value of crop *per* unit of water used is more important; while 44% believed that the tonnes of product per unit of water used is most relevant. In regions where grapes for wine are a major crop certainly the former was the case, while in regions where *e.g.* vegetable crops were grown the amount produced was more relevant.

The results of the question of how best and most fairly to allocate water when 70% of allocation is reached in a given consumptive pool were split across all of the options given. Comments offered included: Grower needs; Provided by government; Real need; Maybe 70% is fully allocated; Allocation by percentage e.g. If 95% available all of 95%; Case by case; Nil, save for a dry year; Pooling - Issue water on basis of size from biggest to smallest; ?? Food security; Need and merit.

Strong support was given to the need to for accurate water usage data by metering for the regulator to effectively manage water resources along with this most respondents believed that metering water is the most effective method of improving water use efficiency.

The question of the value of water captured and stored in farm dams compared to that sourced from groundwater resulted in a significant number of respondents choosing that there should be a difference in the value of these two sources of water.

When respondents considered the question of high and low security water 76% believed that there should be different classes of licence to reflect the securing of the water from high or low security situations.

When faced with the question regarding the risk of securing entitlement to low security water in a dry year responses were split. While 57% answered that they would accept the risk a significant number (43%) did not accept such risk.

Whether licence holders should accept the varying of the amount water taken on an annual basis resulted in an almost even split in the opinion of respondents with those responding in the negative slightly higher than those in the positive (51 to 49% respectively).

When the price of water on an annual trade basis was considered two thirds of responses favoured a regime where the price should be varied depending on the amount of rainfall in a

given year. However, there are obviously still many who do not agree with this as a third of respondents disagreed.

With the previous dry 2010-2011 growing season in Western Australia project collaborative partners DAFWA were interested to gauge if a) growers had seen the quantity and b) the quality of their production had been affected by reduced water availability. While only few respondents reported large production quantity reductions the majority did not believe this had been the case. In terms of the quality of crops produced two thirds of those surveyed reported no reduction in crop quality.

When asked how and by what method(s), users judged the effective use of the water resource available to them, a surprising 27% were unaware as they had not considered this. Using an annual comparison of total crop production was selected by 23% questioned; the amount of crop produced *per* ML of water and the tonnes of marketable crop/product per ML of water applied was used as a gauge by a combined total of 27%. The balance responded with the following comments: Soil moisture; Crop uniformity; Balance/remaining water plus plant vigour at end growing season; Less water = increased quality, decreased tonnage; Value of marketable product/ML; BOM/Weather zone/tensiometers; Dollars/ML; Observation and daily monitoring.

It would seem from the responses, of those involved in the survey, that the great majority of water users are extremely concerned about water availability for their business in the future. With 87% of the respondents being either very concerned or concerned and in discussions with attendees this was a common topic at all of the presentations.

When attendees were asked if the Act that regulates the use and taking of water in Western Australia, Rights in Water Irrigation Act of 1914 would provide water security to enable their business to operate in the future most respondents replied that it could (65%) while a significant 35% expressed a lack of confidence.

6. Please describe any:-

a) technical advances achieved (eg commercially significant developments, patents applied for or granted licenses, etc.) N/A;
b) other information developed from research (eg discoveries in methodology, equipment design, etc.) None to report; and
c) required changes to the Intellectual Property register. None required.

7. Conclusion

This project has developed delivered a range of presentation materials relating to:

- Climate change and impacts of climate change on water availability
- Legislative change and the potential impacts of water reform in WA on water rights and access to water resources
- Consideration of environmental needs and the role of environmental flows in determining water allocation for industry and the community
- Irrigation for water use efficiency.

The presentations are available for viewing online as i-lectures at the following web address:
http://dbs.ilectures.curtin.edu.au/ilectures/ilectures.lasso?ut=3129&id=112196

Eight workshops were conducted throughout the South West of Western Australia and Carnarvon. Strong interest was shown in climate change projects and water law reform will occur in W.A. Both process are inter-related will affect those who depend on water for irrigation.

The consideration of the importance of allocating water to the environment created strong discussion during the workshops and this was a useful point to highlight the importance of statutory regulation around water allocation and access.

Climate change has already (arguably) had a demonstrable impact on water resources in the South West Of Western Australia and is likely to be a driver in future government decisions around water supply. An improved understanding of climate change gives industry and the community the capacity to plan and prepare to future proof their businesses in the face of change.

In conclusion, the project successfully achieved its aims of providing growers *etc.*, in Western Australia, information detailing the proposed statutory changes to water law in and the background to the reasons why this is necessary. While, also, giving relevant background information and tools to assist industry and state/local government bodies in preparing for the changes.

8. Extension Opportunities

Detail a plan for the activities or other steps that may be taken:
(a) to further develop or to exploit the project technology. N/A
(b) for the future presentation and dissemination of the project outcomes. N/A
(c) for future research. N/A

A. List the publications arising from the research project and/or a publication plan.
(NB: Where possible, please provide a copy of any publication/s). None.

B. Have you developed any online resources and what is the website address?

Online audio/visual of the complete set of presentations here:
http://dbs.ilectures.curtin.edu.au/ilectures/ilectures.lasso?ut=3129&id=112196

Part 4 – Final Report Executive Summary

The aim of the this collaborative project is to improve the long term viability of irrigated enterprises in Western Australia by increasing their capacity to effectively assess requirements, manage and secure water resources under the pressure of proposed statutory and predicted climate change.

This project funded by the NPSI and delivered by Curtin University with its collaborative partner the Department of Agriculture and Food Western Australia (DAFWA) aimed to assist growers, irrigators and state/local government bodies in understanding proposed changes to water law in W. A.

Along with this the project also provided the targeted audience with background information of the drivers behind the proposed statutory reforms required by the National Water Initiative, with particular focus on climate change and the importance of sustainability of ecological systems reliant on water, *i.e.* environmental flows and groundwater dependant ecosystems.

To achieve these aims a series of eight presentations were taken to the target audience across key agricultural regions of Western Australia being: Carnarvon, Swan Valley, Harvey, Albany, Scott River, Margaret River, Manjimup and Myalup. Using the database of contacts held by DAFWA invites were sent to growers *etc*. to participate by attending the presentation in their region.

The presentations each consisted of four separate topics being: “Preparing Irrigated Agriculture for Statutory and Climate Change”; “Climate Change: Observed and Projected Changes in Western Australia”; “Environmental Flows and Groundwater Dependant Ecosystems” and “Using Water Wisely”.

Each of these presentations was followed by a survey completed by the attendees designed to provide a greater understanding of grower’s and irrigator’s opinions on a range of issues surrounding water use and governance.

A range of resource materials were developed for attendees and in some cases were sent to those unable to attend, these included: a CD Rom of the presentations; background documents produced by both state and federal government agencies and useful factsheets, produced by DAFWA, to aid growers *etc*. in better managing sustainable water use.

In summary, the project, which began in August 2011 and completed at the beginning of March 2012, achieved all of the aims outlined in the project application.