REPORT FOR

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Directions Paper

Climate Change and Greenhouse Gas Abatement and Management in the Goulburn Broken Catchment

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1. INTRODUCTION

1.1 BACKGROUND

The Goulburn Broken Catchment Management Authority (GBCMA) is a State Government authority established to manage land and water resources in a Goulburn Broken Catchment, which stretches from close to the outskirts of Melbourne in the south to the Murray River in the north.

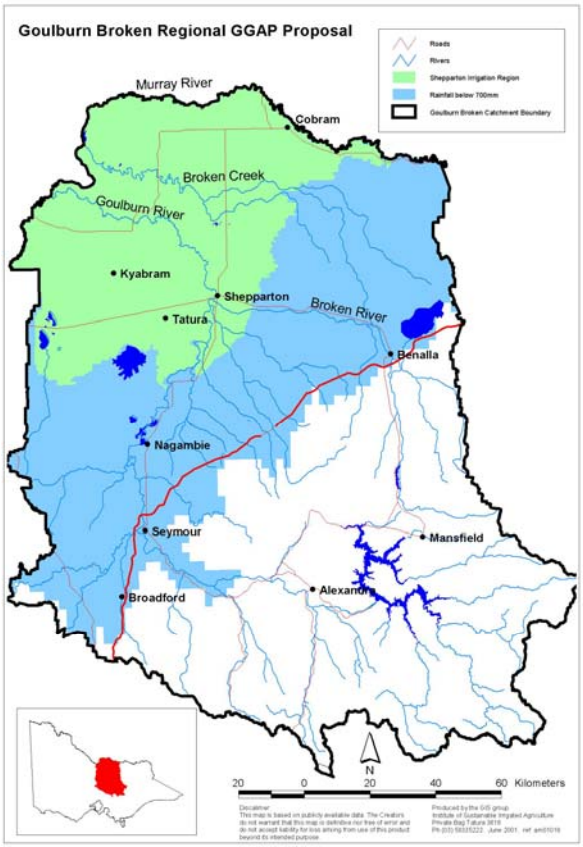
The Goulburn Broken Catchment covers 2.4 million hectares (17% of Victoria), has a population of 250,000 and supports major agricultural, food processing, forestry and tourism industries. The irrigation region contributes 25% of Victoria's export earnings and about $4.5 billion in economic output each year. The dryland region contributes approximately $1.9 billion each year. Based on economic performance, the top five industries in the catchment are dairy farming, followed by livestock (meat production), horticulture (fruit production), timber and hay production[1]. Continued economic growth may be limited by the impacts of global climate change on the region's food producing capability, and by restrictions placed on greenhouse gas emissions from local industry.

Approximately two thirds of the Goulburn Broken Catchment has been cleared for agriculture, mostly in the lower catchment. In the catchment, 95 plant species are considered rare or threatened, and 85 animal species are considered threatened. Much of the remaining native vegetation is of poor quality and not well protected. The Goulburn Broken Native Vegetation Management Strategy has been developed to manage and enhance native vegetation and associated biodiversity in the catchment.

Figure 1**Error! Reference source not found.** shows a map of the Goulburn Broken Catchment with broad zones for greenhouse gas abatement and management. The north western region of the catchment is made up of the Shepparton Irrigation Region where there are significant emissions of nitrous oxide and methane associated with irrigated dairy and horticultural activities. The south eastern region covers the foothills of the Great Dividing Range in a area with average rainfall greater than 700mm per annum, where there are particular opportunities for establishing carbon sinks. The central area of the catchment represents the dryland agricultural area in the 550 to 700mm rainfall zone, where improved land management and farm forestry provide some greenhouse abatement opportunities. This is discussed in the following sections.

[1] An Economic Profile of the Goulburn Broken Catchment, Myfora Pty Ltd – Michael Young and Associates, 2000.

Figure 1: Map of the Goulburn Broken Catchment



As part of its role in managing land and water resource issues in the region, the GBCMA wishes to include greenhouse gas abatement and management within the revision of its Regional Catchment Strategy. To assist in this process, Egis Consulting Victoria Pty Ltd (Egis) was asked by the GBCMA to produce this draft directions paper to provide background information and strategic advice for greenhouse gas abatement and management in the region.

1.2 STUDY APPROACH

At the request of the GBCMA, this directions paper has been prepared based on:

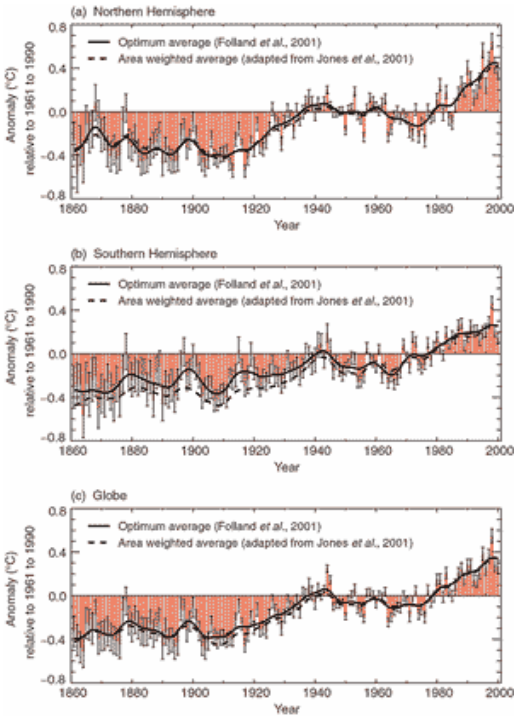
- A review of available documentation on climate change and greenhouse gas abatement and management, particularly in relation to agriculture and natural resource management;
- A review of the GBCMA's proposal to the Australian Greenhouse Office's (AGO) Greenhouse Gas Abatement Program Round 1 (September 2000) and Round 2 (July 2001), and associated background information;
- Consultation with a limited number of key stakeholders;
- Assessment of the collated information and its application to determine key strategies for addressing climate change and greenhouse gas abatement in the Goulburn Broken Catchment.

2. CLIMATE CHANGE AND ITS IMPACTS

2.1 Observed Climate Change

Climate change resulting from the human induced enhanced greenhouse effect is now well recognised. Global average temperatures have risen by 0.6 ± 0.2 ^{o}C since 1900 and Australia's continental average temperature have risen 0.7 ^{o}C from 1910 – 1999, with most change occurring since 1950[2]. This is demonstrated in Figure 2. Global climate change is attributed to human-induced emissions of greenhouse gases, and has been linked to changes in physical and biological systems, including accelerated glacier retreat, sea level rise, lengthening of growing seasons, and the timing of seasonal occurrences such as the flowering of trees, the emergence of insects and egg-laying by birds[3].

Figure 2: Variation in the Earth's surface temperature over the last 140 years - Departure in temperature (^{o}C) from 1961-1990[4]



2.2 Predicted future climate change

Continued increases in atmospheric carbon dioxide concentrations and further climate change are predicted in the future. Atmospheric carbon dioxide

[2] Climate Change Projections for Australia. CSIRO, 2001.

[3] Climate Change and Biodiversity in Australia, Hughes L, 2002, in Life Lines Newsletter, Community Biodiversity Network

[4] IPCC, Climate Change 2001: The Scientific Basis. http://www.ipcc.ch/pub

concentrations are predicted to increase from 350 parts per million (ppm) in 1990 to 430 to 455 ppm in 2030, and 525 to 705 ppm by 2070. The International Panel on Climate Change (IPCC) predicts an average global warming of 1.4 to 5.8^{o}C by 2100 relative to 1990. This is a rate of approximately 0.1 to 0.5^{o}C per decade. This is consistent with the observed rate of global warming, which has been 0.15 ^{o}C per decade since 1970[5].

Box 1: Uncertainty of climate change predictions

The present atmospheric concentration of carbon dioxide is the highest it has been for 420,000 years. Ice core records that go back 420,000 years show that carbon dioxide levels in the atmosphere varied between 200 and 280 parts per million due to glacial cycles. For the past 1000 years global atmospheric carbon dioxide has been quite stable. However, since the beginning of the Industrial Revolution, about 1750, the concentrations of greenhouse gases in the atmosphere have increased dramatically. Human activities, such as burning fossil fuels (coal, oil and gas), land clearing and agricultural practices have increased carbon dioxide by 31% (to about 360 parts per million), nitrous oxide levels by about 17% and methane concentrations have more than doubled. The current rate of increase in carbon dioxide is unlikely to have been experienced during the past 20,000 years at least.

The observed changes in climate, especially temperature increases since about 1970, cannot be explained by natural causes such as solar activity. Reconstructions of climate data for the past 1000 years indicate that this recent warming is unusual and is unlikely to have resulted from natural causes alone.

Scientists use computer models to simulate what the climate may be like in years to come. When only natural variations, such as volcanic and solar activity, are included in the models, the simulations do not match the observed temperature record, particularly during the past 50 years or so. When these computer models include human-induced influences—such as the increase in greenhouse gas emissions, sulfate particles released by fossil fuels and the decrease in ozone in the upper atmosphere—along with natural variations, scientists find that the simulated temperature record matches the observed temperature record quite well.

Text from: Australian Greenhouse Office, Frequently Asked Questions. http://www.greenhouse.gov.au/science/faq/page8.html

[5] Climate Change Projections for Australia. CSIRO, 2001.

2.3 Climate change in Australia and the Goulburn Broken region

Results from global climate change models have been applied to Australia, taking into account regional responses to global warming, to predict climate change in the region. By 2030, annual average temperatures are predicted to be 0.4 to 2.0 ^{o}C higher over most areas of Australia. By 2070, this is predicted to be 1.0 to 6.0 ^{o}C [6]. Daily changes in minimum and maximum temperatures are predicted to be similar to changes in average temperatures. There is limited data available that is specific to the Goulburn Broken Catchment . Data presented for Tatura, however, indicate that the number of winter days below 0 ^{o}C will decrease from the present average of 15 days to 6 to 13 days in 2030 and 0 to 9 days by 2070.

Global warming will also have an influence on other climate variables such as rainfall and evaporation. Predicted changes in rainfall vary throughout Australia, but in most of Victoria including the Goulburn Broken Catchment, the projected average ranges tend towards a decrease from 1990 with a change of -10% to 5% by 2030 and -35% to 10% by 2070. In the Goulburn Broken Catchment, decreases in rainfall are predicted in both summer/autumn and winter/spring seasons. This is in contrast to south west New South Wales where summers are expected to become wetter, and springs drier. It should be noted that local influences may result in some specific changes not detected by this generalised modelling.

Higher temperatures are likely to result in increased evaporation of approximately 0 to 8 % per degree of global warming. When combined with decreased rainfall, this increased evaporation will result in a reduced moisture balance across most of Australia and a decrease of between 80 and 100 mm per degree of global warming in the Goulburn Broken Catchment. This indicates that further limitations on water resources can be expected as a result of climate change in the Goulburn Broken Catchment.

2.4 Climate change impacts on agriculture and natural resources in the Goulburn Broken Catchment

Climate change, including changes in temperature, rainfall, evaporation, and atmospheric carbon dioxide concentrations can be expected to have social, economic and environmental impacts on the Goulburn Broken Catchment. While there is now a high degree of certainty about the predicted changes in atmospheric carbon dioxide concentration and temperature change, changes in rainfall and evaporation are more difficult to predict, as are the magnitude of impact of this change on agriculture and natural resources. Some of these impacts may be positive, such as increase plant growth resulting from higher carbon dioxide concentrations, while the impact of decreased rainfall will be

[6] Climate Change Impacts for Australia, CSIRO, 2001.

negative. The combination of a range of potentially opposing influences is difficult to predict. A discussion of each of the broad natural resource and agricultural system of importance to the Goulburn Broken Catchment are discussed below.

2.4.1 Water resources

The scarcity of water resources as a result of climate change is likely to be the most significant and limiting factor affecting the Goulburn Broken Catchment . There is no specific information available from the Goulburn Broken catchment, however modelling of the impact of climate change on water resources in the Macquarie River Catchment provides some indication of extent of impact expected. Results from modelling in the Macquarie River catchment show a change in the mean annual flow into the Burrendong Dam, the major water storage, from 0 to -30% in 2030 and +5 to -55% in 2070[7]. A similar study on the Macquarie River catchment indicates that critical thresholds, for both irrigation and environmental flows, occur with mean changes in flow of -10% in a drought dominated climate, -20% in a normal climate and -30% in a flood dominated climate, and that considerable hardship would be experienced before these thresholds are reached[8]. This indicates that some effort should be made to better understand the impact of climate change on the Goulburn Broken catchment's water resources, including specific hydrological modelling of the impact of climate change on the major water storages. This also provides a critical driver for better managing environmental flows and water resource use in the Catchment. Improved management will provide multiple environmental benefits such as salinity mitigation, decreased nitrous oxide emissions from dairy pasture, and decreased operating costs.

2.4.2 Dairy production

Dairy pastures grown on irrigated land could be enhanced due to increased carbon dioxide concentrations, but the availability of water resources for irrigation is likely to be significantly constrained. In addition, rising temperatures are likely to lower milk yield from cows. According to CSIRO, dairy cows in the Hunter Valley in NSW kept in the open produce 3% less milk that those kept under shelter. This currently represents a loss of 230 litres of milk per cow per year, and can be expected to increase to 250 to 310 litres in 2030 depending on the rate of global warming. Increasing water use efficiency and providing shelter for dairy cows would limit these losses of production to 60 to 90 litres per cow[9].

[7] Climate change and the risk to long-term water supply in the Murray Darling Basin, R. Jones, C. Page, N. Herron, R. Davis, R. O'Neill, D. Bennett, D. McClintok, 2001.

[8] Assessing the Risk of Climate Change on the Water Resources of the Macquarie River Catchment.

[9] Climate Change Impacts for Australia, CSIRO, 2001

2.4.3 Dryland farming and grazing

The impact of climate change on dryland pastures in the region is difficult to predict. Increased carbon dioxide concentrations in the atmosphere are likely to stimulate pasture growth, but this will be offset by the predicted decrease in rainfall. These two factors may cancel each other out, but rainfall may be the limiting factor affecting plant growth. This would limit animal production. Selecting pasture that is more tolerant to low rainfall and higher temperatures will maximise pasture and livestock yields.

2.4.4 Fruit production

The decreased number of winter days below 0 ^{o}C, from the present average of 15 days to a predicted 0 to 9 days by 2070, will decrease the severity of frost damage that often occurs late in the growing season. However, a degree of winter chill is required by temperate fruit to ensure normal bud-burst and fruit set[10]. The projected increase in average annual temperature will lead to lower yields and poorer fruit quality. Adaptation strategies could include the selection of varieties with lower chilling requirements, or chemical treatments.

2.4.5 Forestry

In a similar way to dryland pasture, the extent of the impact of climate change on forestry will depend on the balance between increased atmospheric carbon dioxide concentrations and changes in rainfall and temperature. However, any benefits are likely to be offset by an increased risk of fire, changes in pests, and in the longer term, nutrient supply.

From an economic viewpoint, the establishment of the Kyoto Protocol does provide an additional incentive to plant trees through the potential establishment of a market for carbon trading. When added to the value of the harvested timber, carbon credit may provide sufficient additional profit to make forestry viable in otherwise marginal areas (See Box 1 for more information).

Any effort to increase forestry in the Goulburn Broken Catchment should be assessed fully to determine the overall social, environmental and economic benefit. When strategically planted, trees can provide multiple benefits including salinity control and enhancing biodiversity. On the other hand, trees can also take up scarce and valuable water resources depending on where they are planted. The Macquarie River catchment study discussed above also assessed the impact of tree planting on water resources. In addition to a decrease of mean annual flow to the major water storages resulting from climate change of 0 to 30%,

[10] Climate Change Impacts for Australia, CSIRO, 2001

extensive tree planting further decreases the mean annual flow by 7 percent[11]. It is therefore important to determine the location of tree planting, taking into consideration all benefits and impacts. It is understood that work of this nature is currently being undertaken in the Goulburn Broken Catchment.

2.4.6 Biodiversity

Climate change will place further pressures on natural systems and biodiversity in addition to other human induced impacts such as land use change and habitat loss, fragmentation and isolation of communities, pollution, weed infestation and over exploitation. Climate change will also provide conditions that favour the survival and spread of pest species and increase the likelihood of fire.

Changes in temperature, rainfall, water availability and atmospheric carbon dioxide concentrations will directly affect the physiology of most plant and animal species. In response to climate change, species will have to be able to adapt themselves to the changing environmental conditions, or be able to migrate to other areas that suit their environmental tolerances. This particularly impacts on species at the upper limit of their temperature range or with a limited ability to adapt. For example, in the Goulburn Broken Catchment the Mountain Pygmy Possum is confined to the alpine areas, which will be severely reduced as a result of global warming. This species has a limited ability to move to higher/cooler environments, and has a limited ability to adapt. It is estimated that this species will be lost with only 1 ^{o}C of warming[12]. In native forests, reduced rainfall and increased temperatures may threaten many eucalypt species, which are unable to adapt to a changing climate[13]. Wetland and riverine environments in the Goulburn Broken Catchment which are currently impacted by reduced environmental flows, will be under further pressure due to a decrease in rainfall.

Most species will be unable adapt to climate change or migrate fast enough to keep up with shifting climate zones in the future. Other environmental pressures such as the increase fragmentation and isolation of communities in managed reserves will further limit the ability of species to colonise new areas. To manage the increased pressure on biodiversity and natural systems, significant human intervention will be required. This will include gaining a better understanding of the environmental tolerances of important natural systems to climate change, identifying areas for protection and re-establishment of threatened communities.

[11] Climate change and the risk to long-term water supply in the Murray Darling Basin, R. Jones, C. Page, N. Herron, R. Davis, R. O'Neill, D. Bennett, D. McClintok, 2001.

[12] Climate Change and Biodiversity in Australia, Hughes L, 2002, in Life Lines Newsletter, Community Biodiversity Network

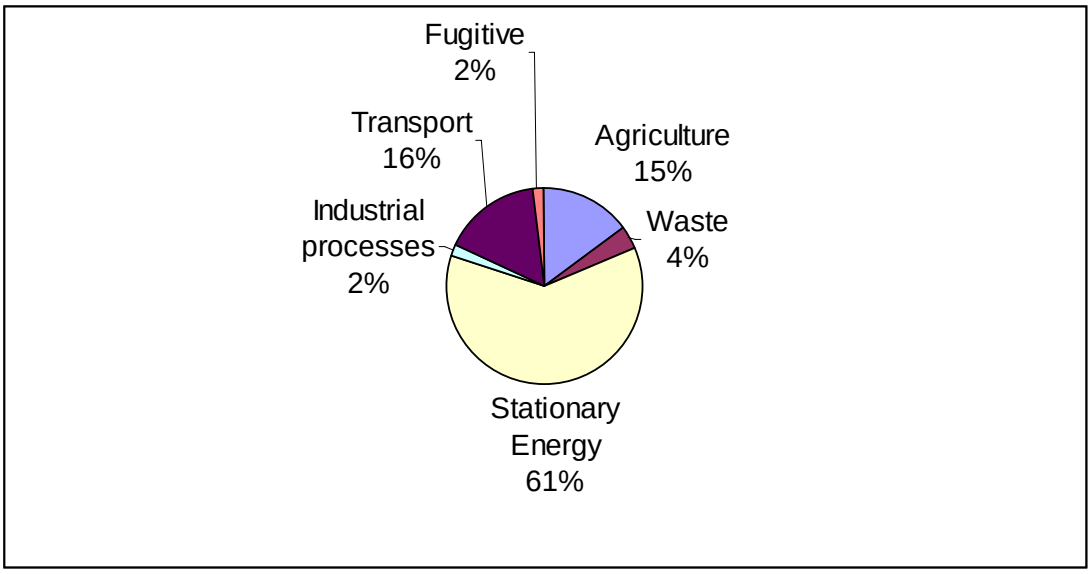
[13] Climate Change Impacts for Australia, CSIRO, 2001.

3. GREENHOUSE GAS EMISSIONS IN THE GOULBURN BROKEN CATCHMENT

It is not possible to provide a specific greenhouse gas inventory for the Goulburn Broken Catchment within the time and budget provided for the production of this report. However, a brief overview of the 1995 Victorian greenhouse inventory and the 1998 National Greenhouse Gas Inventory (NGGI) gives some indication of the main source of greenhouse gas emissions in the region. Where available, emissions profiles for specific industry sectors have been provided.

The major contributions to total $CO_{2\text{-}e}$ emissions by sector (excluding forestry) in Victoria in 1995 are presented in Figure 3 [14].

Figure 3 – Total Victorian 1995 CO2 equivalent emissions by sector (excluding forestry and other)



3.1 AGRICULTURE

At a national level, agriculture makes up 20.5% (93.8 Mt $CO_{2\text{-}e}$) of the total greenhouse gas emissions, and is the second largest source of Australia's greenhouse gas emissions. Similarly, agriculture makes a significant contribution of the State's greenhouse gas emissions at 15% (15.8Mt $CO_{2\text{-}e}$), and is the third largest source after transport (16%) and stationary energy (61%). Agriculture is the major activity in the Goulburn Broken Catchment, and can be considered to make up a significant proportion of the region's greenhouse gas emissions. Emissions from agriculture in the region are made up principally of three greenhouse gases, nitrous oxide, methane and carbon dioxide. Nitrous oxide

[14] Australia's 1998 National Greenhouse Gas Inventory, Australian Greenhouse Office, 1999.

and methane are more potent greenhouse gases than carbon dioxide, with nitrous oxide and methane having a global warming 310 and 21 times that of carbon dioxide. This means that 1 tonne of nitrous oxide has a carbon dioxide equivalent ($CO_{2\text{-}e}$) value of 310 tonnes.

3.1.1 Dairy Industry

The national dairy industry produces approximately 12% of agricultural emissions, and contributes 2.5% of the national greenhouse gas inventory[15]. Due to the increase application of nitrogen fertilisers and increased livestock numbers, greenhouse gas emissions from the dairy industry have increased by 22% since 1990 and are predicted to increase to 44% of 1990 levels by 2010.

Nitrous oxide is produced from the incomplete de-nitrification of nitrogen fertilisers on irrigated pastures and urinary depositions from livestock . Methane is a major by-product resulting from enteric digestion of livestock. Nitrous oxide and methane account for 18% (16.9Mt) and 62.4% (60.3 Mt) respectively of the total greenhouse gas emissions from agriculture, and the agricultural sector is the major contributor of emissions of these two gases nationally.

Electricity, petrol, diesel and gas consumption on dairy farms also contribute to the emission of carbon dioxide and other greenhouse gases including methane, nitrous oxide and carbon monoxide. Energy is consumed primarily in the refrigeration of milk, heating of water and use of vehicles and machinery, including water pumps. It is thought that energy use contributes around 10% to 15% of a dairy farm's greenhouse gas emissions[16].

The Goulburn Broken Catchment contains approximately 3000 dairy farms, 24% of Australia's total, and produces 26% of Australia's milk[17]. Most dairy farms are located in the Shepparton Irrigation District. Dairy industry deregulation is resulting in an increase in herd size, and opportunities for more efficient operations, including natural resource use.

A profile of greenhouse gas emissions from a typical dairy farm in northern Victoria has been produced by the Dairy Research and Development Corporation. This information is summarised in Appendix 1, where it has been extrapolated across the 3000 dairy farms present in the Goulburn Broken

[15] Greenhouse Gas Emissions and Dairy Production Systems, R.J. Eckard & E. Barlow, Institute of Land and Food Resources, The University of Melbourne, 2001.

[16] Greenhouse and Agriculture – Greenhouse emissions from dairy farms, Australian Greenhouse Office Factsheet. http://www.greenhouse.gov.au/land/agriculture/pubs/fs_dairy.html

17 An Economic Profile of the Goulburn Broken Catchment, Myfora Pty Ltd – Michael Young and Associates, 2000.

Catchment. This indicates that the dairy industry in the region contribute 3.1 million tonnes $CO_{2\text{-}e}$ in greenhouse gas emissions. This is consistent with a value of 3.3 million tonnes $CO_{2\text{-}e}$ in greenhouse gas emissions calculated for the GBCMA's Greenhouse Gas Abatement Program submission (See Section 4.3). Under this program, it was estimated that through the implementation of a range of best practice measures for fertiliser and water use for irrigated pastures, an average saving of 500,000 tonnes $CO_{2\text{-}e}$ could be saved per year during the first five year Kyoto commitment period 2008 to 2012.

3.1.2 Livestock production

Based on value of production, livestock production and processing in both irrigation and dryland areas is the second largest agricultural industry in the Goulburn Broken Catchment. This mainly includes beef cattle, sheep for wool production and lambs. Over recent years, sheep numbers have been declining due to the reduced income from wool, and cattle numbers have been increasing.

Enteric methane emissions from livestock and sheep, and nitrous oxide emissions from irrigated pastures as discussed in Section 3.1.1, are the major contributors to greenhouse gas emissions from this sector.

3.1.3 Horticulture

Horticulture, in particular fruit production, is the third largest economic performer in the Goulburn Broken Catchment, which supplies much of Australia's fresh and canned fruit. Fruit production covers approximately 9000 ha of the Goulburn Broken Catchment, mainly in the Shepparton Irrigation Region.

Greenhouse gas emissions from fruit production is likely to be insignificant, due to the minimal need for soil disturbance, and biomass (carbon) accumulation in vegetation. This would offset the later pruning and burning or decay of wood.

Other horticultural activities such as tomato and winegrape production may contribute minor greenhouse gas emissions through disturbance to agricultural soils.

The most significant impact relates more to greenhouse gas emissions resulting from food processing, which is discussed in Section 3.3.

3.1.4 Cropping

Cropping in both the dryland and irrigation areas of the Goulburn Broken Catchment are likely to contribute to the regions greenhouse gas emissions through disturbance of agricultural soils, the use of nitrogen based fertilisers, and any clearing or burning of vegetation.

Measures such as zero tillage cropping, green manure applications, replacing annual with perennial crops, and controlling soil disturbance and erosion provide a significant opportunities for reducing greenhouse gas emissions and enhancing carbon sink capacity of agricultural soils.

3.2 TIMBER PRODUCTION & VEGETATION MANAGMENT

Land clearing in Victoria and the Goulburn Broken Catchment has been an historical source of greenhouse gas emissions to the atmosphere by the release of carbon stored in wood. Much of the Goulburn Broken Catchment has been cleared. At a State level, the forestry sector was a net carbon sink at the time of the 1990 inventory, but a net source in 1996. Forest management, forest fires, reforestation activities and the age of the States forests determine whether Victoria is a net source or sink. Current State government programs, aimed at stimulating farm forestry and plantation establishment, are aimed at enhancing the Victoria's sink capacity.

In the Goulburn Broken Catchment, some clearing of native forest is contributing to the regions greenhouse gas emissions from the forestry sector, whereas plantation establishment is likely to be providing a net carbon sink. Hardwood forestry based on harvesting of native forests in the south east of the Goulburn Broken Catchment (Murrundindi Shire and Mitchell Shire) produce 15% of Victoria's sawn hardwood. Supply of hardwood is unlikely to expand unless the area of hardwood plantations increase. Softwood plantations having been expanding significantly in the Goulburn Broken Catchment in recent years, with a current area of softwood plantation forest in the dryland region of the catchment of 20,000 ha. Most plantations have been established in the high rainfall zone (>700mm) in the east and south east of the catchment.

The GBCMA has been active in encouraging environmental plantings and natural regeneration in the region under existing programs including Bushcare and the National Landcare Program under the Natural Heritage Trust, the Land Protection Incentive Scheme, and the CMA's waterways programs. These programs aim to protect existing vegetation and increase the area of native vegetation in the catchment in priority zones and along waterways, and incorporate trees into farming systems. As these environmental plantings will not be harvested, there is a significant opportunity for these areas to provide significant carbon sinks in the catchment. The GBCMA GGAP submission also identified the potential for farmforestry industry in the catchment with wood production for timber and sustainable firewood supply.

Vegetation carbon modelling undertaken as part of the GBCMA's Greenhouse Gas Abatement Program submission to the Australian Greenhouse Office gives an indication of the extent of greenhouse gas abatement that could be provided

through enhanced environmental plantings and agroforestry. Additional funding to increase current rates of environmental planting by 8,650 hectares over 4 years to 2005 would provide an average of 47,830 tonnes $CO_{2\text{-}e}$/year in the period 2008-2012, increasing to 148,395 tonnes $CO_{2\text{-}e}$/year during the period 2013-2017 as vegetation growth increases. The establishment of 2,000 hectares of hardwood plantation on farmland in the 550 to 700mm rainfall zone over 4 years to 2005 provided an average of 17,325 tonnes $CO_{2\text{-}e}$/year during the period 2008 to 2012. This combined environmental plantings and farm forestry over 10,650 hectares provides a total average of 65,155 tonnes $CO_{2\text{-}e}$/year during the period 2008 to 2012. The potential offset from sinks would be significantly enhanced in future years as vegetation growth increases, and through ongoing planting.

See Box 2 for more information of how this could be used to offset emissions from elsewhere in the catchment.

3.3 FOOD AND DAIRY PROCESSING INDUSTRIES

Other significant emissions from the region are likely to occur as a result of food processing and transport of produce from the region to markets. Dairy and food processing within the Goulburn Broken Catchment contributes significantly to the regions greenhouse gas emissions through energy use associated with processing, refrigeration, fuel use for the transport of produce, and waste production. Milk processing cooperatives and multinationals in the catchment include Bonlac, Murray Goulburn, Tatura Milk industries, Nestlé, and Kraft. Major food processing industries in the Goulburn Broken Catchment include SPC Ardmona Ltd, Henry Jones Foods Pty Ltd, Campbell's Soups, Gigarre Country Foods, Heinz, Unifoods, Cedenco and Simplot.

3.4 TRANSPORT

Road transport is one of the major industries in the Goulburn Broken catchment, with Shepparton often referred to the transport hub of regional Australia. The Mooroopna freight hub handles approximately 12,000 containers a year, and Shepparton is provincial Victoria's largest truck sales and service centre[18]. The greenhouse gas emissions associated with the burning of fossil fuels from transport, therefore, is significant.

Improving fuel efficiency, optimising carrying capacity, minimising route distance, and investigating alternative fuels and transport modes could significantly reduce the regions fossil fuel use and associated greenhouse gas emissions from the transport sector. The City of Greater Shepparton and the Department of State and Regional Development, is undertaking an investigation of the development of

[18] SHEPPARTONONLINE, http://www.shepparton.vic.gov.au/Issues/Profile/profile.htm

the Goulburn Valley Freight Centre (GVFLC). This provides an opportunity to consolidate freight handling, modal change and distribution tasks for the regions within an integrated transport and land use strategy with significant greenhouse gas abatement benefits.

4. ADDRESSING THE CLIMATE CHANGE THREAT

4.1 International and Australian Greenhouse Policy

International concern over global climate change resulting from human induced increases in greenhouse gas emissions has led to the establishment of the United Nations Framework Convention on Climate Change (UNFCCC).

The main objective of the UNFCCC is the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

Australia is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and, along with many other developed countries, has agreed to implement measures to reduce greenhouse gas emissions. Negotiations at the third Conference of the Parties (COP) to the FCCC at Kyoto in December 1997 resulted in the development of the Kyoto Protocol, under which Australia and other developed countries have agreed to average net greenhouse gas emission targets of 5% below 1990 levels over the period 2008-2012.

The Kyoto Protocol allows for a range of activities that will facilitate developed countries in meeting their greenhouse gas emission targets. This includes the recognition of the importance of carbon sinks through the activities of afforestation, reforestation and deforestation under Article 3 of the Kyoto Protocol and the establishment of emissions trading under Article 17. (See Box 1 and 2 for more information)

The Kyoto Protocol itself has not yet been ratified. It will enter force 90 days after it has been ratified by 55 parties, including developed countries representing 55% of the 1990 carbon dioxide emissions from Annex 1 parties. Australia has signed the Kyoto Protocol but, like many other countries, has not yet ratified it. Since the clarification of rules governing the implementation of the Kyoto Protocol at COP7 meeting in Marrakesh last year, many developed countries are now committed to ratifying the Protocol this year.

In 2001, the United States of America, the main national contributor to greenhouse gas emissions rejected the previously negotiated Kyoto targets saying they would harm the US economy, and in February 2002 announced the US 'Climate Change Plan'. Australia's Prime Minister, John Howard has stated

that it is not in Australia's national interest to ratify the Kyoto Protocol if the US and developing countries are not involved. Australia has since established a Climate Change Partnership with the US to focus on practical approaches to address climate change including: emissions measurement and accounting; climate change science; stationary energy technology; engagement with business to create economically efficient climate change solutions; agriculture and land management; and collaboration with developing countries to build capacity to deal with climate change[19]. However, the government has also confirmed that it is committed to working to meet its Kyoto target, and some recent media coverage has indicated a softening of Australia's unwillingness to ratifying the Kyoto Protocol.

[19] Current greenhouse developments in the US, Australia and Europe. Freehills publications, March 2002. http://www.freehills.com.au/

Box 2: Emissions Trading

A key feature of the Kyoto Protocol is that it provides for emissions trading between developed countries as an instrument for fulfilling abatement commitments. Under such a system, activities that reduce greenhouse gas emission below the level required to meet the Kyoto Protocol emissions target could generate carbon credits which may be traded or banked for use in the next commitment period.

Carbon sinks may also be included in an emission trading system. Under the Kyoto Protocol, afforestation and reforestation activities on land that was not forested prior to 1990 could generate carbon credits that may be traded. The details of an international emissions trading scheme are yet to be negotiated, and Australia is yet to decide on the shape of a domestic trading system. However, there are significant opportunities for an emissions trading system to make commercial forestry viable across a broader area and help fund revegetation projects that address Australia's land degradation problem.

There are opportunities for emissions trading within the Goulburn Broken Catchment. The dairy industry produces approximately 3.1 million tonnes of carbon dioxide equivalent per year In comparison, the establishment of environmental planting on 10,650 hectares would offset an average of 65,000 tonnes carbon dioxide per year during the first commitment period of 2008 to 2012. This represents approximately 2% of the annual dairy farm emissions from the region in 2002, one of the largest emission sectors in the catchment. The potential offset from sinks would be significantly enhanced in future years as vegetation growth increases, and through ongoing planting, which could provide a significant offset for the region.

Box 3: Carbon Sinks

Land use, land use change and forestry activities play a key role in the global carbon cycle. Forests and vegetation absorb carbon dioxide from the atmosphere through the process of photosynthesis and store it in their roots, trunks, branches and leaves. Large amounts of carbon are also stored in the soil, and forests and vegetation maintain and enhance soil carbon levels by the continual laying down of organic matter (leaves and plant debris). These vegetation systems, which absorb atmospheric carbon dioxide, are known as carbon sinks. They can play an important role in offsetting greenhouse gas emissions, and this has been recognised within the Kyoto Protocol.

It should also be noted that forest and vegetation systems can be significant sources of carbon dioxide, with deforestation releasing large amounts of stored carbon dioxide to the atmosphere. While it is estimated that approximately 75% of human induced greenhouse gas concentrations come from burning fossil fuels, deforestation is the next major contributor, and the protection of existing forests is vital.

Two key opportunities exist for establishing carbon sink projects in Australia at present:

- Environmental Plantings: Environmental plantings that meet the definitions of a forest, and are planted on land that was not forested in 1990, are eligible for generating carbon credits. Since environmental plantings are not expected to be harvested, the total carbon pool will increase as the trees grow, reaching equilibrium at maturity. Carbon credits could be issued during the first commitment period 2008 – 2012, and any subsequent commitment periods. Once a steady state is reached no further credits would be issued. Carbon credits could provide the economic incentive to plant trees in addition to the environmental benefits of such activities.
- Commercial Forestry: In addition to earning an income from the timber produced, commercial plantations planted on land not forested in 1990 can also earn an income through the generation of carbon credits. However, because the plantation is harvested, some of the carbon in these trees is released to the atmosphere, which may be recorded as a net emission. Therefore, for a commercial plantation to maximise carbon sequestered in any given year, a balance between harvesting and new plantings for the plantations post 1990 forests need to be established, whereby new sequestration equals or exceeds any emission from harvesting.

Greenhouse sinks provide a number of additional benefits including reducing erosion and salinity, and enhancing biodiversity. Residues from plantations, sawmill wastes and short rotation crops may also be used to produce energy. Bio-energy can result in a significant reduction of greenhouse gas emissions if the biofuel replaces fossil fuels, since the burning of renewable biomass fuels are greenhouse neutral as the emission at time of burning is equal to the carbon sequestered during regrowth of sustainable forests.

4.2 Programs to assist with greenhouse gas abatement and management

A number of Commonwealth and State government programs currently exist to encourage greenhouse gas abatement and the establishment of carbon sinks. Legal frameworks for carbon trading are being assessed at a State, Commonwealth and International level, and more accurate monitoring and verification processes are being developed. There are also a number of private initiatives examining the opportunities available for carbon trading through the establishment of carbon sinks, providing an indication of the potential importance of this developing market.

4.2.1 Commonwealth Government

The Australian Greenhouse Office (AGO) has been established as a separate agency within the environment portfolio to provide a whole of government approach to greenhouse matters, and to deliver the Commonwealth Government's $180 million climate change package, *Safeguarding the Future: Australia's Response to Climate Change.* A further commitment of $400 million has been made through the Greenhouse Gas Abatement Program (GGAP). The main AGO Programs of relevance to the GBCMA are listed below.

- ***National Greenhouse Strategy***

  The National Greenhouse Strategy (NGS) provides the framework for advancing Australia's domestic greenhouse response, and is a product of the Commonwealth, State and Territory Governments, with input from industry, non-government organisations and local government. The NGS details both existing actions and additional measures, and includes package of *Safeguarding the Future*, described above. Key sectors covered by the NGS include energy, transport, industry, waste, agriculture and vegetation, and households.

- ***GGAP***

  The Greenhouse Gas Abatement Program (GGAP) is a Commonwealth Government initiative that aims to assist Australia in meeting its commitments under the Kyoto Protocol. The objective of GGAP is to reduce Australia's net greenhouse gas emissions by supporting activities that are likely to result in substantial emission reductions or substantial sink enhancement, particularly in the first commitment period (2008-2012) under the Kyoto Protocol. $400 million has been allocated to the Program between 2000 to 2004.

  GGAP is a competitive program targeting opportunities for large-scale, cost-effective and sustained abatement across the economy. GGAP will only support projects that will result in quantifiable and additional abatement not

expected to occur in the absence of GGAP funding. Priority is given to projects that will deliver abatement exceeding 250,000 tonnes of carbon dioxide equivalents (CO_{2-e}) per annum at a minimal cost to the Commonwealth per tonne of abatement.

Projects funded under GGAP are generally expected to provide complementary benefits, for example opportunities for rural and regional Australia, ecologically sustainable development, employment growth, the use of new technologies and innovative processes, and non-government investment. However the experience of the GBCMA from its Round 1 and Round 2 GGAP submissions (see Section 4.3) is that minimal cost per dollar of abatement and low risk are the main criteria.

- ***Bush for Greenhouse***

  Established in 2000, Bush for Greenhouse aims to increase Australia's sinks capacity by increasing corporate investment in revegetation for environmental purposes.

  The program builds on existing Natural Heritage Trust programs, in particular Bushcare, and the Australian Greenhouse Office's (AGO) Greenhouse Challenge program. By linking revegetation activities with voluntary action by industry, the Bush for Greenhouse program aims to build new partnerships between industry and landholders to achieve greenhouse and environmental outcomes.

  Revegetation needs to be maintained over the long term, cover a wide geographic diversity and use local native mixed species. It is also aimed at reducing land degradation.

- ***Greenhouse Friendly***

  The AGO's recently established Greenhouse Friendly certification program enables product manufacturers and service providers to obtain certification by the Australian Greenhouse Office for products or services whose greenhouse emissions have been offset by activities to reduce greenhouse emissions in other areas (AGO, 2002).

  There are two possibilities for the GBCMA and the agricultural industry in the region under this program:

  1. Further build the image of the 'clean and green' image of the Goulburn Valley by obtaining certification for some of the regions' products.

  2. Putting forward greenhouse gas abatement or sinks projects to offset emissions from other products. For example, BP needs to invest in greenhouse mitigation projects to offset its Ultimate fuel. The GBCMA

projects developed under the GGAP program could be eligible projects with minimal additional investment.

- ***Greenhouse Challenge***

  Established in 1995, Greenhouse Challenge is a joint voluntary initiative between the Commonwealth Government and industry to abate greenhouse gas emissions. Participating organisations sign Cooperative Agreements with the Government that provide a framework for undertaking and reporting on actions to abate emissions. A range of private and public organisations of varying size are currently participating in the Greenhouse Challenge.

  The Greenhouse Challenge has regular annual reporting requirements, and includes an independent verification process by an independent auditor to ensure the stated abatement has been achieved.

  Greenhouse Challenge is a means for an organisation to become actively involved in reducing its greenhouse gas emissions, and gain valuable practical experience in preparation for a potentially carbon constrained economy.

- ***Cities for Climate Protection***

  Cities for Climate Protection Australia is an program which assists local governments and their communities reduce greenhouse gas emissions. The program is funded by the Commonwealth government with $13 million commited over 5 years. CCP is an international trade-marked program of the International Council for Local Environmental Initiatives (ICLEI) delivered in collaboration with the Australian Greenhouse Office (AGO).

  The program provides local governments with a strategic milestone framework, helps them to identify the emissions for their councils and communities, set a reduction goal and develop and implement an action plan to reach that target.

  At 1 January 2002 there were 144 local governments, representing 59.7% of Australia's population involved in the program. The City of Greater Shepparton and the City of Campaspe joined the program in January and December 2000 respectively, and have both reached Milestone 2 of the 5 milestone program[20].

4.2.2 State Government of Victoria

The State Government of Victoria is currently developing the Victorian Greenhouse Strategy (VGS). A discussion paper for public comment was

[20] Cities for Climate Protection – 2000/2001 Program Report, Australian Greenhouse Office webpage. http://www.greenhouse.gov.au/lgmodules/ccp2001/activities.html

released in 2001, and a draft strategy is expected to be released for comment by mid 2002. Little information is currently available on the VGS, except that provided in the discussion paper. The VGS will complement the National Greenhouse Strategy (NGS) released by the Commonwealth Government in 1998. It is understood that the VGS will contain some State government programs to address greenhouse issues similar to the AGO's programs, but not as extensive. Some key greenhouse programs established at a State level include:

- ***Growing Victoria's Greenhouse Sinks***

This program provides funding of $ 9 million over 3 years – with $ 4.5 million focussing on long term environmental plantings that promote biodiversity outcomes and reduce land and water degradation. Matching investment from the private sector is also sought in these areas.

- ***Plantations for Greenhouse***

This program aims to increase the area of carbon sinks in Victoria by funding farm forestry with interested landholders. This initiative offers eligible landowners the opportunity to invest in farm forestry and integrate forestry into the agricultural landscape.

4.2.3 Private Sector

There has been some limited public sector interest in investing in greenhouse gas mitigation projects to offset their own greenhouse risk, and to ready themselves for a carbon constrained economy. In Australia, much of this investment has been in carbon sink projects. However, it is unlikely that there will be significant private sector investment in greenhouse projects until the Kyoto Protocol is ratified, or some other international greenhouse agreement is reached.

The current Greenhouse Friendly program managed by the AGO (see Section 4.2.1) provides another mechanism for investment by greenhouse projects by the private sector. As mentioned previously, BP is looking for project to offset its new greenhouse friendly labelled *Ultimate* fuel. At the current time, investment in greenhouse abatement projects under this program is not widespread in the private sector. Projects developed by the GBCMA for the GGAP bid could be presented for funding under this program.

4.3 Greenhouse Action to date in the Goulburn Broken Catchment

The Goulburn Broken Catchment Management Authority (GBCMA) recognises the importance of putting in place strategies and actions for the management and

abatement of greenhouse gas emissions and to manage the risk associated with global warming.

In September 2000, the GBCMA submitted a funding application to the Australian Greenhouse Office under the Greenhouse Gas Abatement Program. The funding submission included a range of projects to reflect the diversity of opportunities to improve greenhouse gas abatement and management in the region, and contribute to mitigating global climate change. The GGAP proposal was submitted under the Regional Partnerships program theme of GGAP, for projects that "encourage significant and sustained reductions in greenhouse emissions across regional Australia in various sectors". Projects in the proposal included:

- a large scale nitrous oxide and methane project with the dairy industry;
- various energy efficiency projects within the food processing industry;
- extensive farm forestry and environmental plantings;
- waste and wastewater management projects including the capture and reuse methane emissions by industry;
- improving efficiency within the freight transport sector.

Baseline greenhouse gas emissions and projected savings, along with cost-benefit analyses were determined for each project as part of the proposal preparation.

As part of the AGO's shortlisting process, the range of projects was reduced to ensure all projects in the proposal met the AGO's GGAP criteria (See Section 4.2.1). Many of the other projects working with specific industries were assessed as not being viable or were not additional to 'business as usual' requirements for maintaining business operations and competitiveness. The GBCMA GGAP proposal was unsuccessful in Round 1 of the GGAP, but the GBCMA was strongly encouraged by the AGO to re-submit in July 2002.

As part of this Round 2 submission, it was determined that the area where the GBCMA is able to make the most difference in addressing greenhouse gas abatement is in the area of agricultural land management, working with the dairy industry and encouraging farm forestry and environmental plantings. Abatement from these projects was identified at 1,921,213 tonnes of $CO_{2\text{-}e}$ in the first commitment period (2008 – 2012), at a cost of $10.97 per tonne of GGAP dollars invested. While there was significant interest in the GBCMA proposal, it was ultimately unsuccessful as regional partnership projects were unable to compete for government funding with large scale, energy intensive industries who were able to offer a higher level of private sector matching funds. Successful projects abated 1 to 4.1 million tonnes of $CO_{2\text{-}e}$ in 2008 to 2012 at a cost of between $3.65 to $10 per tonne of GGAP funding.

While the GGAP bid was ultimately unsuccessful, the information gathered in the process was valuable. The project identified a range of large and small scale greenhouse gas abatement projects in the region, and raised the profile of the GBCMA in the greenhouse field in Australia, particularly with the AGO. It also identified a number of alliances for greenhouse gas abatement in the region, including the University of Melbourne, Goulburn Valley Water, Murray Dairy and the Department of Natural Resources and Environment to name a few.

5.

6. RECOMMENDATIONS

The following recommendations are made to address climate change and greenhouse gas abatement and management issues in the Goulburn Broken Catchment. These focus on:

- Better determining the threat of climate change to the region;
- Preparing industry in the catchment, particularly agriculture, for the potential constraints put on them to assist in meeting Australia's international commitments to reduce our greenhouse gas emissions

A number of these recommendations have been developed following consultation with the stakeholders listed in Appendix 2.

6.1 INFORMATION GATHERING

6.1.1 Specific modelling of regional climate change and its impacts

Much work has been done over recent years to identify and address greenhouse gas abatement issues, but little has been done to manage the risks associated with global warming. Even if the Kyoto Protocol is ratified and all developed countries (including the USA) meet their Kyoto targets, significant climate change is still predicted. This will require significant adaptation to changing climate, which is particularly important for natural resource and agricultural management.

The extent of the impact of climate change on scarce water resources in the Goulburn Broken Catchment is an area requiring further research. Future water resource management is often based on historical flow information that assumes future climate will remain unchanged. However, CSIRO data suggests that climate change will result in less water availability in the Goulburn Broken Catchment. Water is already an expensive and restricted resource in the Goulburn Broken Catchment, with increasing demands for water resources for environmental flows and a growing dairy industry. To gain a better understanding of climate change in the region, and the impact of water resources, it is suggested that:

- Specific climate change modelling be undertaken for the Goulburn Broken Catchment to better estimate regional changes in rainfall and evaporation under different scenarios;
- Outputs from the regional climate change model be incorporated into hydrological models to determine the impact of changes in rainfall and evaporation of streamflow and the availability of water resources for key uses such as irrigation.

This is a similar approach to that use in the Macquarie Catchment as described in Section 2.4.1 This information would be valuable to assist in the future management of water resources in the region.

6.1.2 Develop a Greenhouse Gas Inventory for the Goulburn Broken Catchment

To gain a better understanding of the greenhouse gas sources and sinks in the catchment, and provide a baseline against future greenhouse management could be measured, it would be beneficial to develop a Greenhouse Gas Inventory for the Goulburn Broken Catchment. This should focus particularly on the natural resource and agricultural sectors of relevance to the GBCMA's activities, but should also be coordinated with work being undertaken in other sectors. For example, the City of Greater Shepparton has developed an inventory for its activities under the Cities for Climate Protection Program. Similarly, some work has been done to develop a profile of greenhouse gas emissions from dairy farms.

The GBCMA could play a central role in consolidating greenhouse gas emission and sink information and in managing a coordinated approach to reducing greenhouse gas emissions and enhancing carbon sinks. For example, greenhouse gas emissions from growth of the dairy industry could be offset by sinks elsewhere in the catchment. This is discussed further under Coordination.

6.2 COORDINATION

6.2.1 Incorporate greenhouse action as an integral part in all strategies and programs

Greenhouse mitigation action should be a key component considered in all programs managed by the GBCMA. Greenhouse gas abatement or sink enhancement can be an additional benefit of many projects aimed an improving agricultural and natural resource management. For example, improved water use and fertiliser application efficiency in the dairy industry can provide a significant reduction in nitrous oxide emissions. Similarly, environmental plantings, aimed at providing biodiversity and salinity benefits, if properly planned and managed can be significant carbon sinks. To maximise such multiple benefits, greenhouse

should be considered in all relevant programs and strategies, and built into the cost sharing arrangements of natural resource management programs.

6.2.2 Develop a catchment approach to greenhouse management

A regional approach to greenhouse gas abatement and management is recommended, whereby emissions from one sector may be offset by another sector within the catchment. For example, while there are significant opportunities to reduce greenhouse gas emissions and improve productivity in the dairy industry through optimising water, fertiliser and electricity use, it would be not make economic sense to establish forest sinks on highly productive irrigated dairy pastures. A better approach would be to optimise land use according to land capability, increasing the agricultural productivity from the most productive agricultural areas, while focusing on marginal agricultural land as the main area for the establishing carbon sinks. To assist industry familiarise itself with domestic and international emissions trading, an informal emissions trading system within the catchment could be established.

The GBCMA, as the authority responsible for managing land and water resources in the region, would be well placed to coordinate greenhouse action in the region.

The development of a regional Greenhouse Strategy would provide a framework for managing the risk of climate change and greenhouse gas management in the region, and is discussed further below.

6.2.3 Industry involvement

Feedback from industry contacted as part of this report indicated the importance of including industry in all greenhouse strategies and action in the region. The approach used in the development of the GGAP proposal, coordinating input from a range of players involving industry, GBCMA, State Government, and a research organisation was identified as a good model for coordinated greenhouse management in the region. Including industry bodies was seen as the most successful way of including landholders in action to address greenhouse issues. For example, Murray Dairy has offered its services to facilitate any activities aimed at including the dairy industry in greenhouse gas abatement and management.

6.2.4 Continue to build a relationship with the Australian Greenhouse Office and Department of Natural Resources and Environment

Through the development of its Round 1 and 2 GGAP bid, the GBCMA has established a significant positive profile within the AGO. It also highlighted the need for the Commonwealth Government to support greenhouse gas abatement in the agricultural sector, as agriculture makes up 20% of Australia's greenhouse gas emissions. It is important to continue to build this relationship, and continue

to seek support for greenhouse action in the agriculture sector. Within current AGO programs, the new Greenhouse Friendly Program provides some opportunities for the GBCMA, and should be explored further.

At a State level, the Victorian Government is due to release the Victorian Greenhouse Strategy (VGS). The VGS has been developed by the Greenhouse Policy Unit of the Department of Natural Resources and Environment. It is understood that programs to address agricultural greenhouse gas emissions with be an important part of the VGS, and some funding programs will be established. GBCMA should work closely with DNRE to identify opportunities for coordinated greenhouse action in the catchment.

6.3 STRATEGY DEVELOPMENT

As outlined in Recommendation 6.2.2, it is recommended that a specific greenhouse strategy be developed for the Goulburn Broken Catchment. This would provide a structured framework for addressing greenhouse gas abatement and management in the region, and should include:

- Adaptation strategies and actions for addressing predicted climate change on agricultural sustainability and natural resource management in the region;
- Strategies and actions to reduce the greenhouse gas emissions and vegetation sinks in the region.

The Strategy should be aligned with the Commonwealth's National Greenhouse Strategy and the Victorian Greenhouse Strategy. This would facilitate opportunities for funding greenhouse action, and demonstrate a willingness of the region to address greenhouse issues.

This paper goes a long way towards the development of a more formal greenhouse strategy.

6.4 FUNDING

The GBCMA should continue to seek opportunities for accessing funds for greenhouse gas abatement in the region. Some of the funding opportunities have been discussed in the main document and recommendations above, and are summarised below:

- **AGO Greenhouse Friendly program**: Explore opportunities for project put forward in the GBCMA's GGAP bid to be privately funded as offset projects for Greenhouse Friendly certified products.

- **Victorian Greenhouse Strategy programs**: Keep up to date with development of the VGS and supporting programs. It is understood that the VGS will include programs to address greenhouse gas emissions and sinks in the agriculture and land management sectors.

- **Greenhouse benefits in existing programs:** Promote the greenhouse benefits associated with in existing programs (eg NHT) and enhancement of cost sharing arrangements and funding opportunities.

APPENDICES

Appendix 1 Greenhouse gas emissions profile of dairy farms in the Goulburn Broken Catchment

	Carbon Dioxide (t CO2-e)	Methane (t CO2-e)	Nitrous Oxide (t CO2-e)	Total (t CO2-e)
Energy generation				
Electricity use				
• milk harvest/storage	68.573	0.149	0.148	
• irrigation				
Fuel/Oil use	24.495	0.082	0.21	**93.657**
Pasture Management				
• improved pasture			26.793	
• fertiliser application			5.894	**32.687**
Livestock				
• enteric emissions		671.79		
• methane from faeces		14.832		
• nitrogen from faeces			113.167	
• nitrogen from urine			107.304	**907.093**
TOTAL (t CO2-e)	**93.068** (9%)	**686.853** (66%)	**253.516** (25%)	**1033.437**
No. dairy farms				3000
Total dairy farm emissions (t CO2-e)				**3,100,311**

Appendix 2 - People contacted during development of Directions Paper

Name	Organisation	Comment
Roger Jones	CSIRO, Division of Atmospheric Research	Phone conversation 14/3/02, documents provided
Peter Whetton	CSIRO, Division of Atmospheric Research	Phone conversation 14/3/02, documents provided
Richard Eckard	Institute of Land and Food Resources, University of Melbourne	Phone conversation 15/3/02, documents provided.
Rod Anderson	Department of Natural Resources and Environment	Phone conversation 15/3/02.
Snow Barlow	Institute of Land and Food Resources, University of Melbourne	Phone conversation 21/3/02.
Nives Milanovic	Dairy Research and Development Corporation	Phone conversation 24/3/02.
Maurice Incerti	Murray Dairy	Phone conversation 21/3/02, document provided