North Central RCS – Climate Change Discussion Paper

Preamble – The North Central Regional Catchment Strategy (RCS) is the principle framework for land, water and biodiversity management in North Central Victoria. This discussion paper has been written to assist in the development of the North Central RCS. The discussion paper attempts to articulate our current understanding of climate change and the links to the RCS.

Climate change

Climate Change has the potential to impact on all environmental assets within the North Central Region. This discussion paper provides some background around the current understanding of climate change within the North Central region. Discussion papers for Biodiversity, waterways, wetlands and land/soils have identified priority environmental assets across the region. While future climate change is likely to affect environmental assets in a myriad of unanticipated and synergistic ways the identification of asset specific threats and subsequent actions would seem to be a strategically responsible approach to a complex problem.

Vision/Objective :

To understand the potential impacts of climate change on the region and to develop and implement adaption strategies that protect significant environmental assets and build the capability of the community to respond.

Description

The following description has been taken from the Victorian Government Web site http://www.climatechange.vic.gov.au .

The scientific consensus

A majority of the world's scientists agree that human activities have resulted in observed increase in global average temperatures, particularly since the middle of the 20th century.

Recent data indicates that the global mean temperature has increased by between 0.2 and 0.6°C since the late 19th century, while Australian average temperatures have increased by 0.8°C. The World Meteorological Organisation (WMO) releases a statement each year on the status of the global climate. For 2008, the global mean temperature was 14.3°C, making it the tenth warmest year on record that dates back to 1850.

The Intergovernmental Panel on Climate Change (IPCC) was established by the WMO and the United Nations Environment Programme (UNEP) to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation.

The IPCC's Fourth Assessment Report (2007) concludes that global warming has accelerated in recent decades, and there is new and stronger evidence that warming over the past 50 years is attributable to the increase in greenhouse gas emissions associated with human activities.

The latest science

The Victorian Government regularly monitors updates in climate change science through the Victorian Climate Change Adaptation Program.

The most recent synthesis for Australia is '*Climate Change 2009: Faster Change and More Serious Risks*', often referred to as the Steffen Report, produced by the Australian National University on behalf of the Commonwealth Department of Climate Change.

Key findings from the report show that:

- the earth's climate is changing faster than expected and while climate change science is still evolving and some areas remain uncertain, it appears that climate change impacts will be more rapid and severe.
- it is clear that greenhouse gas emissions need to be reduced urgently because long term impacts are starting to develop now such as melting of snow and ice in the Antarctic.
- large scale changes, such as melting of glaciers and ice sheets or significant changes to the global carbon cycle, once started cannot be stopped or reversed by human interventions in the short term and may take thousands of years to recover.

Critical risks for Australia include:

- sea level rise

- ocean acidification (when carbon dioxide reacts with water to create carbonic acid)
- severe recurring droughts and drying trends
- increase in extreme weather events such as heatwaves, bushfires and floods.

The Copenhagen Synthesis Report was released earlier in 2009 and updates the findings of the 2007 Fourth Assessment by the IPCC and was published in preparation for the UN Climate Change Conference scheduled to take place in December 2009 in Copenhagen. It takes a more global perspective of the implications of new developments in climate change science. Highlights of global risks identified include:

- current estimates show that global warming is around 50 per cent greater than was reported in 2007
- small increases in average temperature could lead to impacts on human well-being in the future
- heat extremes will increasingly have serious implications for food production and security
- if carbon dioxide levels continue to rise, climate change will become irreversible (for example, reduced rainfall in some regions and global sea level rise).

Climate Change in the North Central Region (ref DSE 2004 and incorporating CSIRO projections)

Summers in the North Central region range from warm in elevated southern regions (average maximum temperatures less than 25ºC) to hot in the north (more than 30ºC). In winter, average maximum temperatures are mostly around 12 to 15ºC, also increasing from south to north. Frosts are common throughout the region. Annual rainfall averaged across the region is 500mm, peaking in winter. Since 1950 the region has experienced a warming trend of around 0.1ºC per decade in mean temperatures, with a slight tendency for maximum temperatures to have increased faster than minimum temperatures, particularly in autumn and winter. These trends are likely to be at least partly related to the effect of climate change. Regional rainfall is subject to significant natural variability, independent of the effects of climate change due to the enhanced greenhouse effect. However, the dry conditions of the period from 2003-2010 which have mainly affected southern areas of the region, are unusual.

Future climate in the North Central region is going to be warmer and drier than it is presently. Further details of this future climate are described below.

Summary of projected climate changes for the North Central region

Temperature

- annual warming of 0.3 to 1.6ºC by 2030 and 0.8 to 5.0ºC by 2070
- day time maximum temperatures and night time minimum temperatures will warm at a
- similar rate
- warming will be similar throughout the seasons
- a 10 to 50% increase in the number of hot summer days (over 35ºC) by 2030 and a 30 to
- 300% increase by 2070
- a 0 to 70% reduction in the number of frost days by 2030 and a 50 to 100% decrease in frost
- days by 2070

Precipitation

- annual precipitation decreases likely (changes of +3 to -15% by 2030 and +10 to -40% by
- 2070). Decreases likely in all seasons, but less so in summer
- extreme heavy rainfall events may become more intense

Drought

- droughts are likely to become more frequent and longer
- dry conditions that currently occur on average one in every four years may increase to up to
- one in three years by 2030
- due to hotter conditions, droughts are also likely to be become more intense

Water resources and fire

- increased evaporation rates
- drier soil likely, even if precipitation increases
- decreased average run-off in streams
- hotter, drier conditions likely to increase bushfire risk

Policy Context

The Australian Government have released the Plan "Securing a Clean Energy Future". This Plan has a number of initiatives that may have a significant effect on the North Central Region. Theses include:

- Price on Carbon
- Carbon Farming Initiative
- Biodiversity Fund

These initiatives are still being developed and it is unclear at this stage how the will effect the North Central Region. Although it is clear that further planning is required on how the North Central Region can ensure positive environmental outcomes from this initiative.

The Western Region Sustainable Water Strategy States "The global climate system is warming, as is now evident from observations of increases in global average air and ocean temperatures, and rising global average sea level. A range of recent reports taking into account published research since 2007 highlight that the observed changes appear to be at the more severe end of the predictions made by the IPCC in 2007". (WRSWS, DSE 2011)

The North Central CMA commissioned Arthur Rylah Institute (ARI) to undertake a study to better understand the potential impacts on vegetation from long term impacts of climate change. This project had an ambitious aim, to develop models to help understand the possible impacts and risks to natural ecosystems from a changing climate, and how these changes may manifest across Victoria, and particularly for regional and local landscapes in central Victoria. It integrated data on plant species' distributions, and environmental data that are important drivers of plant species distributions, to construct probabilistic models of current and future distributions under a series of climate change scenarios.

This project highlighted the complexity and uncertainties in using climate change information to understand the impacts on ecosystems and at an appropriate scale. It was agreed that many of the current threats are still likely to be a more immediate threat to these ecosystems than climate change.

Risks

The ability to accurately predict the absolute affects of climate change on the North Central region is beyond the parameters of documents such as *Climate Change in the North Central Region*, and the *North Central Regional Catchment Strategy*, and indeed this discussion paper. However, by linking regional climate change projections with specific threats to natural resource management priorities, it is possible to determine areas of the region that will require attention from resource managers in the future.

Waterways and wetlands

Climate projections suggest that waterways and wetlands could experience significant ecological decline as a result of the affects of climate change. Altered flow regimes resulting from decreased rainfall and higher evaporative rates could potentially have severe impacts on the regions waterways and wetland ecosystems, possibly changing some ecosystems altogether (NCCMA 2003).

The Northern Region Sustainable Water Strategy indicates forecast reduction for the Loddon and Campaspe catchments from climate change of 9% and 10% assuming low level of climate change up to 54% to 58% reduction assuming high level of climate change. These estimates articulate the potential for significant changes and impacts to our highly significant river and wetland systems.

Water resources

Likely future reductions in rainfall and increased rates of evaporation will mean less water for dams and storages in the North Central region (DSE 2004).

The NRSWS articulates the potential impacts form climate change on water resources. Table 2.1 from Chapter 2 of the NRSWS outlines the potential impact.

Table 2.1 Forecast change in total inflows in the major river systems in the Northern Region (compared with the long-term average)[16]

River system	Water availability scenarios at 2055			
	A – Low climate change	B – Medium climate change	C – High climate change	D – Continuation of low inflows (July 1997 - June 2007)
Murray*	+ 8%	-21%	-40%	-43%
Kiewa	-5%	-19%	-32%	-23%
Ovens	-6%	-24%	-41%	-33%
Broken	-7%	-31%	-51%	-53%
Goulburn	-7%	-25%	-43%	-49%
Campaspe	-9%	-31%	-54%	-72%
Loddon	-10%	-34%	-58%	-74%

Note: * Refers to total Murray system, not just Victoria's share.

Observations and learning from recent drought (Based on North Region Sustainable Water Strategy)

- Reduced water availability will result in; increased risk of zero allocations years for irrigators: greater frequency, severity and duration of urban water restrictions: and reduced environmental flows.
- Over the past 12 years there has been a disproportionate reduction in water availability for the environment compared with consumptive users. This is because most of the environmental flow is provided by unregulated flows and spills from storages, rather than secure entitlements.

Land

Dryland

Projected warming and rainfall decreases could have profound impacts on dryland agriculture if climate change proceeds as expected (NCCMA 2003). Dryland grazing and broadacre cropping may derive some benefit from higher CO2 concentrations, which will increase crop water use efficiency but reduce grain quality (AGO 2003). However, warmer temperatures and reduced rainfall in most areas would offset this, reducing pasture production and variety, and growth of most grain and horticultural crops (Ash, 2001). Broadacre and horticultural cropping may experience an increased reliance on nitrogen based fertilisers as a result of reduced growth rates, in order to maintain current productivity (DEH 2005).

Future animal production may also be significantly restrained by reduced feed and availability of suitable grazing pastures, heat stress, availability of suitable water, and susceptibility to pest species (DEH 2005).

Studies by Davison *et al* (1996), McKeon *et al* (1998), and Jones and Hennessy (2000), have investigated the negative impacts of heat stress on dairy and beef cattle. Effects include weight loss, reduced birth weights in calves, decreased reproduction rates, reduction in milk yield, susceptibility to parasites, and in extreme cases death. The incidence of heat stress will increase further with warming associated with climate change, making heat stress adaptation a future agricultural management priority (AGO 2003).

Observations and learning from recent drought

- Severe stress on cropping and grazing activities
- Increased risk of soil erosion
- Alternative more drought resistant species used (i.e Lucerne, native grasses)
- Change in management approaches (less input intensive approaches to manage risk)

Irrigated Land

Irrigated agriculture in the North Central region will experience significant impacts as a result of climate change. Along with impacts common to both dryland and irrigated land, water allocation is a main regional issue that is expected to be affected by climate change.

The biggest challenge facing sustainable land and water management, as well as the viability of the region's agricultural industries and resilience of regional communities, are the threats posed by climate change. The threats include reductions in water availability and allocation, changes to historic land-use, and a rate of change that current markets can not respond to positively (NCCMA 2011).

The key message coming from government is 'that our water management needs to incorporate long-term planning for a future with less water.'[1] Even if the region returns to "average" patterns of rainfall, with reservoirs filling and spilling, it is highly unlikely to see any additional water allocated for the development of irrigated agriculture. In essence, it is reasonable to assume the future of irrigated farming will be one of irrigation footprint retraction and "producing more using less water" as governments readjust the balance between agricultural, human and environmental use of our finite water resources. Targetting the most sustainable use of land and water resources will be a key challenge for landholders and government in the region (NCCMA 2011).

Horticulture operations will also be affected particularly those dealing with flower and fruit cultivation. Again predicted lower water allocations, increased summer rainfall intensity and warmer winters will impact on the growth and development of many flower and fruit species grown in the region (NCCMA, 2003). Basher *et al* (1998) found that many species of fruits cultivated in temperate regions require winter chill for normal bud burst and fruit set. The onset of warmer winters may disrupt these stages of development and reduce fruit yield. A projected decrease in winter temperatures would also indicate a decline in frost frequency, reducing the likelihood of frost damage to fruit crops late in the growing seasons (Ash 2001).

Ecosystems and biodiversity

Biodiversity and ecosystems were identified by the IPCC's Third Assessment Report as a key sector likely to be strongly influenced by climate change (IPCC 2001a). Many Australian species of plants and animals have large annual climactic variability, but limited long-term climactic variability, meaning they can cope with change year to year, but not with long-term change to the average climate (Pouliquen-Young and Newman 1999). Therefore many Australian ecosystems are particularly threatened by climate change. Important systems in the North Central region including freshwater wetlands and riparian ecosystems are amongst the most vulnerable to the predicted changes (NCCMA 2003).

Areas of greatest concern in relation to biodiversity in the North Central region highlighted in *Climate Change in the North Central Region (2004)* include:

- Risks to already fragmented remnant patches – effect of climate change on distribution and resilience of these remnants may be accelerated due to distance between patches.
- Risks to flora and fauna that inhabit narrow climactic ranges
- Risks to significant wetland ecosystems (Kerang and Gunbower Ramsar)
- Alterations to fire regimes and regional hydrology, placing pressure on native flora and fauna communities
- Impacts on salinity including short-term in-stream salinity increases, and long-term groundwater discharge decreases

Flora and fauna species unable to adapt to climate change or unable to migrate to more suitable habitat due to habitat fragmentation, topography, or soil differences may risk extinction (NCCMA 2003). Species in lower catchment areas already exposed to the impacts of land clearing, salinity, altered hydrology and habitat fragmentation, will be of greatest risk (NCCMA 2003).

Encroachment of pest animals and plants also poses a serious problem. Invasion of pest species is usually greatest after intense weather events or land disturbance (Ash 2001). Increased intense rain events predicted with climate change would prove destructive to native ecosystems, providing opportunities for pest species to invade and become established, particularly in remnant vegetation patches already separated from larger stands of native habitat. Species such as foxes, rabbits, and European carp are generalist pest species whose populations could become problematic after such events, while species such as the Fruit fly that have previously been controlled by climactic boundaries could have disastrous impacts on the horticultural industry of the region (Ash 2001).

Adaptation options

Adaptation is an essential aspect of addressing the issue of climate change. Adaptation is important as a means of maximising gains and minimising losses that will result from inevitable climate changes we will continue to experience (AGO 2003). Strategies that include complimentary mitigation and adaptation actions are most suitable for addressing the long-term impacts of climate change on natural resources, infrastructure, and the sustainability of industries at a regional level (AGO 2003).

[1] Department of Sustainability and Environment, *Sustainable Water Strategy. Northern Region Discussion Paper. Managing Water Scarcity. The Next 50 Years*, January 2008, p2.

The *Regional Response to Climate Change – Native Revegetation Action Plan (2003)* (NRAP) is the initial response to climate change in the North Central region. The strategy aims to develop and promote the commercial benefits of carbon sequestration through native revegetation and the implementation of land use change. The response adopted by NRAP, while focussed on climate change, is integrated to achieve multiple outcomes across a number of priority areas in the region (NCCMA 2003).

By embracing native revegetation and the development of carbon sink forests, NRAP is responding to the strong consideration given to carbon sink development by the Kyoto Protocol (1997) (NCCMA 2003). The protocol states that the reduction of net emissions of greenhouse gases through reduced fossil fuel burning, land clearing and methane production are important to combat the onset of climate change (NCCMA 2003). Trees act as carbon sinks, keeping carbon dioxide out of the atmosphere unless they are cleared or cut down (AGO 2001). Carbon sinks can play pivotal roles in conservation and adaptation in a number of management areas including waterways and wetlands, land management, biodiversity, and provide economic opportunities for rural and regional communities.

Some benefits of carbon sinks and commercial forestry that can be experienced by regions in mid to low rainfall zones have been highlighted by the Australian Greenhouse Office (2001). As the North Central region lies in a mid to low rainfall zone, it is expected that these benefits will be attainable. They include:

- Generation of farm income through sale of products and outside investment
- Diversification of farm income
- Amelioration of environmental issues such as dryland salinity both on private and public property
- Provision of natural resource management benefits such as biodiversity and increased native habitat
- Sequestration of carbon to help meet greenhouse targets
- Securing raw materials for processing industries
- Generation of employment and other social benefits
- Reduced demand on public expenditure for environmental repair

Waterways and Wetlands

The recent extreme drought can be used to potentially understand the risks of future climate change and can be used to understand how we may adapt to dryer long term outlook. Listed below is some observations and learning from the recent drought that may be useful in understanding future adaption and mitigation strategies.

Observations and learning from recent drought

- highly stressed waterways and wetlands
- very little water to meet ecological needs
- adaptive management critical
- additional environmental reserve important to buffer against dry periods
- Protecting drought refuge important

The Northern Region Sustainable Water Strategy 2009 provides clear direction regarding adaption strategies for rivers and wetlands in the context of climate change. Drought and climate change mean that a stronger approach is required for managing rivers, wetlands and floodplains. This will focus on three ways to improve environmental management:

1. Targeted recovery and efficient use of environmental water.
2. Complementary river restoration works and measures.
3. Integrated and adaptive management of environmental water and works.

It is still unclear how the Draft Murray Darling Basin Plan will influence the river and wetlands within the North Central CMA.

Water resources

The Northern Region Sustainable Water Strategy also provides clear direction about the future management of water within the North Central Region. The NRSWS provides policy that will assist in adapting to a dryer climate. The policy directions include:

- Sharing water resources in the Murray Darling Basin
- Secure rights to water – taking into account the risk to environment due to climate change
- Certainty and flexibility for entitlement holders – providing irrigators with greater certainty
- Efficient and Sustainable Irrigation – Irrigation Modernisation both through delivery system and on farm
- High value river, wetlands and floodplains – see above
- Safe and secure drinking supplies – Providing potable water
- Prosperous dynamic and resilient communities. Supporting communities in dealing with these challenges

Land

Agricultural adaptations are wide and varied, and are dependent on how particular practices are affected by climate change. Over the recent drought land holders have used many techniques to deal with and adapt to dry conditions. The following are examples of adaptive actions that have been used or are relevant to North Central agricultural practices.

CROPPING

- Develop further risk amelioration approaches (e.g., zero tillage and other minimum disturbance techniques, retaining residue, extending fallows, row spacing, planting density, staggering planting times, erosion control infrastructure) and controlled traffic approaches, even all-weather traffic
- Research and revise soil fertility management (fertiliser application, type and timing, increase
- legume phase in rotations) on an ongoing basis
- Alter planting rules to be more opportunistic depending on environmental condition (e.g., soil
- moisture), climate (e.g., frost risk) and markets
- Develop warnings prior to planting of likelihood of very hot days and high erosion potential
- Select varieties with appropriate thermal time and vernalisation requirements, heat shock resistance, drought tolerance, high protein levels, resistance to new pest and diseases and perhaps varieties that set flowers in hot/windy conditions.

LIVESTOCK / GRAZING

- Research and promote greater use of strategic spelling of paddocks
- Develop regionally safe carrying capacities i.e., constant conservative stocking rate
- Modify timing of mating based on seasonal conditions
- Develop water use efficiency strategies to manage potentially lower irrigation water availabilities
- Research intensive livestock management in tropical environments particularly dealing with heat stress management
- Further selection for cattle lines with greater thermoregulatory control.

HORTICULTURE

- Change varieties so they are suited for future conditions and re-assess industry location Research on altering management to change bud burst, canopy density, etc., in fruit trees
- Undertake risk assessment to assess sustainability in more marginal areas (e.g., chilling requirements). (Source – AGO 2003, Howden *et al* 2003)

Ecosystems and biodiversity

The priority issue of biodiversity enhancement is closely linked to NRAP, as biodiversity and carbon sinks are strongly aligned. The revegetation of native flora will attract and provide habitat for native fauna, particularly if commercial forests are linked to existing remnant vegetation and habitat corridors (NCCMA 2003). Changes to land use on private property will also increase the amount of native vegetation patches across the landscape, further increasing habitat and reversing the impacts of dryland salinity and erosion (AGO 2003). Therefore, large-scale revegetation has considerable conservation potential, not only as habitat links, but also as buffer systems for remnant habitats (NRMMC 2004).

However, commercial forests do not provide the exact type of vegetation that is ideal for enhancing biodiversity. Ecosystems function best when there are vegetation classes, including grasses and understory shrubs as well as larger trees (NCCMA 2003). While commercial forests may not provide perfect habitat for native systems, they serve as a basis for the revitalisation of important ecosystems in the region. Like some species of flora, there will be native fauna that is forced to relocate to more suitable climate zones as a result of increased regional temperatures (AGO 2003). The species that will be most threatened will be those that survive only in a small geographic or climactic range. Small changes to temperature or rainfall may threaten their survival (NRMMC 2004). It is important that further research is done to investigate possible adaptive measures that could be undertaken to ensure that the biodiversity of the North Central region is protected and continually enhanced throughout future climate changes.

Do you feel that climate change risks and adaptation options have been described appropriately in the context of RCS development?

Community Context

A range of direct and indirect climate change impacts may affect Victorian communities. Flooding and sea-level rise, heatwaves, water shortages, increased frequency and intensity of storms, greater air pollution and higher urban temperatures pose the greatest threats.

Community Perspectives on Climate Change
The North Central CMA commissioned Charles Sturt University to undertake social research in understanding landholders response to climates change (CSU 2009). This study interviewed various landholder from Kamarooka (largely primary production focused) and Muckleford (more lifestyle focused landholders). Summary of the study is provided below:

Overall, there were few differences in the challenges identified by believers and non-believers in climate change or informants in the Kamarooka and Muckleford areas. At some point in the interview process, every informant touched on the influence of climate variability on their land management. Both climate and economic issues were frequently mentioned, though, only a minority of interviewees identified climate variability or climate change as the most significant issue they faced in their decision making.

Non-believers were typically more confident in their ability to adapt to drier climate. Believers and those who were unsure about climate change were typically less confident of their ability to adapt successfully. In the Muckleford area this lack of confidence in adaptive capacity was associated with high levels of personal stress. There were some important differences in the responses of landholders interviewed in Kamarooka and Muckleford to drought and climate change. Adoption of lucerne by many Kamarooka landholders is a good example of the contrast between the two areas. Kamarooka interviewees explained that lucerne, in combination with the efficiency gains from adopting minimum tillage technologies and larger equipment had helped them cope with the current drought better than previous droughts. This trend represents a powerful example of the capacity of landholders to adapt to drought and climate change, highlighting the important role that the physical environment and access to natural resources may play in adaptive capacity.

Gaps in knowledge - What are the key gaps in knowledge in context of RCS (broad region wide gaps in knowledge ?)

There are many gaps in relation to climate change, these include:

- Improving the Climate Change Science (more confident predictions on changes into future)
- Potential implication on our environment
- Changes to Landuse
- Adaption Strategies for landholders and environment
- Implications of current Government Policy

There is much work to do and the North Central CMA will work to better understand how these information gaps can bee better understood and how this relates to the North Central Region.

Have the knowledge gaps been identified? If not what additional gaps in knowledge should be described?

Any overall actions, planning required

The implications of climate change on environmental, economic and social values is difficult to predict given the uncertainty in climate model outcomes, variability in climate and the ability to adapt to these changes. Given the global need to take action, the North Central RCS will focus on how the region can adapt to changes in climate and how best to achieve good environmental outcomes for the region under current and future climate policy and scenarios. Further support and research should be undertaken to provide more certainty regarding these gaps in knowledge.

Carbon sequestration activities driven by climate policy have the potential to significantly enhance or adversely impact on values and services provided by the natural assets of the region. It is recommended that a North Central Carbon Action Plan be developed to help guide future carbon sequestration activities within the North Central CMA region and ensure alignment with the RCS.

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Have regional issues/actions been identified appropriately? If not what additional regional scale issues/actions should be identified?

RCS direction and recommendations

It is recommended that a North Central Carbon Action Plan be developed to help guide future carbon sequestration activities within the North Central CMA region.

Do you agree with the overall RCS directions and recommendations? If not what additional directions and recommendations should be included?

What part could your organisation play in meeting the directions and recommendations set out in this discussion paper and subsequently in the RCS?

Overall, do you have any additional comments or issues you would like to raise in regards to this discussion Paper?

Implementation Reference to regional sub-strategies and action plans which specify the actions and who is responsible

References

Understanding rural landholder responses to climate change Rik Thwaites, Allan Curtis, Nicki Mazur and Digby Race November 2008 Institute for Land, Water & Society Charles Sturt University Report No. 48 Prepared for: North Central

Climate Change 2009, Faster Change & More Serious Risks Australian Government, Department of Climate Change, Will Steffen.

Potential impacts of a changing climate on selected terrestrial ecosystems of Northern Victoria, Report on an Ecosystem Risk Project to North Central Catchment Management Authority, Graeme Newell, Matthew White and Peter Griffioen*

Western Region Sustainable Water Strategy, Department of Sustainability and Environment 2011

NCCMA 2011 – Loddon Campaspe Region Irrigation Land and Water Management Plan, North Central CMA

Appendix A

Climate Change 2009, Faster Change & More Serious Risks Australian Government, Department of Climate Change, Will Steffen.

The IPCC's Fourth Assessment Report (AR4) is an outstanding source of information on our current scientific understanding of the climate system and how it is responding to the changes in the atmospheric concentration of greenhouse gases caused by human activities. In particular, the AR4 provides an excellent overview on issues where there is strong agreement, and points towards those issues where further research is required. But climate science is a rapidly moving field as researchersrespond to the challenges laid out by the IPCC and the needs of governments and other groups for even better knowledge about climate change. Over the past three to four years, many new developments have occurred and many significant new insights have been gained. The most important of these are:

- **The climate system appears to be changing faster than earlier thought likely. Key manifestations of this include the rate of accumulation of carbon dioxide in the atmosphere, trends in global ocean temperature and sea level, and loss of Arctic sea ice.**
- **Uncertainties still surround some important aspects of climate science, especially the rates and magnitudes of the major processes that drive serious impacts for human societies and the natural world. However, the majority of these uncertainties operate in one direction – towards more rapid and severe climate change and thus towards more costly and dangerous impacts.**
- **The risk of continuing rapid climate change is focusing attention on the need to adapt, and the possible limits to adaptation. Critical issues in the Australian context include the implications of possible sea level rise at the upper end of the IPCC projections of about 0.8 m by 2100; the threat of recurring severe droughts and the drying trends in major parts of the country; the likely increase in extreme climatic events like heatwaves, floods and bushfires; and the impacts of an increasingly acidic ocean and higher ocean temperatures on marine resources and iconic ecosystems such as the Great Barrier Reef.**
- **Climate change is not proceeding only as smooth curves in mean values of parameters such as temperature and precipitation. Climatic features such as extreme events, abrupt changes, and the nonlinear behaviour of climate system processes will increasingly drive impacts on people and ecosystems. Despite these complexities, effective societal adaptation strategies can be developed by enhancing resilience or, where appropriate, building the capacity to cope with new climate conditions. The need for effective reduction in greenhouse gas emissions is also urgent, to avoid the risk of crossing dangerous thresholds in the climate system.**
- **Long term feedbacks in the climate system may be starting to develop now; the most important of these include dynamical processes in the large polar ice sheets, and the behaviour of natural carbon sinks and potential new natural sources of carbon, such as the carbon stored in the permafrost of the northern high latitudes. Once thresholds in ice sheet and carbon cycle dynamics are crossed, such processes cannot be stopped or reversed by human intervention, and will lead to more severe and ultimately irreversible climate change from the perspective of human timeframes.**

The executive summary figure places the climate change dilemma in a broad perspective. The nearly 1,000-year northern hemisphere temperature record gives an indication of the envelope of natural variability within which contemporary civilisation has developed. The IPCC projections, shown on the same timescale as the palaeo-record, depict not only the magnitude but especially the rate of the climatic changes that may lie ahead. The right-hand side of the figure illustrates why societies should be concerned about these projections.