F I N A L R E P O R T

Economic Analysis of the Corangamite Soil Health Strategy

Prepared for

Department of Primary Industries

PO Box 103
Geelong Victoria 3220

November 22 2005

42443948

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Date: November 22 2005
Reference: 42443948
Status: Final report

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Executive Summary

This report provides a benefit-cost analysis of improvements in soil health from the actions included in each program of the Corangamite Soil Health Strategy (CSHS). This analysis considers the on-farm (private) and off-farm (public) benefits both *with* and *without* the Strategy. This work expands on earlier work completed in December 2003 by assessing the off-farm (public) benefits of the CSHS.

Specifically, consideration is given to a range of soil processes that represent "threats" to the assets and asset values of the Corangamite region. These assets and asset values include agricultural production, environmental health, public infrastructure and utilities, water quality and cultural heritage. Soil processes that pose threats to these assets include: soil acidity, acid-sulfate soils, soil structure decline, soil salinity, waterlogging, soil erosion, soil nutrient levels, landslides, contaminants, soil biota decline, and organic carbon decline.

The analysis distinguishes between actions that will generate benefits on-farm, which flow to landholders, and benefits realised offsite that accrue to the community more generally.

The benefit-cost analysis quantified the benefits and costs of:

- on farm CSHS actions relevant to the cropping, dairy, broad acre grazing and private forestry industries;
- on-farm actions to address soil (sheet and gully) erosion;
- off-farm actions from addressing landslides and acid sulphate soils; and
- actions that reduce the impact of sediment export on public infrastructure.

Due to insufficient data, the analysis was not able to quantify the benefits of:

- improvements in water quality and river health from CSHS actions that reduce sediment and nutrient export;
- avoided legal and investigation costs to municipalities, the Corangamite CMA and state agencies, due to the implementation of Erosion Management Overlays;
- increased soil biota and organic carbon in the soil profile;
- reduced off-farm impacts from acidification and contamination; and
- reduced impacts of saline discharge on public infrastructure.

Benefits and Costs

The development of the CSHS represents a major first step in addressing the important issue of soil health in the region. Overall the CSHS is estimated to be economic by delivering significantly more economic benefits than the costs of implementing the Strategy. After allowing for program implementation costs with a present value of $11.4 million, a net present value (NPV) of $12.9 million is estimated.

The CSHS is estimated to deliver on-farm benefits of around $23 million and off-farm benefits of $1.3 million in present value terms (discount rate of 8 per cent over 30 years). These benefits are considered a significant under-estimate due to the inability to quantify the benefits of all elements of the Strategy – in reality the proportion of public benefits would be greater.

On-farm benefits

The net benefits for agricultural industry programs under the CSHS are estimated to be greatest by far for the broad acre grazing industry ($19.9 million). Positive benefits were also estimated for the dairy ($2.8 million) and cropping industries ($1.7 million). While, the overall NPV for the private forestry program was estimated to be negative, the implementation of the industry code of practice was estimated to produce substantial economic gains.

Off-farm benefits

As noted above, the assessment of off-farm benefits from the CSHS was largely hampered by information gaps. Prospective benefits from actions that provide off-farm benefits are estimated for actions addressing landslides ($508,000), acid sulphate soils ($541,000) and soil erosion ($221,000). However, the NPVs for each program were negative after allowing for implementation costs.

Recommendations

Extension efforts to agricultural producers under the Strategy should focus on the specific on-farm actions with the highest estimated payoff. These include:

- Graze and spell rotation, fertiliser management and land class fencing for the broad acre industry;
- Minimum till in the cropping industry;
- Reversing wet soils and introducing best management practices for nutrient export in the dairy industry; and
- Implementing the code of practice in private forestry.

Demonstrating the economic merit of these actions will be an important part of encouraging adoption of these practices.

The analysis showed that the investment in the remediation of sheet and gully erosion is negative from a landholders' point of view and marginal from a public benefit point of view. Such works should be restricted to sites with high sediment (and nutrient) loads that are closely connected to waterways with high values (economic, social and environmental) *and* where water quality is a threat. The Barwon and Corangamite basins are areas where return on investment is likely to be highest.

It is likely to be more worthwhile to focus on extension activities to assist landholders to avoid the formation of erosion sites rather than treat already degraded sites. The Leigh, Woady Yaloak and Moorabool landscape zones are areas of high priority for this work.

Based on a marginal NPV, actions to stabilise landslides should be focused on locations where there is a very high risk to public safety and public infrastructure.

Of particularly high importance is the need to map soil threats in the region, particularly priority landslide risk sites, the location of potential acid sulphate soils and soil erosion sites.

Priority research and development actions

In terms of off-farm issues, significant further research should be conducted into assessing the off-site impacts of soil health issues. In particular there is a need to gain a better understanding of the connectivity between land (soil) and water resources and to clarify the contribution of soil erosion to sediment and nutrient loads through the region. Other areas where research would be valuable include:

- improved research into the prediction of landslide impacts;
- improved understanding of the extent of soil biota and organic carbon decline and the existence of public benefits to be gained by addressing these issues.
- research into off-site impacts of drainage works on salinity.

Directions for cost-sharing

The Corangamite Catchment Management Authority has two factors to consider in assessing prospective benefits as part of its responsibility for addressing environmental threats to the region's assets. Firstly whether a prospective action is economic and secondly who will benefit from this action. The first factor indicates whether this work should proceed, the second factor indicates how the funding of this work should be shared. For actions relating to particular agricultural industries, the benefits will flow primarily to landholders. For actions that reduce sediment and nutrient export, the benefits will accrue to the community more broadly. Public funds should be directed towards the latter category of actions. For both types of actions the Corangamite CMA has a crucial central co-ordinating role. For profitable on-farm CSHS actions, landholders should bear the on-farm cost of implementation. However, it is appropriate for programs providing information and extension services in this area to be co-funded by government and industry.

Implementation

The successful implementation of the CSHS will clearly require adequate funding and support from local government and relevant State government agencies. A very important stakeholder is also the region's agricultural industry. This stakeholder manages most of the land in the region and the vast majority of land where soil health is a priority threat. A pre-requisite for the success of the Strategy will therefore be the ownership of the CSHS by this industry and its involvement in implementing it.

Requirement for a more accurate economic analysis

A more accurate economic analysis, addressing all aspects of the CSHS will require substantial additional information. It is recommended that this analysis be updated after progress has been made in implementing the research and mapping actions, as recommended above. A key area of research is the link between on-ground actions and impacts on water quality and river health.

1.1 General

As identified in the Corangamite Soil Health Strategy (CSHS), some soil processes threaten agricultural industries, environmental health, and public assets throughout the Corangamite Catchment Management Authority (CCMA) region.

Various natural resource management sub-strategies of the Regional Catchment Strategy (RCS) have been developed that partly address threats to soil health in the region. These are outlined in the CSHS and include:

Corangamite Salinity Action Plan

Corangamite Waterway Health Strategy

Corangamite Biodiversity Action Plan

Corangamite Native Vegetation Plan

Corangamite Nutrient Management Plan

Corangamite Weed Action Plan

Corangamite Rabbit Action Plan

Corangamite Landcare Strategy

Coast Action Plans

The CSHS is being prepared to build on existing work and develop an over-arching framework that addresses *all* soil health threats.

The specific objective of this report is to undertake a benefit cost analysis of the CSHS.

1.2 Background & Acknowledgements

This report represents the second stage of work prepared in December 2003 as a joint collaboration between RMCG Consulting and URS Australia Pty Ltd (URS). The earlier report examined the benefits and costs of the Draft CSHS, but due to time constraints, focused primarily on private benefits. This report has been prepared to expand on the earlier analysis in providing a more detailed assessment of the public benefits of the CSHS.

This report has utilised some of the work completed since the December 2003 report was prepared. This includes further mapping of gully and sheet erosion and landslide sites, a draft benefit cost analysis of the Corangamite River Health Strategy and a paper on the public benefits of the CSHS by Peter Dahlhaus of Dahlhaus Environmental Geology Pty Ltd.

In completing the current project, URS would like to acknowledge the valuable assistance of Troy Clarkson from the Department of Primary Industries and Peter Dahlhaus (Dahlhaus Environmental

Geology Pty Ltd). The waterway management unit of the Corangamite Catchment Management Authority provided advice for assessing the impacts of improved soil health on waterways.

1.3 Structure of the report

The costs of poor soil health into the future were identified *with* and *without* the Corangamite Soil Health Strategy. This information was used in a benefit-cost analysis of the actions included in each Program. Cost sharing principles, based on the economic principles of beneficiaries' pay and/or polluters pay were discussed to assist in formulating cost sharing arrangements for each action. Finally, principles to consider for directing investment in the region to improve natural resources are discussed.

Important Note

There is often imperfect scientific knowledge from which to make predictions about the losses in farm production and off-farm impacts resulting from the various causes of poor soil health. This means that the results of any economic analysis of soil health must at best be regarded as indicative. Whilst this study identified major deficiencies in technical data, it provides useful information about priorities for further research

The Corangamite Catchment Management Authority (CCMA) region encompasses an area of 1,335,000 hectares, which is around 6 per cent of the total area of Victoria. The major river catchments in the region include the Barwon, Moorabool, Corangamite (including the Woady Yaloak River system) and Otway Coast Basins.

2.1 Current land Use and Enterprise Mix

Land use data within the CCMA region was sourced from the Strategic Resource Planning Unit of the Department of Primary Industries, based in Bendigo.

Table 2-1: Land Use in the Corangamite Region

Land Use	Area	
	Hectares	%
Agriculture	899,893	67%
Production Forest	133,356	10%
Conservation & Natural Environments	117,469	9%
Plantations/Plantation Forest	34,689	3%
Water (incl Lakes Rivers, Wetlands)	47,388	4%
Services (incl. roads)	54,419	4%
Residential	38,583	3%
Other	9,456	1%
Total	1,335,252	100%

Source: Strategic Resource Planning Unit, Department of Primary Industries (2003).

2.2 Agricultural land use

Agricultural land use in the CCMA region is primarily (over 80 per cent) improved pastures for grazing. Table 2-2 shows that the next biggest land use is cropping (mainly cereals).

Table 2-2: Area of agricultural land uses in the Corangamite region

Agricultural Land use (excluding forestry)	Area (Hectares)	Total Area (%)
Grazing Modified Pastures	736,695	82%
Grazing Natural Vegetation	61,796	7%
Cropping	94,676	11%
Horticulture (incl. irrigated)	4,952	1%
Irrigated Pastures/Cropping	988	0%
Intensive Agriculture	785	0%
Total	899,893	100%

2.3 Production Systems

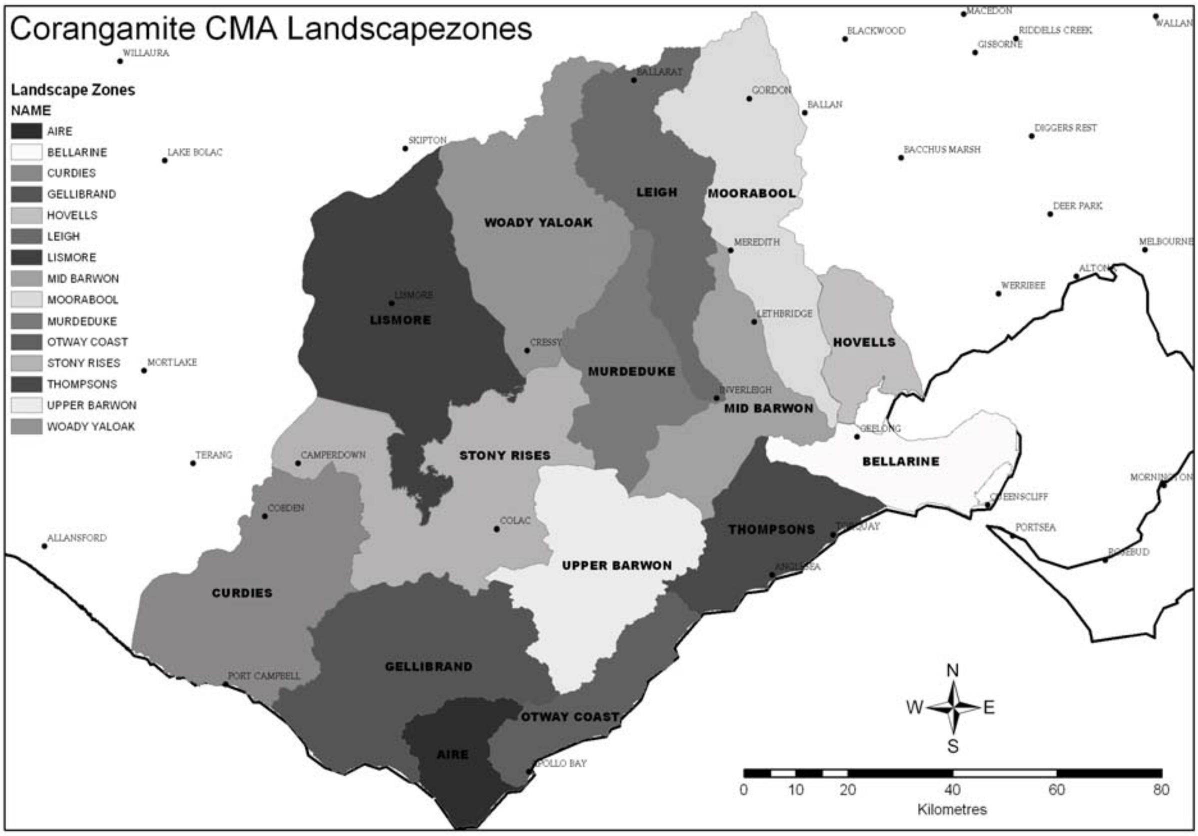
Production systems vary in the study area, and the benefits of the proposed action will be different for different production systems. MacEwan (2003) stated that there are five main production systems in the study region, which are relatively specialised geographically with their own set of soil management problems. Partly based on these, the main production systems that have been identified in the CCMA region are:

1. Broad Acre Cropping
2. Dairy
3. Broad Acre Grazing of Cattle and Sheep
4. Farm Forestry
5. Native Public Forestry

2.4 Landscape zones

There are fifteen landscape zones that have been identified in the CCMA region, as noted in the CSHS. These zones are used to manage other Corangamite sub-strategies such as the River Health Strategy. Landscape Zones are areas associated with sub-catchment and social boundaries. Figure 1 presents these landscape zones.

Figure 1: Corangamite CMA landscape zones



3.1 Introduction

Some soil processes are "threats" to the asset values of the Corangamite region. These asset values include agricultural production, environmental health, public infrastructure and utilities, water quality and cultural heritage. The Corangamite Soil Health Strategy Technical Group identified the following soil health threats in the study area: soil acidity, acid-sulfate soils, soil structure decline, soil salinity, waterlogging, soil erosion, soil nutrient levels, landslides, contaminants, soil biota decline, and organic carbon decline.

It is common that degraded or unhealthy soils will be characterised by the simultaneous occurrence of several of these processes. For example, as the acidity of a soil increases, its structure may decline leading to erosion, increasing nutrient loads in streams, increasing groundwater levels and salinity.

Just as some practices jointly produce various forms of degradation, it is fortuitous that other practices can jointly produce reductions (benefits) in various forms of degradation. For example, the planting of deep rooted perennials in appropriate locations may simultaneously reduce groundwater recharge, reduce nitrate leaching – the latter being one of the major causes of soil acidification - and reduce erosion.

A brief description of each soil health threat is provided below. A more detailed description is available in the Draft Corangamite Soil Health Strategy.

3.2 Soil Acidity

There is currently incomplete information available about the extent and distribution of soil acidity problems in the Corangamite Region. However it is likely that grazing production systems are generally more greatly affected. The existence of soil acidity problems is indicated by the extensive application of lime by farmers in the region.

3.3 Soil Erosion

A preliminary analysis of the extent of sheet and gully erosion is provided by Feltham et al (2005) using analysis of aerial photography and some site inspection. The analysis provides estimates of the area and number of sheet and gully erosion sites. While this analysis is not yet complete, it does indicate that the Leigh, Woady Yaloak and Moorabool are key landscape zones where soil erosion is an issue.

Another soil erosion issue in the Region is the movement of coastal sand dunes. There is currently limited information on the extent of the threat that these sand movements pose to assets in the Region.

3.4 Acid Sulfate Soils (ASS)

There is limited information available on the distribution of potential acid sulfate soils in the CCMA region. Some indication is provided by the Cox *et al* (2005) desktop study of the Greater Geelong area.

The total estimated area of potential ASS has been estimated at 11,300 hectares (Cox *et al* 2005), and 13,845 (DPI, 2003). Cox *et al* estimated that 54 square kilometres (0.40 per cent of CMA area) of potential ASS is located in inland areas while 59 square kilometres (0.44 per cent of CMA area) is located in coastal areas.

3.5 Soil Structure

There is currently limited data on the extent and distribution of soil structure decline in the Corangamite Region. However soil structure decline is most likely to occur in cropping followed by dairying areas, with broad acre grazing country also affected.

3.6 Soil Salinity

Soil salinity is the result of salt accumulation in the soil to the extent of reducing the capacity of the soil to support plant growth. The issue of salinity in the Corangamite Region is covered comprehensively in the Corangamite Salinity Management Plan. The Salinity Management Plan seeks to minimise the extent of salinity in the region. The inclusion of salinity in the CSHS is limited to managing sites where salt is discharging onto land.

3.7 Soil waterlogging

Waterlogging, specifically pugging (compaction by livestock), is a significant issue in the Corangamite region, primarily in the clay soils the Heytsbury and Volcanic Plains areas used for dairy farming.

3.8 Landslides

Corangamite landscapes are among the most landslide prone in Australia. Extreme rainfall is the dominant trigger for landslides in the region. The total number and area of landslide sites in the Corangamite region have been estimated by Feltham *et al* (2005). Landslides and erosion pose risks to infrastructure assets, water quality assets, agricultural assets, environmental assets, and human life.

3.9 Soil nutrient levels

Soils in the Corangamite Region have inherently low nutrient levels relative to the requirements of the region's current agricultural systems. This has led to the inclusion of a fertiliser application regime in these systems. In some instances excessive nutrients have been applied to create an environment of excessive soil nutrients, while in other cases a decline in nutrients has occurred.

There has been little quantification of the extent of nutrient level problems. However there is anecdotal evidence that some soils in dairy areas have excessive phosphorous levels both from an agricultural production and environmental perspective. Areas also exist where nutrient deficiencies are the cause of unproductive agricultural systems and poor amenity attributes.

3.10 Contaminants

The contamination of soil with chemicals largely stems from past practices. Examples of contamination include hydrocarbon contamination from fuel tanks and pesticides (e.g. Dieldrin). There is currently little information about the level of soil contamination in the Corangamite Region. This makes it difficult to assess the importance of this issue at present.

3.11 Soil biota and organic carbon decline

There is little currently known about soil biota in the Corangamite Region, including trends in biota levels. Organic carbon levels have also not yet been mapped in the Corangamite Region.

4.1 Benefit Cost Analysis

Benefit cost analysis has been used in evaluating the proposed actions of the Corangamite Soil Health Strategy. This methodology is applied by:

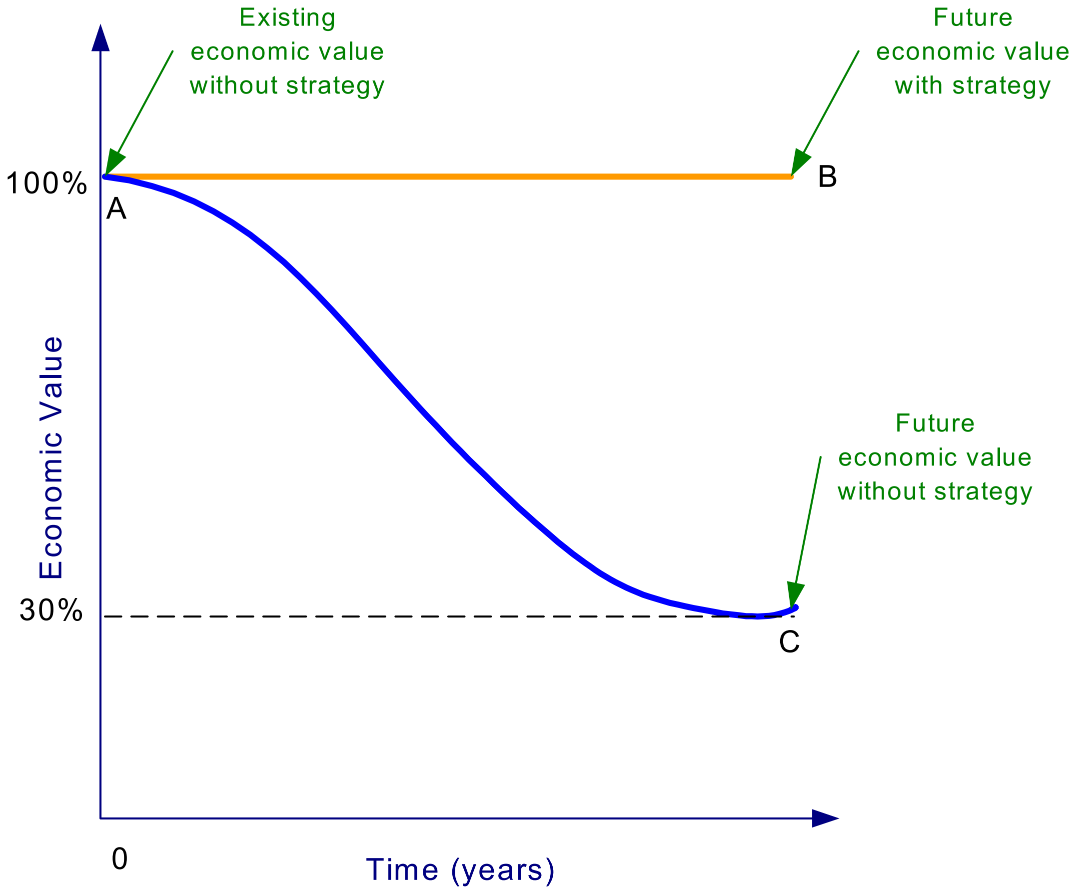
- estimating the impacts of soil degradation *without* the Corangamite Soil Health Strategy;
- estimating the impacts of soil degradation *with* the Corangamite Soil Health Strategy;
- subtracting the *without* estimates from the *with* estimates to obtain the benefits of the Corangamite Soil Health Strategy; and
- comparing the benefits and costs.

The process of discounting enables the direct comparison of amounts of money that accrue in different time periods. Discounting gives greater weight to initial benefits and costs and less weight to those in the distant future. The present value of a future sum is lower the higher the discount rate. A 'real' discount rate (based in inflation-free interest rates) of 8 per cent has been used in this evaluation with an investment horizon of 30 years. A sensitivity analysis using a rate of 4 per cent is also provided. For more information on discounting, refer to Appendix A.

4.2 With and Without Strategy Scenarios

The benefits of any strategy are measured as the difference in benefits with and without the intended strategy. An example is depicted in Figure 4-1. This diagram shows the 'with strategy' scenario as a constant line, suggesting a preservation strategy (as opposed to an improving strategy, which is also possible) while the 'without strategy' scenario shows the future decline in economic value without the proposed strategy. The area ABC in Figure 4-1 corresponds to the benefits of this strategy.

Figure 4-1: With and without strategy scenarios



The unifying principle is that the 'with' and 'without' scenarios must be adequately defined and described because the difference between these two scenarios gives the magnitude of the respective benefits.

4.3 Classes of Benefits

All the benefits that might arise from a soil health action must be listed in the analysis and valued where possible. It can also be useful to classify the benefits in different ways. In this analysis, we make use of three broad classifications of the social benefits that might arise from a soil health program, namely:

- use and non-use benefits;
- priced and unpriced benefits; and
- private and public benefits.

4.3.1 Use and non-use benefits

The use benefits of a soil health action program are those that stem from improvements in the productive use of the soil. Use values will constitute the most obvious benefits because the majority of the soil affected by the action program is used in agriculture. Healthier soils produce higher yielding crops and greater farm income. There may also be important off-site benefits from improved soil health, for example, that result from improved water quality due to reduced erosion. This has a "use value" as improved water quality would reduce the frequency of algal blooms and make the waterways more attractive for recreational use.

Use values can be distinguished from those values people place on such things as the landscape or waterways even though they do not make use of them. These non-use values are more controversial than use values and are associated, amongst other things, with the benefit people might derive from knowing that improved habitat for native fish or wildlife exists because of improvements in water quality.

4.3.2 Priced and unpriced benefits

We can distinguish between those goods and services provided by actions of a soil health strategy that are traded in markets and those which are not. The former are called priced, or market values, while the latter are referred to as unpriced, or non-market values.

The goods and services produced from agricultural use of the soil are traded in markets and, therefore, can be readily priced. But, of course, not all use values are priced. For example, there is no market for enhanced recreational opportunities that arise from improved water quality. Non-use values do not have price, however methods exist to impute these values.

4.3.3 Private and public benefits

The total benefits of the CSHS include both private goods and public goods. Private goods and public goods are terms used in discussions about the extent of excludability of a particular good. By excludability, we mean the ability for users of a good to deny access to other potential users. A major difficulty is that there are degrees of excludability so, in discussing these matters economists have described the two extremes of the possible variation in extent of excludability. The terms 'private goods' and 'public goods' are used to represent those two extremes.

The use of a pure private good is totally excludable; that is, the person possessing the good can deny access to all other potential users. A car is a pure private good - you cannot legally drive my car without my permission.

By contrast, a pure public good is totally non-excludable; that is, once a unit is produced, it is available to all. For example, citizens cannot be excluded from the benefits of a program of national defence.

Public and private goods can also be categorised by another characteristic termed the 'rivalness' characteristic. Again, pure public and pure private goods represent the extremes of this characteristic.

A pure private good is rival in consumption, that is, your satisfaction is diminished by my consumption. The meal I eat cannot be enjoyed by anyone else. Similarly in soil health, a higher crop yield due to better management will only benefit the landholder.

By contrast, a pure public good is totally non-rival in consumption, that is, it can be made available to many users simultaneously without diminishing the satisfaction gained by any one user. The two of us can enjoy a TV transmission simultaneously and your enjoyment does not diminish mine. Similarly in soil health, reduced sediment inflow into a stream will result in better water quality in the stream for the local community and tourists' enjoyment.

Public and private goods seldom exist in the pure forms and many goods possess these two characteristics to varying degrees. This means that there are relatively few examples of pure private goods and public goods - the use of most goods has a degree of excludability, and there is a continuum between pure private goods and pure public goods.

The distinction between private goods and public goods provides the economic characteristics of a good relevant in considering whether government needs to be involved in the provision of a particular good and, if so, who should bear the cost for the provision of that good.

On-Farm Private Benefits and Costs of the CSHS

5.1 Estimating the on-farm benefits and costs of the CSHS

The private (on-farm) benefits and costs of the appropriate soil health strategy actions were estimated for each of the major production systems in the Corangamite region. In doing so it was assumed, where costs for additional farm capital are not costed, that the existing farm assets are adequate for implementation of the various actions. The change in operating costs resulting from the actions has been included in the analysis, but not any expenditure on business assets such as extra livestock. The impact on farm cash flow from funding the additional variable costs and extra livestock capital can be considerable, even though it will be generally offset by extra income.

The process for estimating the on-farm benefits and costs is quite detailed. The findings of this analysis are summarised in this section. A more detailed analysis is provided in Appendix B. For a list of the key assumptions used in the benefit cost analysis, see Appendix C. Throughout this report all benefits and costs have been discounted at 8 per cent over 30 years.

5.2 Assessment of CSHS actions

In reality, farmers adopt a mix of practices rather than specific practices in isolation. To account for this we have estimated the cost and benefits of adopting a combination of the practices under the CSHS for each production system. This has been based on estimates of:

- Average private (landholder) costs per hectare;
- Average private (landholder) benefits per hectare, such as increased yield;
- Current levels of adoption by landholders;
- Rates of new adoption by landholders (both with and without the CSHS).

These estimates were prepared by RMCG, the CSHS Project Steering Committee and other experts. The net benefit of each action reflects a combination of the actual on-farm impact of each action, the expected increase in adoption under the strategy and the program costs associated with implementing each action.

5.3 CSHS actions not assessed

Where the action is to investigate a practice and the on-farm benefits and costs are uncertain, the practice has not been assessed (i.e. no benefits have been included). More specifically, this applies to the following CSHS Actions relating to cropping and dairy systems:

- investigate alternative practices for stubble management to encourage stubble retention for cropping;
- support research into no-till practices for cropping; and
- further investigate and extend management strategies to reduce nutrient loss to waterways from dairy farms.

5.4 Cropping production systems

The CSHS farm practices relevant to on-farm private costs and benefits for cropping are (CSHS action number in brackets):

- To adopt cropping management practices that reduce compaction and maintain soil structure (E6). This action has two components: to increase the adoption of minimum tillage practices; and to increase in the establishment of crops through direct drilling and stubble retention.
- To apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (Action E3).

These actions are summarised throughout the report as “controlled traffic”, “minimum till” and “lime and fertility”.

A summary of the on-farm benefits, costs for CSHS actions relevant to the cropping production systems is provided in Table 5-1. In Table 5-1 ‘net on-farm benefits’ represent the total on-farm benefits, such as improved crop yields, resulting from implementation of the CSHS *less* the benefits that would have occurred anyway without the CSHS being implemented. Similarly ‘net on-farm costs’ represent the difference in costs between the ‘with’ and ‘without’ CSHS scenarios. The difference between net on-farm benefits and net on-farm costs is the total net present value (at farm level) of the increased adoption of soil health practices under the CSHS.

Table 5-1: On-farm benefits and costs of CSHS actions relevant to cropping production systems.

($'000)	Present value		On-farm NPV
Management Actions	Net on-farm benefits	Net on-farm costs	
Cropping			
Controlled traffic	$8,262	$7,201	$1,060
Lime & fertility	$5,587	$3,980	$1,607
Stubble retention			
Minimum Till	$4,451	-$20	$4,471
Combined	$5,473	$3,729	***$1,744***

Results in Table 5-1 shows that, overall, the on-farm benefits of implementing the CSHS cropping actions is expected to exceed the on-farm costs by around $1.7 million in present value terms. Of the cropping actions assessed, the minium till action is clearly the most economic, producing a net present value of $4.5 million. The lime and fertility action also is estimated to provide significant net present values.

5.5 Dairy production systems

The relevant CSHS actions to dairy production systems are:

- Apply appropriate rates of fertiliser and lime in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (E3);
- Implement best management practices for wet soils on dairy farms to improve soil health (E8); and
- Implement best management practices to reduce nutrient and sediment export to waterways (E2).

These actions are summarised in Table 5-2.

Table 5-2: An overview of CSHS relevant to dairy production systems.

Action	Specific actions and assumptions made
Drainage & grazing management	Installation of surface and sub-surface drainage, improved grazing management and installation of feed pads.
Fertiliser management	Soil testing and application of appropriate rates of fertiliser.
Effluent reuse	Installation of irrigation infrastructure for effluent reuse.
Reduce machinery compaction	Timing of operations to avoid significant soil impacts, using smaller machinery and/or larger lower pressure tyres. Extra cultivation costs and costs arising from reduced flexibility and crop yields due to reduced timeliness.
Reduce sediment loss	Establishing buffer strips along riparian zones.
Liming	Application of 2-5t/ha every seven years at the re-establishment of perennial

A summary of estimates for on-farm costs and benefits of each CSHS dairy action is provided in Table 5-3.

Table 5-3: On-farm benefits and costs of CSHS actions relevant to dairy production systems.

($'000)	Present value		On-farm NPV
Management Actions	Net on-farm benefits	Net on-farm costs	
Dairy			
Fertiliser Management	$11,257	$10,010	$1,247
Reverse wet soils	$16,099	$13,489	$2,610
BMP reduce nutrient export	$10,871	$5,684	$5,187
Combined	$13,123	$10,303	***$2,820***

The results in Table 5-3 show that, overall, the on-farm benefits of implementing the CSHS cropping actions are expected to exceed the on-farm costs by around $2.8 million in present value terms. Of the dairy actions assessed, the BMP action to reduce nutrient export provides clearly the highest net on-farm benefits.

5.6 Broad Acre Grazing Production Systems

The relevant CSHS actions to the broad acre grazing industry are:

- Implement appropriate grazing practices based on land class boundaries to sustain long-term soil health (E4);
- Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (E3);
- Strategically establish trees to act as windbreaks to control wind erosion (E2); and
- Increase the establishment of perennial pastures, with a preference for direct drilling (E5).

These actions can be summarised in Table 5-4.

Table 5-4: Details of CSGS broad acre grazing actions.

Action	Detail of action and assumptions made
Rotational grazing	Additional fencing, livestock and management
Lime/fertiliser management	Soil testing and application of appropriate rates of lime and fertiliser
Land class fencing	Installation of fencing and livestock water infrastructure.
Trees as windbreaks	Cost of trees, labour and fencing to install windbreaks
Introduce perennials (where absent)	Pasture establishment costs including seed, machinery usage and labour

Table 5-5: On-farm benefits and costs of CSHS actions relevant to broad acre grazing production systems.

($'000)	Present value		On-farm NPV
Management Actions	Net on-farm benefits	Net on-farm costs	
Broadacre Grazing			
Graze and spell rotation	$79,091	$43,939	$35,151
Fertiliser management	$46,081	$9,216	$36,865
Land Class fencing	$31,604	$18,871	$12,733
Trees as wind breaks	$1,424	$896	$528
Direct drill pastures (introduce perennial pastures)	$4,305	$2,832	$1,474
Combined	$44,056	$24,117	***$19,939***

Results in Table 5-1 shows that, overall, the on-farm benefits of implementing the CSHS broad acre grazing actions are expected to exceed the on-farm costs by around $20 million in present value terms. Of the cropping actions assessed, the graze and spell and fertiliser management actions provide similarly high on-farm net present values, far in excess of other actions. Land class fencing is also expected to provide significant benefits with a NPV of $12.7 million on farm. Using trees as wind breaks and direct drilling pastures is expected to provide far lower net benefits.

5.7 Private Plantation and Farm forestry

The relevant Corangamite Soil Health Strategy actions for block plantations on sloping sites are:

- Implement Codes of Forest Practices related to soil health for all plantations (E9).
- Promote farm forestry plantations in areas that benefit soil and catchment health (E8); and
- Develop a discussion group to improve the implementation of private forestry BMPs (E8).

These actions can be summarised in Table 5-6.

Table 5-6: Details of private forestry actions.

Action	Detail of action and assumptions made
Implement code of practice	Forestry best practices ranging from site preparation to post-harvest. Practices evaluated include ground preparation (ripping and mounding), road design, construction and maintenance.
Forestry to improve catchment health	Establishing plantations in marginal areas that benefit soil and catchment health. Plantation on these sites generally have sub-optimal tree growth rates and higher establishment costs than for more suitable areas.

Table 5-7: On-farm benefits and costs of CSHS actions relevant to forestry production systems.

($'000)	Present value		On-farm NPV
Management Actions	Net on-farm benefits	Net on-farm costs	
Forestry Production			
Implement code of practice	$7,838	$1,057	$6,780
Better road construction			
Forestry to improve catchment health	-$176	$726	-$902
Support delivery of specialist technical advice			
Combined	$2,133	$3,560	***-$1,427***

Results in

Table 5-7 shows that, overall, the on-farm benefits of implementing the CSHS cropping actions are expected to be around $1.4 million less than on-farm costs. Of the forestry actions assessed, implementing the code of practice is the only action expected to be economic. The on-farm net present value of this action is significant at $6.8 million.

5.8 Public Native Forestry

The relevant Corangamite Soil Health Strategy actions are:

- Implement Codes of Forest Practices related to soil health for all plantations (Action E9); and
- Increase awareness and skills in road design construction and maintenance (under Action E8).

However, the costs and benefits from implementing the soil health strategy have not been evaluated for public native forestry as the Code of Forest Practices is already enforced on Public land. Also, changes in the management of public native forests in the Corangamite Region are proposed over the next 5 years or so, creating large uncertainties for an assessment today.

5.9 Sum of Net Benefits for all Production Systems over time

Table 5-8 shows the sum of the net benefits due to the CSHS for all production systems evaluated in this assessment. These figures are calculated as the difference in net benefits between the *with strategy* and *without strategy* scenarios in the years 2005, 2015, 2025 and 2035. The figures show that the total on-farm net benefits can reach just under $3.0 million per year within 10 years and over $4 million per year within 30 years with the implementation of all of the CSHS actions.

Table 5-8: Sum of Net Benefits for all production systems

Production System	2005	2015	2025	2035
Cropping	$0	$116,974	$339,128	$739,976
Dairy	$0	$193,920	$543,817	$1,158,898
Grazing	$0	$2,724,383	$2,895,739	$2,897,841
Private Forestry	$0	-$111,526	-$264,021	-$471,051
Public Native Forestry	Not assessed			
Total		**$2,923,750**	**$3,514,662**	**$4,325,666**

6.1 Overview of off-farm (public) benefits of soil health

In addition to generating off-farm benefits many of the actions under the CSHS relate to the generation of benefits that are realised off-farm and benefit the community more generally. This is important as the CSHS is a community strategy that receives significant public funding. Off-farm benefits relate in part to the on-farm management actions discussed in section 5 but also to some additional actions discussed in this section.

The major off-farm or public benefits associated with implementing the Soil Health Strategy are likely to be:

- reduced risks to public infrastructure from acid sulfate soils, erosion, sedimentation and landslides;
- reduced risks to public health and safety from landslides;
- reduced groundwater discharge and associated salinity benefits to waterways/water bodies and infrastructure;
- improved wellbeing of citizens from knowing that the environment in the region is in a healthy condition; and
- reduced risks to waterways/water bodies associated with sediment and nutrient transport and acidification, leading to improved water quality.

Within this Section, the public (off-farm) benefits of the soil health strategy are estimated for each landscape zone in the Corangamite region. Estimates of both the *on-farm* and *off-farm* costs and benefits of addressing soil erosion are estimated in Section 6.2. Benefits of an off-farm nature are more difficult to quantify than on-farm economic gains. Where sufficient information is available, the best possible attempt at quantifying these off-farm benefits has been made. For other areas, there is simply insufficient information to provide any quantitative assessment.

This report provides the first attempt to comprehensively estimate the public benefits of addressing soil health in the Corangamite CMA region. As the Strategy is further developed, and new research and extension activities are undertaken, there should be greater scope to provide more reliable estimates of the public benefits from the Strategy. For example there may be advancements in the availability of computer modelling to predict sediment transport from gully erosion sites to waterways across the region. For a list of the key assumptions used in the benefit cost analysis, see Appendix C.

6.2 Soil erosion: gully, tunnel, sheet and rill erosion

Soil erosion posses a threat to farm land assets and production systems but importantly has off-farm impacts through the export of sediment to water ways. Soil erosion occurring in areas outside farmland can also impact on private assets such as houses and public infrastructure.

The relevant actions in the Corangamite Soil Health Strategy for soil erosion are:

- To implement best management practices to reduce nutrient and sediment export to waterways in all agricultural industries (E2).
- To develop and implement a soil health incentives plan (G1), for example to encourage landholders to stabilise erosion sites.
- Co-invest with municipalities to develop Erosion Management Overlays (EMOs) (F2). This assists in identifying risks to potential developments on land in each overlay.
- To map all soil health threats (C2), specifically to complete erosion mapping by 2006. This will provide an improved understanding of soil health issues in the region enabling continuous improvement of the CSHS.

In this Section the costs and benefits of stabilising gully, tunnel, sheet and rill erosion are assessed. Stabilisation measures can include a mixture of fencing, pasture or tree establishment, or structural works, depending on the severity of the erosion site. Because tunnel erosion results in gully erosion, the estimated impacts of tunnel erosion are therefore assessed under gully erosion. Similarly, sheet and rill erosion have been combined and will be hereafter be referred to as “sheet erosion”.

The detail of cost and benefits assumptions used to calculate the costs and benefits of sheet and gully actions is summarised in Appendix D.

6.2.1 Sheet erosion

Costs

A key assumption was that the development and implementation of a soil health incentives plan is expected to lead to the stabilisation and renovation of 31 sheet erosion sites ranging in severity from “small”, “medium” and “large”. This work is expected to be conducted over the 5 years of the strategy. Based on this, the total costs of sheet erosion site control were estimated (Table 6-1).

Table 6-1: Costs of sheet erosion site stabilisation and renovation.

	Small	Medium	Large	Total
Number of sites treated	21	8	2	31
Unit costs for treatment	$400	$3,049	$4,760	
Total Cost	$8,400	$24,396	$9,520	$42,316
PV Costs	$6,708	$19,481	$7,602	$33,791
PV Foregone production	$21,382	$12,218	$4,073	$37,673
PV Total Cost	$28,090	$31,699	$11,675	$71,464

Benefits

Benefits from treating gully erosion sites were estimated in the following areas and are presented in Table 6-2. Benefits were estimated under two key areas: reclaiming agricultural production on erosion sites; and preventing the loss of productive land through further erosion of these sites. Assumptions used in the estimate are provided in Appendix D.

Table 6-2: Benefits from the stabilisation and renovation of sheet erosion sites.

	Small	Medium	Large	Total
Number of sites treated	21	8	2	31
Avoided land lost	$5,400	$3,086	$1,029	$9,514
Reclaimed Production	$19,504	$8,359	$3,715	$31,578
PV Total private benefit	$24,904	$11,444	$4,744	$41,092

The present value of costs from addressing sheet erosion ($71,464) is about double the present value of benefits ($41,092).

6.2.2 Gully erosion

Costs

The total costs of gully erosion site control were estimated based on the unit costs in Table 6-1. It was assumed that a total of 36 sites would be treated ranging in severity from “small”, “medium” to “large”. This work is expected to be conducted evenly over the 5 years of the strategy.

Table 6-3: Costs of gully erosion stabilisation and renovation.

	Small	Medium	Large	Total
Number of gullies treated	14	13	9	36
Unit costs for treatment	$3,000	$11,633	$40,567	
Total Cost	$42,000	$151,233	$365,100	$558,333
PV Costs	$33,539	$120,766	$291,548	$445,853
PV Foregone production	$11,404	$39,709	$43,315	$94,428
PV Total Cost	$44,943	$160,476	$334,862	$540,281

Benefits

Benefits from treating gully erosion sites were estimated based on reclaiming agricultural production on gully site areas, preventing the loss of productive land through further erosion of these sites and in achieving better farm access. Benefits are also likely to be realised through a reduction in pest plant and animals, particularly rabbits and foxes. However these benefits were not quantified due to the high level of uncertainty in making estimates. Estimated benefits are presented in Table 6-4:

Table 6-4: Benefits from gully erosion stabilisation and renovation.

	Small	Medium	Large	Total
Number of gullies treated	14	13	9	36
Avoided land lost	$288	$1,671	$3,471	$5,431
Reclaimed Production	$7,174	$4,783	$0	$11,956
Better Farm Access	$1,576	$5,854	$0	$7,430
Pest Plants & Animals	Not Quantified			
PV Total benefits	$9,038	$12,308	$3,471	$24,817

For gully erosion the present value of costs (around $540,000) are substantially greater than the present value of private benefits (around $25,000).

6.2.3 Extension activities in soil erosion

Extension activities are expected to reduce the future rate of sheet and gully erosion by improving landholders understanding of how to best prevent this type of erosion from occurring. At present the annual rate of expansion of the area of sheet erosion is estimated at two percent (Dahlhaus pers. com 2005). This is based on an expectation that without any action the area of sheet and gully erosion sites would increase by 50 percent over the next 25 years. It is assumed that under the strategy this rate could be halved to one percent. This provides an estimated net present value of $300,722.

For gully erosion the current rate of expansion is also estimated at two percent (Dahlhaus pers. com 2005). Assuming, again, that this could be halved under the strategy to one percent, a net present value of $161,687 is estimated.

6.2.4 Off-site impacts on infrastructure

Under the CSHS it is planned to prepare an Erosion Management Overlay (EMO) for each municipality in the region. Essentially an overlay will require that developers take reasonable action to assess the risks posed by landslide and soil erosion to the proposed development. For example, an assessment by a specialist consultant may be required before the development is approved. This is expected to have a major impact on the consideration of risks associated with soil erosion and landslides.

EMOs will assist in preventing erosion damage to residential developments and urban and rural infrastructure (roads, bridges, culverts, etc.) through more appropriate planning and development taking into account soil erosion and mass wasting (landslide) risks. It will assist in reducing sediment loads and turbidity of waterways and water bodies.

Benefit

There are two recent examples in the Corangamite region that provide an indication of potential benefits from addressing damage to infrastructure caused by sedimentation. During a flood event in February 2005, there was a build up of sediment and debris at a bridge on the Bacchus Marsh - Geelong Road. The cost of ameliorating this site was low (around $3,000. A more severe incident was a site of road collapse on the Jetty Road. This resulted from widespread erosion during a flood event in February 2005. The immediate cleanup operation cost was only around $5,000 although it is envisaged that the total cost may be in the order of $200,000 or more. Note that benefits that relate specifically to landslides are estimated in section 6.4.

The development of EMOs will reduce the likelihood of future events of this nature. However, EMOs will only provide benefits for new developments regarding events that are episodic in nature. This makes the benefits of this work difficult to forecast. However some attempts have been made to make conservative estimates in this area.

The types of destructive events caused by export of sediment through soil erosion are categorised according to their probability of occurrence and severity of their consequence in Table 6-5. Information was provided on the ‘do nothing’ (without strategy) probability of a given event occurring. This data is also reproduced in Table 6-5. These probabilities were then revised according the estimated impact of the introduction of EMOs and other actions regarding soil erosion in the region. Finally estimates were made of the expected economic impact of these events based on experiences in the area (Table 6-5). For example, it is estimated that without the Strategy (EMOs) there is a one-in-five chance of an event occurring each year that causes “significant damage” to infrastructure with an estimated cost of $250,000. This probability is expected to be reduced to one-in-ten years under the introduction of the Strategy.

Given the conservative assumptions used, and gaps in available data, it is likely that these estimates substantially under-estimate the total risks (economic, social and environmental) associated with these events.

Table 6-5: Benefits associated with the Erosion Management Overlays through reducing erosion and sedimentation under the CSHS.

Type	Consequences	Estimated annual probability (without strategy)	Estimated annual probability (with strategy)	Cost of event	Total benefit
1	Significant damage damage to infrastructure assets (eg. section of road requires replacement: e.g Jetty Road)	0.25	0.125	$250,000	$31,250
2	Minor damage to infrastructure (e.g. Clifton Springs golf course, installation of rennovation mattresses)	1	0.5	$12,500	$6,250
3	Damage that requires cleanup only (e.g. Geelong Bacchus Marsh Road)	2	1	$3,000	$3,000
				Average annual benefit:	$37,500

The annual benefits of sedimentation avoidance actions under the CSHS are estimated at $37,500 per year. If we assume that these benefits are progressively realised over a 10-year period, the present value of benefits equals $293,115.

Benefits not included

Benefits not included in this analysis are the avoidance of other costs resulting from damage to assets, such as those involved in the assessment and dispute over damages to assets. For example the destruction of a house may lead to legal action from the affected party against the municipality. Having an EMO is likely to provide some level of protection for municipalities against such legal action. Other costs will include investigation costs for each damage site and other unforeseen costs incurred by the municipalities and State Government agencies. It is very difficult to predict these costs, but they could be significant.

6.2.5 Net benefits of sheet and gully erosion program

In assessing the benefits and costs of sheet and gully erosion, the costs of works have been compared with the primarily private benefits from undertaking these works. The other benefits of soil erosion that have not been quantified include:

- reducing sediment and nutrient flow into waterways; (reduced impact on water quality and aquatic habitat values) (off-farm benefit). These benefits are assessed as part of the broader discussion of the impact of the Strategy on water quality (Section 6.3);
- possible amenity benefits (off-farm benefit);
- reduced loss of soil biodiversity (on- and off-farm benefit); and
- reduced loss of carbon storage capacity (on- and off-farm benefit).

The overall costs and benefits for managing soil erosion are summarised in Table 6-6.

Table 6-6: Summary of costs and benefits from managing soil erosion

	Actions	Benefits	Costs	Net
Soil Erosion – works	G1	$41,092	$71,464	-$30,372
Gully Erosion – works	G1	$24,817	$540,281	-$515,464
Soil erosion – extension	E2	$308,378	Included under total program costs	$308,378
Gully erosion – extension	E2	$165,803		$165,803
Off Site Impacts to Infrastructure	F2	$293,115		$293,115
Reducing sediment and nutrient flow into waterways	Various	Not quantified		
Potential ammenity benefits	Various	Not quantified		
Potential reduced loss of biodiversity	Various	Not quantified		
Potential reduced loss of carbon storage capacity	Various	Not quantified		
Total		$ 833,204	$611,744	$ 221,459

These results show that the private on-farm benefits are low relative to the costs of on-farm works. This highlights that significant public benefits are required to justify soil erosion works under the CSHS. Such public benefits are likely where erosion is causing substantial losses in asset values for priority waterways.

The analysis suggests that there are greater potential net benefits to be achieved from focusing on extension activity to assist landholders to prevent new sheet and gully erosion sites being formed in the first place. Implementation costs for extension activities are included under total program implementation costs, presented in section 7.2.

On farm net benefits, or more accurately net losses, from addressing sheet and gully erosion will occur in proportion to the level of erosion in each landscape zone. Based on the data prepared by Feltham (2005), key landscape zones are the Leigh, Woady Yaloak and Moorabool due to the extent of erosion in each area and the risk posed to water quality. Unfortunately, given the incompleteness of the data set, it is not possible to assign the total benefits presented in Table 6-6 to a landscape zone level.

6.3 Improved water quality and stream habitat

An important benefit of many of the actions proposed in the Corangamite Soil Health Strategy, landholders will be to reduce the amount of sediment and nutrients that enter waterways and therefore improve water quality and water way health.

Under the CSHS the actions of liming acid soils, applying gypsum, establishing deep rooted pasture species, and improving grazing management are all likely to reduce erosion and, therefore, reduce the amount of nutrient exported from agricultural land in the Corangamite region. Addressing gully, sheet and rill erosion will also reduce nutrient export. Any increase in rates of adoption for these management actions due to the CSHS will therefore have economic benefits for the region.

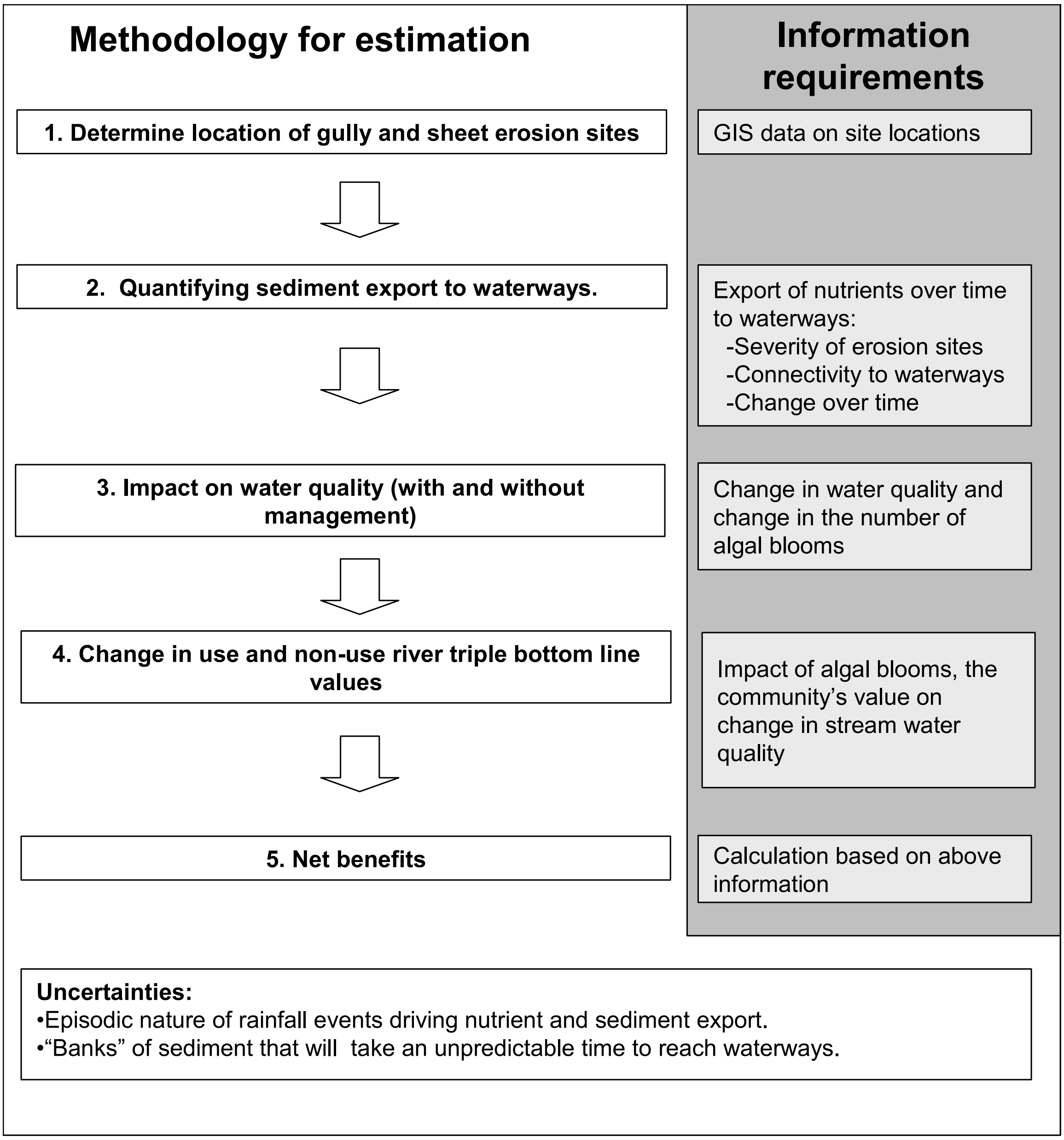
The economic impact of nutrient run-off on streams in the Corangamite catchment was studied previously in 1998 by the former Read Sturgess and Associates in an economic assessment of Corangamite's Nutrient Management Strategy. This work is outlined in Appendix E.

However, in this evaluation, it has not been possible to obtain actual data to quantify these benefits for the CCMA region. However, an evaluation framework for assessing such benefits is presented in Figure 6-1. Further detail on the methodology and information requirements for applying this framework, and how an assessment would be undertaken in practice is provided in Appendix F.

Of particular importance to making future estimates is the decision support tool 'RiVERS'. This model has been developed to prioritise investments in waterways under the Corangamite River Health Strategy, which is presently being prepared.

Actions under the CSHS to reduce impacts on waterways should be linked to priority waterways, as identified under the River Health Strategy, where water quality or algal blooms are an issue. These waterways are identified in Appendix F. Any management actions within the CSHS that reduce erosion and target priority waterways, will achieve river health benefits.

Figure 6-1: Proposed methodology for estimating the impact of sheet, rill, gully and tunnel ("point-source") erosion on export of nutrients and sediments to waterways.



6.4 Landslides

6.4.1 Background

The types of landslides to which the Corangamite region is prone are categorised according to their probability of occurrence and severity of their consequence in Table 6-7. Information was provided on the 'do nothing' probability of a given landslide impacting on different types of assets and infrastructure, and public safety (Dahlhaus Environmental Geology 2003). This data is also reproduced in Table 6-7.

For example, it is estimated that there is a one-in-ten chance that a new landslide will cause major damage to infrastructure assets, such as roads, while there is a one-in-500 year chance of catastrophic damage to environmental assets.

Table 6-7: The relative likelihood of landslides having different types of consequences 'without the CSHS'.

Type	Type of Consequence	Annual probability of occurrence	Years between landslide events
1	Catastrophic damage to environmental assets (eg Lake Elizabeth)	0.002	500 years
2	Loss of life	0.02	50 years
3	Catastrophic damage to infrastructure assets (e.g. buildings destroyed)	0.04	25 years
4	Major damage to infrastructure assets (e.g. section of road destroyed)	0.1	10 years
5	Medium damage to infrastructure assets, environmental assets (eg pipeline stabilisation works)	0.2	5 years
6	Minor damage to all classes of assets (e.g. road closed for a day)	1	1 year

An estimate of the number of landslides of types 1 to 6 in the Corangamite region are presented in Table 6-8 (P. Dalhaus and A. Miner pers. com. 2005).

Table 6-8: Total estimated landslides in the Corangamite region categorised by their estimated consequence.

Type	Type of Consequence	Proportion of total Corangamite region landslides
1	Catastrophic damage to environmental assets (eg Lake Elizabeth)	Less than 1%
2	Loss of life	Less than 1%
3	Catastrophic damage to infrastructure assets (e.g. buildings destroyed)	5%
4	Major damage to infrastructure assets (eg section of road destroyed)	20%
5	Medium damage to infrastructure assets, environmental assets (e.g. pipeline stabilisation works)	20%
6	Minor damage to all classes of assets (e.g. Road closed a day)	55%

Estimates of the economic impact of each type of landslide are presented in Table 6-9 and Table 6-10. The consequences that were documented for individual landslides in recent years ranged between $20,000 and $800,000 for damage primarily to municipal infrastructure.

It is particularly difficult to place a value on the catastrophic damage to environmental assets given the rarity of these events. The most severe landslide in living memory was the 1952 Lake Elizabeth landslide. This event had a very large economic impact, probably in the tens of millions of dollars and possibly even up to $100 million. This landslide formed a dam of earth, rock and trees across the East Branch of the Barwon River, resulting in the river being completely blocked for 14 months. This prevented the supply of water for downstream irrigation and environmental benefits during this period. When the top section of this dam collapsed, a flood of mud and water flowed down the Valley, causing damage for up to 10 kilometres. Damage included the destruction of infrastructure such as bridges, roads and railway line, the demolition of farm infrastructure such as sheds and fences, and the loss of production on several farms for around one year. However, this does not impact on the analysis of the CSHS as it is not expected that the actions noted above will be able to impact on avoiding landslides with such severe consequences.

For events where there is a loss of life, an economic value of $1.5 million has been assigned. Putting a value against human life may at first appear controversial. However this figure only estimates the cost to the economy of the loss of a member of the community. The figure of $1.5 million is based on a publication on the economic costs of natural disaster by the Bureau of Transport Economics (BTE 2001). Clearly, the benefits of avoiding loss of life will extend well beyond the loss to the economy.

Given the conservative assumptions used, and gaps in available data, it is likely that these estimates substantially under-estimate the total risks (economic, social and environmental) associated with these landslides.

Table 6-9: The costs associated with different types of consequences for landslides.

Type	Type of Consequence	$
1	Catastrophic Damage to environmental assets (e.g. Lake Elizabeth)	$10 million
2	Loss of Life	$1.5 million
3	Catastrophic Damage to Infrastructure Assets (e.g. buildings destroyed)	$500,000
4	Major damage to Infrastructure Assets (e.g. Section of Road Destroyed)	$150,000
5	Medium Damage to Infrastructure Assets, environmental assets (eg Pipeline stabilisation works)	$50,000
6	Minor damage to all classes of assets (e.g. Road closed for a day)	$10,000

6.4.2 Management Actions

The management of landslides requires a landslide risk assessment to be completed to ensure that priority areas (where the risk to assets including human life is greatest) are targeted for management. Within the CSHS, we have included costs to achieve the following management options:

- To map all soil health threats (C3), specifically to complete landslide mapping by 2006.
- Co-invest with municipalities to develop Erosion Management overlays (EMOs) (F2). This includes actions to:
  - Encourage the implementation of uniform standards for landslide risk management;
  - Develop and encourage adoption of a landslide risk management process for all works; and
  - Develop and implement a community education and awareness program on landslide risk management.
  - Conduct stabilisation work on sites where there is a high risk of future mass wasting occurring and where there is a major threat to public infrastructure and safety.

6.4.3 Benefits

By applying these management actions, it was estimated by Dahlhaus (2003) that the probabilities shown in Table 6-7 could be reduced by “one of more orders of magnitude”. More conservative assumptions have been made regarding the likelihood of these consequences (P. Dalhaus and A. Miner pers. com. 2005) as they relate specifically to the actions proposed under the CSHS, as presented in Table 6-10. Annual benefits of landslide management are also presented in the table.

The annual benefits of landslide management actions under the CSHS are estimated at $65,000 per year. If we assume that these benefits are progressively realised over a 10-year period, the present value of benefits discounted at 8 per cent over 30 years, is equal to $508,066.

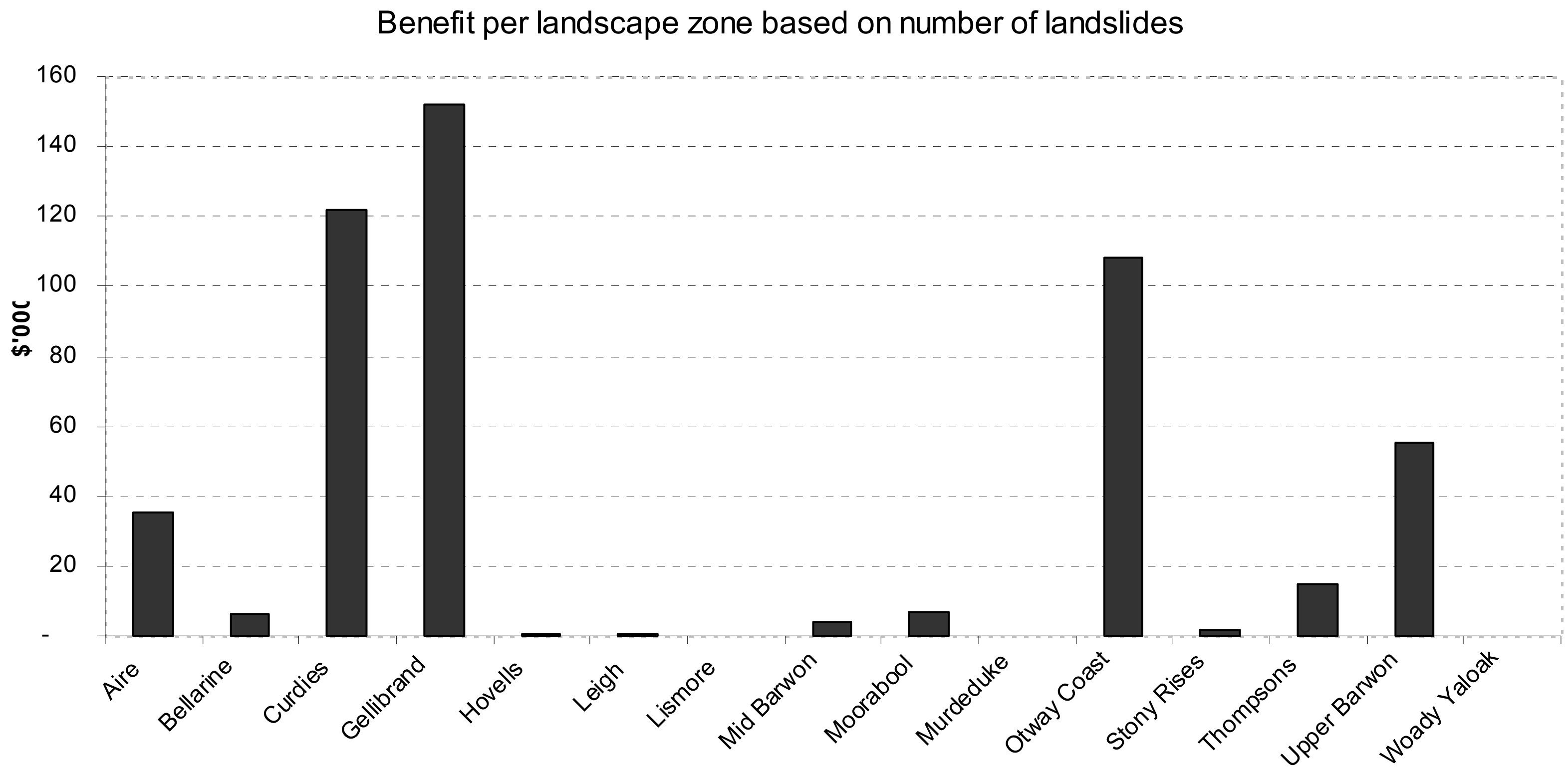
Table 6-10: Estimated benefits associated with landslide management in the CSHS.

Type	Consequences	Estimated annual probability (without strategy)	Estimated annual probability (with strategy)	Cost of event	Total benefit
1	Catastrophic damage to environmental assets (eg. Lake Elizabeth)	0.002	0.002	$50,000,000	$0
2	Loss of life (eg. Lal Lal)	0.02	0.01	$1,500,000	$15,000
3	Catastrophic damage infrastructure assets (eg. Buildings destroyed; The Dell; Moorabool)	0.04	0.01	$500,000	$15,000
4	Major damage to infrastructure assets (eg. Section of road destroyed; Turtons Trk; Princetow n)	0.1	0.05	$250,000	$12,500
5	Medium damage to infrastructure assets, agricultural assets, environmental assets (eg. Pipeline stabilisation w orks; Deviation Rd; Western Beach)	0.2	0.1	$100,000	$10,000
6	Minor damage to all classes of assets (eg. Road closed for day; Great Ocean Rd; Skenes Crk Rd)	1	0.5	$25,000	$12,500
			Average annual benefit:		$65,000

The preliminary data generated by Feltham (2005) were used in conjunction with the data in Table 6-10 to express the present value of Landslide actions under the CSHS per landscape zone. Benefits per landscape zone (displayed in Figure 6-2) were calculated by allocating benefits to landscape zones based on number of landslides recorded. It should be reiterated here that the data from Feltham (2005) is indeed preliminary.

Clearly, and as expected, Curdies and Gelibrand are the two landscape zones most likely to offer the greatest returns on investment in actions to minimise the risks posed by landslides.

Figure 6-2: Distribution of benefits from CSHS landslide control based on the number of recorded landslides in each landscape zone.



6.5 Acid Sulfate Soils (ASS)

6.5.1 Background

Undisturbed, potential ASS cause little or no problems. However, if allowed to oxidise (when potential ASS is exposed to air due to removal of topsoil or water) acid sulfate soils can begin to release sulfuric acid that impacts on agricultural production, infrastructure and the environment. Urban and regional development is often the main cause of disturbance of potential ASS. Most acid sulfate soils in the Corangamite region are present in thin layers with some level of sea shell deposits which is likely to neutralise any sulfuric acid released by ASS (Austin Brown, DPI, pers. comm.). Due to there being little or no ASS exposed in the Corangamite Region to date, coupled with the growing awareness of the potential threats and occurrence of ASS, the likelihood of future oxidisation of ASS is relatively low, compared to some other areas of Australia.

However, if an unsuitable development occurs in an ASS environment, such as concentrated housing or an industrial development, the higher costs (relative to a more appropriate site) could be of some significance. Development on ASS and Potential Acid Sulfate Soil (PASS) areas could lead to higher costs through increased requirements to maintain and replace infrastructure and private buildings. Benefits associated with the management of the problem would therefore flow to the broader community responsible for funding infrastructure work and to the owners of buildings in the development. While benefits exist from having a better understanding of the location of ASS and PASS. It is extremely difficult to quantify these benefits in dollar terms.

Work by Rampant *et al* (2003) estimated that there are 13,845 hectares of ASS in the Corangamite Catchment Management Region. This work reported that around 85 percent of all ASS were located within the City of Greater Geelong. An investigation of ASS on the proposed development in the City of Greater Geelong was recently conducted by Cox *et al*. (2005). Cox *et al'*s study suggested that the extent of the problems posed by acid sulfate soils is less than predicted by Rampant *et al* (2003). Rampant *et al'*s study suggested that ASS were confined to areas that were wetlands or areas zoned "Public Conservation and Resource". This was with the exception of the tidal flat adjacent to the smelting plant at Point Henry. Overall this site was assessed as having a marginal likelihood of being a true Acid Sulfate Soil. However, disturbance of ASS could lead to acid production and this site will need to be assessed before any development can commence.

New information about ASS and PASS in the region will assist in the planning of private development and public infrastructure to take into account the potential damage from these soils. This information will be included into the Municipal Strategic Statements for municipalities where necessary. The key benefit from mapping ASS and PASS would be to inform appropriate development in the region. Better knowledge of where to place these assets will generate economic benefits by reducing future asset damage. The relative benefit of this work will depend on the extent of acid sulfate soils actually identified.

The potential consequences of oxidisation of ASS are not well understood for Corangamite. However, acid sulfate soils are a major economic and environmental problem in New South Wales and Queensland. In Queensland alone, the estimated total cost to industry of managing ASS in Queensland is $189 million per annum (National Working Party on ASS 1999).

The existence of ASS causes economic costs to urban and industrial development by requiring the additional treatment of sites to prevent the formation of ASS. In Queensland these soil treatment costs are estimated to be in excess of $100 million per annum. On top of this ASS can also have a low load bearing capacity which threatens the stability of foundations. This also increases the potential relocation costs created during the process of avoiding ASS by moving development to non-ASS land. This increases the economic cost of development.

Public infrastructure can also be impacted upon due to the effect of ASS corroding concrete and steel structures. For example the National Working Party on Acid Sulfate Soils cites an example in Tweed Shire Council (northern NSW), of a $4 million investment to replace acid-corroded iron water pipes situated in an ASS area.

The Tuckean Swamp in New South Wales (where sulfuric acid is released from ASS) is another example that may be viewed as an indication of the potential environmental, economic and social benefits that can be derived from managing ASS. Read Sturgess and Associates (1996) estimated that for the best outcome, management of ASS around the Tuckean Swamp can produce a net present value of total benefits of greater than $15.5million.

The Tuckean Swamp study considers the benefits of managing the consequences of waterway acidification from ASS, whereas, in the Corangamite, the main actions would be focussed on managing the likelihood of acidification occurring in the first place. Nevertheless, it could be said that the present value of the *impact* on the Tuckean Swamp from ASS could be greater than $15.5 million, which may provide an indication of the magnitude of the *potential* value of preventing acidification occurring in areas such as the Barwon Estuary. The Anglesea River has also been identified as a potential area of impact from ASS. In reality it is an involved process to predict the environmental benefits of controlling ASS in the Corangamite Region due to uncertainties. No attempt is made here to estimate a figure for this. However there is greater scope to explore the impacts of ASS on assets and infrastructure.

6.5.2 Management Actions

The relevant actions in the Strategy which relate to ASS are:

- To map all soil health threats (C2). The specific management action is to "map ASS and potential ASS in potential risk areas by 2008". This essentially involves extending the Cox et al study to other risk areas of the Catchment.

Once identified, some possible management actions that can be used to address potential acid sulfate soils may include:

- Avoid disturbance of potential ASS - given that potential ASS are harmless while remaining saturated or buried, the best defence from the development of ASS is to avoid disturbance. That is, being aware of the occurrence of potential ASS and taking the appropriate steps not to expose or drain these soils;
- Re-cover potential ASS if exposed and take measures to ensure it remains wet;
- Apply lime to ASS (eg. in deep channels) to neutralise the acid (if ASS occurs); and
- Submerge ASS with freshwater to prevent oxidisation or flush soils with seawater to neutralise acid.

6.5.3 Benefits

The impact of ASS on infrastructure is likely to be significant. It has been estimated that testing, treating and monitoring ASS accounts for up to 25% of costs of new subdivisions in ASS areas in Queensland. The fact that developers choose to pay this cost suggests that the average present value of the additional costs of corrosion in a development in an ASS location is at least 25 percent higher than that in non-ASS locations. The key types of development that are at risk of being inadvertently placed on ASS or PASS are coastal housing and tourism developments and public infrastructure such as roads.

On this basis it is reasonable to expect that the prior knowledge that a site contains acid sulfate soils before a development proceeds can be expected to save 25 percent on total development costs. While potential development is difficult to predict, there have been suggestions of housing development in PASS areas.

A reasonable assumption is that the mapping and development of overlays provides prior knowledge of ASS on 15 housing development sites over a 15 year period. Typical costs for constructing a new dwelling are $200,000, while it has been estimated that additional infrastructure provided by developers and governments can typically be around $35,000 and $60,000 respectively (Applied Economics 2003). This brings the average cost of a new dwelling to around $300,000. Investments during construction which prevent the impact of ASS on infrastructure represent a present value benefit of $541,205 (discounted at 8 percent over a 15 year period). This figure allows 2 years for the information to be incorporated into Municipal Strategic Statements. This assumption if very conservative both in terms of the number of houses affected and the level of savings provided. Table 6-11 illustrates the benefits of the ASS elements of the strategy if more housing development sites were to benefit from the work.

It is not expected that other studies would be conducted in the absence of the implementation of the strategy, thus there would be no benefits expected in the absence of the strategy.

Table 6-11: Estimated development benefits from prior knowledge of Acid Sulfate Soil areas.

	Extent of development that benefits from prior knowledge of Acid Sulphate Soils.			
Number of houses to benefit over 15 years	5	15	25	50
Prevent value of benefits				
Housing construction	$122,306	$366,919	$611,531	$1,223,062
State/local government provided infrastructure (water, sewerage & drainage)	$36,692	$110,076	$183,459	$366,919
Developer-provided infrastructure (roads, drainage etc)	$21,404	$64,211	$107,018	$214,036
Total	**$180,402**	**$541,205**	**$902,008**	**$1,804,017**

6.6 Other Non Quantified Impacts

The CSHS will provide other benefits that were not possible to quantify during this study. These other benefits are discussed below.

6.6.1 Urban and Peri-urban Program

The key action under the CSHS in this area is to "Develop a Soil Health Action Plan for each municipality (F1) that aims to improve the management of soil threats in relation to urban parks and gardens, urban wastes, nutrient export and contaminants."

This action can be expected to provide a generally higher level of environmental amenity in urban areas and provide off-site benefits through reduced sediment and nutrient export.

6.6.2 Impact of salinity on public infrastructure

The relevant action is to "Map all soil threats (C3). The specific management action is "Linking with the Corangamite Salinity Action Plan (SAP), to complete the mapping of saline discharge sites by 2007".

The economic benefits of undertaking work to map salinity discharge sites was assessed in 2003 (CCMA 2003). In the Study, it was concluded that utilities providers (gas, electricity, phone and rail) required assistance through improved mapping of saline discharge areas - the key relevant action in the CSHS – to target areas at risk. Otherwise it was concluded that utilities providers would be able to manage their assets with little input from the Corangamite CMA.

Salinity discharge was noted as a priority in terms of impact on infrastructure in the following regions: Lake Corangamite; Cola – Eurac; Warncourt; Murdeduke; Modewarre; Geelong – Lake Connewarre; and Lara. However, there was insufficient information available to provide an accurate assessment of the impact of these discharges.

6.6.3 Other soil health issues

The CSHS relates to other soil issues through the action to "Map all soil threats (C3)". Quantification of benefits is not possible for the following issues due to the lack of information about their extent in the Corangamite region.

Reduction in acidification/contamination

Land use in Australia has changed the hydrology and the biogeochemistry of the landscape, giving rise to a new set of chemicals that will be released from the land and infiltrate the country's waterways. The implications for water quality are unknown, but many believe impacts of acidification and contamination will be as great as that of salt. Whilst best management practices are encouraging farmers to plant deep-rooted legumes like lucerne to reduce the risk of salinity, these plants cause a buildup of acid in the soil. The area of acid soils in Australia is far larger than the area affected by salt and potentially a much greater threat to agriculture and natural ecosystems.

Key water quality parameters are: arsenic; hormones; pH; sediment/turbidity; groundwater nitrates; metals, toxic organics, oils and surfactants. A review of contaminants in regional waters showed that in some parts of the Corangamite CMA region there are potential threats with: arsenic; pH; sediment/turbidity (limited); groundwater nitrates; and metals. Further work under action C3 will improve knowledge in this area.

Soil biota decline

Soil biota decline and organic carbon decline are important potential threats. However, at present, there is a limited understanding of the conditions of these two attributes throughout the Corangamite Catchment.

Soil biota play an important role in improving soil structure and breaking down organic matter releasing nutrients for plants. Thus soil biota is vital for maintaining agricultural productivity. The biological state of a soil also provides a good indicator of soil health which, it is thought, may provide an early indication of land degradation, which can help develop more sustainable land practices (CSHS 2005).

There are a range of on-farm actions that are available to improve, or arrest a decline in, soil biota. This includes using legume-based crop rotations and retaining stubbles.

Prospective benefits of addressing soil biota decline:

Addressing soil biota levels clearly provides on-farm benefits through increasing agricultural productivity. There may also be some, mostly off-farm, benefits from assisting to reduce the risk of land degradation which could reduce the level of nutrient and sediment export to waterways.

However little is known about soil biota in the Corangamite region. This is noted later as an area that requires further research.

Organic carbon decline

Organic matter refers to anything that contains carbon compounds that were formed by living organisms (CSHS). There are three main components of soil organic matter (OM): dead forms of OM – mostly dead plants; living parts of plants – mostly roots; and living microbes and soil animals (CSHS 2005). High organic carbon levels are essentially for soil health as it improves soil structure, increases fertility, encourages soil biota and reduces erosion.

Organic carbon has not been mapped in the region, although there is an understanding that higher organic carbon levels will be found in high rainfall areas with thick perennial vegetation and minimal agricultural activity.

Prospective benefits of addressing organic carbon decline

Maintaining organic carbon levels therefore provides the on-farm benefits of maintaining agricultural productivity, while also contributing to the off-farm benefits of reducing sediment, nutrient and salt export. It is likely that the on-farm benefits of maintaining organic carbon levels will outweigh the off-farm benefits.

Obtaining a greater understanding of the importance of organic carbon levels in the Corangamite Region is noted later as an area that will require further work.

7.1 Summary of the Net Benefits of the CSHS

The total net benefits calculated for the CSHS are estimated at $27.3 million. As shown in Table 7-1, the vast majority of estimated benefits relate to on-farm benefits. The majority of on-farm benefits have been calculated for grazing farming systems, with net benefits also for dairy and cropping systems. Private forestry returns a negative figure. As noted earlier, the estimate for off-farm benefits is a substantial under-estimate of the true figure. Of the off-farm benefits estimated, benefits are split quite evenly between landslides and acid sulphate soils with soil erosion activities providing lower net benefits.

Table 7-1: Overall net benefits of the CSHS.

Production System Type	Present Value @ 8% discount over 30 years ($'000)		
	With CSHS	**Without CSHS**	**Net Present Value**
Cropping	$7,665	$5,921	$1,744
Dairy	$7,239	$4,418	$2,820
Grazing	$34,784	$14,844	$19,939
Private Forestry	-$6,003	-$4,576	-$1,427
Total On-farm Benefits	**$43,683**	**$20,607**	**$23,076**
Landslides			$508
Acid Sulphate Soils			$541
Soil erosion (site remediation, extension, EMOs)			$221
Improved Water Quality	Not quantified (qualitative analysis provided)		
Total Off-farm Benefits			**$1,271**
Total Benefits			**$24,347**

7.2 Costs to Implement the CSHS

The present value of the total costs for implementing the CSHS has been estimated at $11.4 million (see Table 7-2). The annual equivalent cost of this present value cost is $1.0 million per year. Details about the implementation costs for each program are provided in Appendix G.

Table 7-2: CSHS Implementation Costs

Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
Grazing Implementation Costs	$476,047	$5,359,236
Cropping Implementation Costs	$210,430	$2,368,973
Forestry Implementation Costs	$59,806	$673,281
Dairy Implementation Costs	$121,225	$1,364,722
Landslides	$61,587	$693,332
Acid sulphate soils	$23,090	$259,945
Erosion management overlays	$42,559	$479,125
Municipal soil health plan	$17,733	$199,636
TOTAL	**$1,012,477**	**$11,398,250**

7.3 Comparison of Benefits and Costs

Calculations show that, overall, the proposed actions of the CSHS are economic, even if most all of the off-farm benefits being quantified. Table 7-3 compares the net benefits with the costs of implementing the CSHS, calculated at 8 per cent over 30 years.

Table 7-3: Comparison of Benefits and Costs at 8% Discount

	Present Value (discounted at 8% over 30 years) $ million
Total Benefits	24.3
Total Implementation Costs	11.4
Overall NPV of Strategy	**12.9**

The results show that the CSHS is an economically feasible strategy with a net present value of around $12.9 million at 8 per cent discount. For more information on net benefits and costs for individual management actions, see Appendix I. Table 7-4 compares the net benefits with the costs of implementing the CSHS, calculated at 4 per cent over 30 years. The figures show that, overall, the net present value of the CSHS increases to around $29.2 million.

Table 7-4: Comparison of Benefits and Costs at 4% Discount

	Present Value (discounted at 4% over 30 years) $ million
Total Benefits	44.9
Total Implementation Costs	15.7
Overall NPV of Strategy	**29.2**

Please note that because of the way the benefits of the CSHS have been presented, that is, net of on-farm costs, it is not appropriate to present the results as a benefit cost ratio (BCR).

Recommendations for prioritising decision making and determining cost

8.1 Directions for resource allocation and decision making

The CMA has a central co-ordinating role for environmental threats in the region. Investing in addressing many of these threats will be worthwhile, while for other issues, investment may not be worthwhile. The first step in selecting investments in the region is whether the benefits (economic, social and environmental) exceed the costs of the project.

The second step is to determine how funding for the work should be shared between stakeholders, according to the likely beneficiaries from the work (this issue of cost-sharing is discussed in detail in section 8.3 and appendix H). The beneficiaries of this action will differ depending on the threat. For some areas such as soil structure stabilisation, the beneficiaries will principally be agricultural producers, while for other threats such as landslides affecting public infrastructure, the beneficiaries will be the community. Government (taxpayers' or ratepayers') funds should be directed towards activities that provide benefits to the public. This includes areas that have greatest off-farm benefit and areas that pose greatest risk to public health and safety and public infrastructure.

However the second step is independent of the first step. It is important the projects are funded in accordance with the beneficiaries of the work, however, the decision of prioritising actions is separate from cost sharing. Activities under all CMA strategies should focus on areas where net benefits will be greatest. The work undertaken will then depend on the availability of funds from different stakeholders.

An important point to emphasise is that the CMA has a core role to co-ordinate and undertake work funded from a variety of sources. It provides a critical mass of staff with appropriate skills. Furthermore, for a range of issues it will be more efficient for the CMA to undertake work centrally than for different groups of people to undertake the work themselves.

A key stakeholder for the CSHS is clearly the region's agricultural industry. This stakeholder manages most of the land in the region and the vast majority of land where soil health is a priority threat. For threats where the benefits flow to individual agricultural producers, the CMA's role will be principally one of extension and facilitation. This will rely on participation of the industry. Furthermore the participation of landholders in monitoring threats such as gully erosion and landslides will be vital. A pre-requisite for the success of the Strategy will therefore be the ownership of the CSHS by the industry and their involvement in implementing it.

8.2 Prioritisation of Management Actions

Priority on-ground activities with high on-farm benefit

In assessing priorities within the CSHS, the project team have identified the impact and importance of a range of soil health threats to determine which of those threats pose the greatest risk to the region. This section focuses on areas of high on-farm benefit.

Whilst it is necessary to understand the greatest soil health threats in the Corangamite region, priority actions within the CSHS should be based on the extent with which these threats can be managed (the reduction in risk is the benefit of the action) and the costs of associated actions.

For example, salinity may be a **very high** risk in the Corangamite region, but the costs to manage the risk, say by sub-surface drainage, would involve substantial economic costs and environmental impacts. For this example, the overall net benefits could be negative making it a poor investment decision. Alternatively, soil structural decline is a **high** risk in the Corangamite region, but the costs to manage the risk, say by increased use of best management practices, are small relative to the potential on-farm benefits. For this example, the overall net benefits are likely to be positive making it a good investment decision.

For most agricultural land use systems, one or a group of management actions will target a range of threats. So rather than develop costs and benefits for each soil health threat, we have assessed costs and benefits for individual management actions. Whilst we have assessed the benefits and costs of individual management actions, the net benefits shown for individual actions are not mutually exclusive and hence the individual benefits and costs can not be added.

The benefits and costs are shown for individual management actions in Table 8-1. The results show an interesting difference between the per unit net private benefits, and the overall NPV, which has taken into account the net private benefits, the overall adoption and the implementation costs required to achieve adoption.

For broadacre grazing, the priority management action is *E3 fertiliser management* with a NPV of over $36.4 million, followed closely by the management action E4 *graze and spell* with a NPV of $34.3 million. This differs somewhat from what the per unit private benefits would suggest, which is that the management action *E4 graze and spell* is more cost effective.

This difference between per unit private benefits and NPV is even more pronounced when we compare costs and benefits between farming systems. Note that the greatest NPV for cropping is that associated with the management action *E5 minimum tillage.* This management action has a per unit private benefit of over $22 per hectare, which is almost double that shown for *E3 fertiliser management* for broad acre grazing. Despite this, due to differences in the extent of adoption, the NPV for *E3 fertiliser management* is far in excess of that shown for *E5 minimum tillage.*

Ultimately priorities for the region should be based on the overall benefits to the region, which is captured in the NPV estimates (net of program implementation costs).

Table 8-1: Sorted priority actions within the CSHS.

Production system	Management Actions	Unit Net Private Benefits ($/ha)	NPV at 8% over 30 years (net of implementation costs)
Broad acre	E3 Fertiliser management	$12.00	$36,438,950
Broad acre	E4 Graze and spell rotation	$20.00	$34,725,635
Broad acre	E4 Land Class fencing	$8.46	$11,008,394
Forestry	E9 Implement code of practice	$41.12	$6,554,974
Dairy	E2 BMP reduce nutrient export	$30.49	$4,769,477
Cropping	E5 Minimum Till	$22.00	$3,878,004
Dairy	E7 Reverse w et soils	$19.31	$2,345,278
Cropping	E3 Lime & fertility	$10.50	$930,714
Dairy	E3 Fertiliser Management	$8.23	$564,295
Cropping	E6 Bed Farming	$9.37	$12,927
Forestry	E8 Better road construction	$0.00	-$50,926
Cropping	E5 Stubble retention	$0.00	-$51,542
Broad acre	E5 Direct drill pastures (introduce perennial pastures)	$10.27	-$228,323
Forestry	E8 Support delivery of specialist technical advice	$0.00	-$268,345
Broad acre	E2 Trees as w ind breaks	$2.22	-$553,527
Forestry	E8 Forestry to improve catchment health	-$64.49	-$1,031,160

Priority on-ground actions providing off-farm benefits

The ability to provide clear directions for on-ground actions that provide off-farm benefits is somewhat limited by the dearth of information available to estimate benefits in this area. However there is sufficient information to provide some general priorities in actions focused on off-farm benefits.

Sheet and gully erosion

It will be most efficient to capture water pollutants, such as sediment and nutrients, close to their source (Corangamite Water Quality Plan, Read Sturgess 1998). On this basis the hierarchy of preferred actions for addressing water quality is:

- Firstly source control
- Followed by breaking connectivity of drainage flows
- Followed by capture in the lower catchment
- In rare cases, treatment or removal of pollutants from waterways.

This suggests a greater emphasis on controlling erosion sites than taking downstream action. However, the Benefit Cost Analysis suggests that landholders have weak incentives to stabilise and renovate existing gully erosion sites. The return on investing in existing sheet erosion sites is likely to be more profitable but incentives may still be weak. While it was not possible to estimate the off-farm benefits of sheet and gully erosion control, the present value of benefits are expected to be in the hundreds of thousands of dollars rather than millions. The analysis in section 6.2 indicates that, for the investment in planned sheet and gully erosion site remediation to break even from an economic perspective, off-farm benefits would need to be around $0.5 million in present value terms. This suggests that it will be a very marginal investment from a CMA point of view.

Given the low on-farm benefit, remediation works should be restricted sites that will deliver very high off-farm benefits. The greatest potential off-site benefits will be provided by those sites with high sediment (and nutrient) loads, that are less costly to renovate, and are closely connected to waterways with high values (economic, social and environmental) where water quality is a threat. Work on the Corangamite Nutrient Management Strategy has highlighted that the Barwon and Corangamite basins are the key areas where returns on investment in water quality are likely to provide the best return.

Rather than investing in remediation it appears to be more worthwhile to focus investment on extension activities to assist landholders to take action to prevent the formation of sheet and gully erosion sites in the first place. This is in line with the common observation that prevention is often cheaper than cure in environmental management. Priority landscape zones for this work are the Leigh, Woady Yaloak and Moorabool.

Landslide stabilisation

Any landslide stabilisation works should focus on the locations where there is a very high risk to public safety and public infrastructure or priority waterways. However, conducting mapping and identifying risk areas will be more important to the region, as noted below. The two priority landscape zones for this area of work are Curdies and Gelibrand.

Mapping soil threats

The analysis revealed that there is a shortage of information about the condition of the region in regard to a range of soil health threats. Conducting mapping work to identify the extent of these threats, and the risk they present, is a key role for the CMA as a central co-ordinator of activity in this area on behalf of the region's community. This mapping work is assessed to have a low cost compared to the potential benefits from improved information about soil health risks in the region. This work includes:

- Finalising mapping of soil erosion in the region, including planned work with local Landcare groups and other community groups, would be useful to improve the existing mapping of key risks of gully erosion. A large number of gully erosion sites will pose risks to private rather than public assets, so it would be beneficial to link these to an extension campaign to help farmers do the work themselves.

- Identifying landslide and potential landslide sites near the location of public infrastructure.

- Rolling out mapping of acid sulfate soils across the region, focusing on coastal landscape zones. It will be necessary to implement a "zero tolerance" policy to any acid sulfate soils discovered in the region. As noted earlier, this is an area where the economic impact of ASS is difficult to estimate, and it is essentially driven by the number of ASS "sites" that actually exist in the region. It is highly recommended to further estimate (beyond the existing Cox *et al* work) the location of potential ASS sites and ground-truth whether these are actually true ASS areas. This is based on the estimated low cost relative to the potential benefits flowing from this work.

The generation of this information will assist in conducting future analyses for investment in soil health in the region.

8.2.1 Priority research and development actions.

Assessing off site impacts of soil health threats.

An increase in capability to assess the offsite impacts of soil health threats would improve the assessment of the off site benefits of the CSHS. In particular, there is currently insufficient knowledge to accurately assess the impacts of gully and sheet erosion on priority waterways. Further research is required to clarify the extent of connectivity between land (soil) and water resources, and to clarify the contribution of soil erosion to sediment and nutrient loads throughout the Corangamite CMA. Specific information requirements regarding this topic were highlighted in section 6.3. Utilisation of modelling work, such as the CSIRO's SedNET model should be valuable in this area.

General research

Other areas where research would be valuable include:

- improved research into the prediction of landslide impacts;
- research into off-site impacts of drainage works on salinity;
- improved understanding of the extent of soil biota decline and the existence of public benefits. This is widely recognised as an important threat, but there is currently little information about this threat in Corangamite; and
- improved understanding of the impacts of soil carbon decline and its importance as a threat in the region.

More broadly the ongoing use of the Department of Primary Industry's Land Use Impact Model (LUIM) will provide insights into future strategy development.

8.3 Cost sharing principles

A discussion of cost sharing principles is provided below. A more general overview of cost sharing principles in natural resource management is provided in Appendix H.

8.3.1 Costs to develop and manage the implementation of the CSHS

The costs to implement the CSHS include the costs of co-ordination, quantifying off-site impacts of various threats, monitoring activities, training programs and demonstration sites, and various investigations and research programs.

These costs are devoted to the production of goods and services that are largely of a public benefit, although some could be regarded as "industry benefit". This is because this work provides coordination, knowledge, information and ways of doing things that are available to all (at least in the Corangamite region) and one person's use of the knowledge or information does not reduce that available to others. Because of their public and industry nature, it is likely that there would be too little investment in the understanding and management of soil health threats if the provision of these goods and services were left entirely to the free market.

It is this 'public good' aspect of knowledge and information that justifies government, and industry, intervention.

Therefore, it is proposed that costs of implementing CSHS be funded by government possibly with some contribution from industry funding bodies. This is because the knowledge and information gained from the research program in the Corangamite Region, and the development of extension approaches, would also be available to other regions with similar soils, rainfall and land use patterns.

8.3.2 Costs resulting from implementation of the CSHS

The costs associated with adopting the various on-farm actions fostered by the CSHS would be borne privately by landholders if they produced sufficient revenue to overcome farmers' thresholds of profitability. Considerations include the risks, cash flows and skills associated with the actions.

If this was the case, the relevant landholders would be expected to accept bearing all of these costs because of the profits gained from doing so, provided, of course, they are aware of these benefits. The analysis presented here has suggested that various actions are likely to be profitable to farmers in the production systems of the Corangamite region, for example improved grazing and cropping practices.

In the event that the levels of profitability estimated here led to the estimated patterns of adoption, there is no reason for a government contribution because off-site benefits will be automatically produced jointly with the landholders' benefits. Therefore, it is proposed that the costs of implementing the CSHS actions be borne by landholders.

On the other hand, there is uncertainty surrounding the realisation of landholder benefits, such that the estimated profit may be below farmers' thresholds for adoption. This may create a case for government involvement to achieve the targeted rates of adoption by cost sharing and/or other mechanisms. For example, for gully erosion works, the analysis has shown that the benefits to be realised by the landholders from undertaking action are far less than the costs. Thus adoption of these work will be limited under a free market. There may however be a role for some funding by government of this work where the public benefits are significant. This will only be where gully erosion sites are exporting sediment and nutrient to priority waterways.

The acid sulfate soils and landslide programs, including the implementation of Erosion Management Overlays, clearly have a public good nature. This is because they benefit the broader community of the region and the benefits will be readily available to the community after the work is completed. Government funding is therefore justified. On this basis government funding is also justified for the priority research and development actions recommended in section 8.2.1.

Cost and benefits

The present value of benefits for the Corangamite Soil Health Strategy (CSHS) are estimated at $24.3 million, while the present value of the total costs for implementing the CSHS have been estimated at $11.4 million. The annual equivalent costs of implementation are $1.0 million per year. The results show that the CSHS is an economically feasible strategy with a net present value of around $12.9 million. These figures are based on discounting over a 30 year investment horizon using an 8 per cent discount rate.

The estimated benefits of the Strategy realised on farms in the region ($23 m) are far higher than the off-farm benefits ($1.3m). However the assessment of a range of threats was not possible due to information gaps. In assessing the overall value of the Strategy, consideration also needs to be given to the significant benefits likely to arise through impacts on threats such as water quality and river health, salinity, soil organic carbon and soil biota.

On-farm net benefits are anticipated to be greatest in the broad acre grazing industry ($19.9 m), while lower, though positive, net benefits were estimated for the dairy ($2.8m) and cropping industry ($1.7m). A negative net benefit was estimated for private forestry (-$1.4m) industries.

Priorities

While the Strategy is economically feasible, some elements of the CSHS have higher priority than others.

Actions with on-farm benefits

Areas of expected high net benefit are those focusing on improved fertiliser management and improved graze and spell management in broad acre grazing, and minimum till, bed farming and fertiliser use in the cropping industry.

Areas of expected negative net benefit include actions focused on using trees as windbreaks, increasing the use of direct drilled pastures, supporting technical advice in forestry, and promoting forestry in the region to improve catchment health.

Actions with off-farm benefits

Of farm benefits are expected to mainly arise from addressing the risks posed by acid sulfate soils and landslides. These benefits arise through identification of high risk areas and taking action to incorporate this information into planning guidelines. This work will be important to provide information to benefit future development in the region.

Extension to assist landholders prevent soil erosion was also assessed to be worthwhile. However, the profitability of undertaking on-ground works to renovate sheet and gully erosion sites was assessed to be negative from a landholder's perspective. Public benefits will exist for those sites where there is a high impact on priority waterways.

Research

The analysis revealed that generally there is insufficient information regarding soil health processes in the Corangamite region. On this basis, further research is recommended in the following areas:

- The relationship between on-farm sheet an gully erosion and river health;
- Predicting landslide impacts;
- Off-site impacts of drainage works on salinity; and
- Improved understanding of the extent and importance of soil biota and soil carbon decline.

Cost Sharing

Government funding, possibly with some industry funding, is appropriate for *co-ordinating* the implementation of the program. This is because the implementation of the Strategy mainly relates to generating goods and services that are largely of a public benefit, although some could be regarded as "industry benefit".

The costs associated with *adopting* the various on-farm actions fostered by the CSHS which are profitable from a landholder's perspective should be borne entirely by landholders. The analysis presented here suggests that various actions are likely to be profitable to farmers in the production systems of the Corangamite region, for example improved grazing and cropping practices. Programs providing information and extension services in this area are however appropriate to be co-funded by government and industry.

The existence of actions which are below landholder's threshold profitability for adoption, but which generate off-farm benefits, may create a case for government involvement to achieve the targeted rates of adoption by cost sharing and/or other mechanisms. For example, gully erosion works could fall into this category. However, it was assessed that government funding of this action will only be justified where gully erosion sites are exporting sediment and nutrient to priority waterways.

The acid sulfate soils and landslide programs, including the implementation of Erosion Management Overlays, clearly have a public good nature and are appropriate for public funding. Government funding is also justified for the priority research and development actions noted above.

Implementation

The development of the CSHS represented a major first step in providing an overall strategy for addressing the important issue of the soil health in the region. The successful implementation of the Strategy will clearly require adequate funding and support from local government and relevant State government agencies. A very important stakeholder is also the region's agricultural industry. This stakeholder manages most of the land in the region and the vast majority of land where soil health is a priority threat. A pre-requisite for the success of the Strategy will therefore be the ownership of the CSHS by industry and their involvement in implementing it.

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BENEFIT-COST ANALYSIS

Benefit-cost analysis is a conceptual framework for the evaluation of programs and projects in the public sector. It differs from financial analysis conducted by firms in the private sector in that it accounts for gains (benefits) and sacrifices (costs) irrespective of to whom they accrue. The following are some key concepts and calculations involved in benefit-cost analysis.

CONCEPTS AND CALCULATIONS

Present Value (PV) is the equivalent value today of a future benefit or cost. It is calculated as the value of a future sum or sums discounted at a given discount rate. The present is usually referred to as year zero. The present value of a sum of money S (benefit or cost) which is to be received in year t is calculated as:

$$PV = S_t \, [1 / (1 + i)^t] \qquad (1)$$

Where i is the discount rate specified as a decimal fraction (for example, 0.08 for 8 per cent). If $100 is to be received as a benefit in year 10, the present value of that benefit at a discount rate of 8 per cent is $46.32 (that is, $100/(1.08)^{10}$). Thus, $46.32 now is equivalent to $100 in year 10. This is because $46.32 invested now at 8 per cent would grow to $100 in year 10. If the discount rate were 4 per cent, $100 in year 10 has a present value of $67.56.

The present value of stream of benefits (costs) in years 1 to T is the sum of the present values of the amounts received (paid) in each year.

$$PV = S_0 + S_1[1 / (1 + i)] \ldots + \ldots S_t[1 / (1 + I)^t] \ldots + \ldots S_T[1 / (1 + I)^T] \qquad (2)$$

Net Present Value (NPV) is the present value of all benefits minus the present value of all costs. This is equivalent to the sum of the flow of annual net benefits, each of which is expressed as a present value.

An annuity is a series of equal annual sums of money. The present value of a fixed term annuity ‘a’ that ends in year t (say, year 30) is calculated as:

$$PV = a \, [(1 + i)^t - 1] / [i(1 + i)^t] \qquad (3)$$

The present value of a perpetual annuity is calculated as:

$$PV = a / i \qquad (4)$$

The annuity or annualised amount equivalent to a given PV is obtained by making ‘a’ the subject in the appropriate formula.

The discount rate is a complicated phenomenon that can be thought of as the rate of exchange between value today and value in the future. We do not delve into the issues that help to determine the appropriate rate - the interested reader is referred to the references at the end of this Appendix.

It is recommended that the rate used in the analysis be regarded as the ‘real’ or inflation-free discount rate. The real rate is approximately equal to the nominal rate minus the rate of inflation. Use of a real rate of discount means that year zero values of benefits and costs can be used throughout the analysis. If the nominal rate were used, benefits and costs would have to be measured in the dollar values in the year they accrue.

As the above formulae show, PV is inversely related to the rate of discount, therefore, a project may be acceptable at a low discount rate but not at a higher rate. As illustrated by Investments A and B below, this can occur if the project yields benefits in the distant future. It is prudent, therefore, to test the sensitivity of the results of a benefit-cost analysis to this key parameter.

Investment A (cost = $550 in year 0, benefit = $1,200 in year 10)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	810	550	260
6	670	550	120
8	556	550	6

Investment B (cost = $550 in year 0, benefit = $1,500 in year 15)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	833	550	283
6	626	550	76
8	473	550	-77

Conclusions:

- at a discount rate of 4 per cent, both investments are sound but B would be preferred;
- at a discount rate of 6 per cent, both investments are sound but A would be preferred; and
- at a discount rate of 8 per cent, only Investment A is profitable and would be preferred. Investment B is not profitable at this discount rate.

It should be noted that these sorts of results are not uncommon. The example shows the importance of demonstrating to the decision makers the sensitivity of the results to the discount rate. Their funding decisions will be influenced by the beliefs about the appropriate rate at the time.

DECISION RULES IN BENEFIT-COST ANALYSIS

(i) The NPV rule.

The prime decision rule in benefit-cost analysis is that a program or project should, subject to budget constraints, be accepted if the PV of benefits exceeds the PV of its costs, that is, the program's NPV is greater than zero.

(ii) The Benefit:Cost Ratio (BCR) rule

The BCR of a program is calculated by dividing the PV benefits by the PV of its costs:

BCR = PV benefits / PV costs

A program with a BCR greater than one is acceptable because the PV of benefits exceeds the PV of costs. A benefit cost ratio of 1.3 indicates that $1.30 PV of benefit is received for each $1.00 PV of cost.

The BCR is a useful adjunct to the NPV but it should not be used as the sole decision rule because it may give an incorrect ranking if the projects differ in size.

REFERENCES

The following texts on benefit-cost analysis are recommended for the interested reader.

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Appendix B

DETAILED ANALYSIS OF ON-FARM BENEFITS AND COSTS

Cropping Production Systems

The CSHS farm practices relevant to on-farm private costs and benefits for cropping are (CSHS action numbers are noted in brackets):

- Adopt cropping management practices that reduce compaction and maintain soil structure (Action E6), specifically:
- Increase the adoption of minimum tillage practices;
- Increase the establishment of crops through direct drilling and retain stubble;
- Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (Action E3).

Private Costs

Adopt cropping management practices that reduce compaction and maintain soil structure

The capital cost of converting machinery for use in raised bed cropping has been estimated by the CSHS cropping group as around $120/ha.

The development of raised beds for cropping incurs a cost of approximately $200/ha (approximately equal for contractors or on-farm labour).

The annual cost at 8 per cent interest with a 7-year replacement of machinery is $63.60/ha.

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil.

Estimates from previous RMCG soil health investigations indicate the following:

- Liming costs based on continuous cropping of wheat and canola are approximately $18/ha (0.25t/ha/year at $73/t)
- The cost of manure spreading to improve soil organic matter and fertility is approximately $8/ha (0.2t/ha/year at $40/t)

Good management of soil fertility and soil health may result in a decrease or increase in fertiliser use depending on existing conditions and practices. It is assumed that overall across the production system fertiliser costs will remain neutral as a result of improving soil fertility.

Total annual costs for liming and increasing soil fertility are $26/ha.

Increase the establishment of crops through direct drilling and retain stubble.

The CSHS cropping group indicated that specialised machinery costs of approximately $20/ha/year are equal to the savings in labour, machinery and fuel costs that result from minimum tillage.

This relates well to previous investigations by Rendell et al. (1996) that found in the Wimmera and Mallee savings in fuel costs ($20/ha/year) were offset by increases in chemical pesticide use ($20/ha/year).

Therefore total additional costs for minimum tillage are assumed to be zero.

Total Private Cost

The combined adopted cost for CSHS farm practices for cropping is presented in Table 10-1.

Table 10-1: Total Private Costs for Cropping

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional Annual costs
	$/ha/yr	$/ha/yr	$/ha/yr
Controlled traffic	63.6	0	63.6
Lime & fertility	0.0	26	26.0
Minimum till	19.9	-20	-0.1
Adopted combined improved practice			**$29.8/ha/yr**

Private Benefits

Adopt cropping management practices that reduce compaction and maintain soil structure

Controlled traffic (i.e. raised beds) and drainage technologies have been developed to ameliorate waterlogged soils in the region's agricultural industry. By limiting to traffic to certain "tracks" this impact is restricted to a very small part of productive area. According to CSHS working group members, raised beds in waterlogging prone areas can provide 100 per cent yield increases and controlled traffic cropping in dryer areas can increase yields by 10 per cent per year.

We have adopted a 10 per cent increase in income per year based on previous experience.

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil

The cropping working group indicated that increasing soil fertility and reducing soil pH can result in higher yields. It was also suggested that the production may be of higher quality and command a higher price, although it was noted that the opposite could also occur.

We have adopted a 5 per cent increase in yield from liming and soil fertility increases.

Increase the establishment of crops through direct drilling and retain stubble

The CSHS working group has suggested that minimum tillage can result in yield increases of up to 10-20 per cent. Whilst this is possible for early adopters in ideal situations, it is likely the average benefit will be significantly lower than this. For example the FAST report by Rendell et al. (1996) found no significant differences in yield resulting from minimum tillage.

Therefore we have revised this down to 3 per cent based on previous experience.

Combined Private Benefits

The benefits of the strategy action cannot simply be summed, as the full benefit of each action may not be realised if other actions have been/are adopted.

Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted costs are presented in Table 10-2.

Table 10-2: Combined Benefits

Farm Practise	Current gross income	Production increase	Increase in gross income
	$/ha/yr	%	$/ha/yr
Bed farming	730	10%	73
Lime & fertility	730	5.00%	37
Minimum till	730	3.00%	22
Combined benefits			**44**

Private Cost-Benefits of combined CSHS Farm Practices

The annual net private benefit of CSHS farm practices for cropping is shown in Table 10-3.

Table 10-3: Annualised Cost and Benefit of CSHS farm practices for cropping

	$/ha
Combined Private cost	$29.84
Combined Private benefit	$44
Net Private Benefit	$13.96

Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience. Long term trends in ABS data were used to determine the future total area for cropping.

Assumed adoption rates for the no intervention scenario are presented in Table 10-4. The no intervention scenario is what we would expect to occur without the CSHS. It is the baseline to compare CSHS actions against.

Table 10-4: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current adoption. (% of cropping	% Increase Each Year Given No	Area (ha)			
			2005	2015	2025	2035
Total area		1%	94,038	103,876	114,744	126,749
Controlled traffic	10%	5%	15,314	24,945	40,633	66,186
Lime & fertility	20%	2%	47,019	57,316	69,868	85,168
Minimum till	60%	1%	56,423	62,326	68,847	76,050
Combined	**42.10%**	**2.67%**	**28,211**	**36,705**	**47,755**	**62,131**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the CSHS farm practices are presented in Table 10-5.

Table 10-5: Land Areas of Farm Practices Given CSHS Implementation

Farm Practice	Strategy adoption	Area (ha)			
		2005	2015	2025	2035
Total area	2.5%	94,038	120,377	154,092	197,251
Controlled traffic	7.4%	15,314	31,125	63,260	128,573
Lime & fertility	3.8%	47,019	68,273	99,134	143,944
Minimum till	3.3%	56,423	77,689	106,969	147,285
Combined	**4.80%**	28,211	45,086	72,053	115,150

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are approximate estimates and depend upon the level of extension, economic conditions and effectiveness of the CSHS.

The above adoption rates result in significant increases in the area where each practice is undertaken. The largest increase is in the area of bed farming which reflects the estimates of the cropping working group of 80 per cent of all cropping being in beds within thirty years. In reality, this adoption rate may be artificially high (refer to Appendix J for discussion).

Total Private Benefit of CSHS Farm Practices

The total private net benefits of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and net benefits to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 10-6 presents the cost and benefit amounts for the no intervention scenario.

Table 10-6: Benefits of no intervention for cropping

	2005	2015	2025	2035
Total Cost	$841,919	$1,095,380	$1,425,147	$1,854,190
Total Benefit	$1,235,662	$1,607,661	$2,091,650	$2,721,345
Net Benefit	**$393,743**	**$512,280**	**$666,503**	**$867,155**

Table 10-7 presents the cost and benefit amounts for the strategy being implemented.

Table 10-7: Benefits of CSHS farm practices for cropping

	2005	2015	2025	2035
Total Cost	$841,919	$1,345,498	$2,150,285	$3,436,441
Total Benefit	$1,235,662	$1,974,752	$3,155,916	$5,043,572
Net Benefit	**$393,743**	**$629,254**	**$1,005,631**	**$1,607,132**

Table 10-8 presents the net cost and benefit amounts for the CSHS for cropping.

Table 10-8: Net Benefit of CSHS farm practices for cropping

	2005	2015	2025	2035
Total Cost	$0	$250,118	$725,138	$1,582,251
Total Benefit	$0	$367,091	$1,064,266	$2,322,227
Net Benefit	**$0**	**$116,974**	**$339,128**	**$739,976**

A significant on-farm net benefit of over $5 million by year 30 may be expected through the implementation of the CSHS.

Table 10-9 shows the net present value of implementing the CSHS for cropping at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 10-9: Net Present Value of CSHS on Cropping

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$7,665
Without CSHS	$5,921
Net Present Value	$1,744

Dairy Production Systems

The relevant CSHS actions, and associated farm practices are:

- Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (Action E3);
  - Application of appropriate rates of fertiliser; and
  - Liming.
- Implement best management practices for wet soils on dairy farms to improve soil health (Action E8)
  - Grazing management waterlogged soils; and
  - Timing and use of farm machinery.
- Implement best management practices to reduce nutrient and sediment export to waterways (Action E2);
  - Reduce nutrient loss to waterways from dairy farms; and
  - Reduce sediment loss from dairy farming systems.

Private Costs

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil;

Application of appropriate rates of fertiliser

Operating costs arise from testing of soil nutrient levels, which facilitates efficient nutrient application and management. According to the CSHS dairy group and RMCG client records these costs are approximately $600/property/year or $3/ha/year assuming an average property size of 200ha.

Liming

The liming of soils occurs at 2-5t/ha every seven years at the reestablishment of perennial pastures at an annualised capital cost of $39.8/ha. Liming also occurs over a quarter of pastures each year at a rate of 1t/ha at an annual operating cost of $15/ha.

This results in an annual cost of $54.8/ha assuming a cost of $50/t for lime based on RMCG records and CSHS dairy group estimates.

Implement best management practices for wet soils on dairy farms to improve soil health

Grazing management for waterlogged soils

The actions that have been identified to manage water logged soils and their associated costs are presented in Table 10-10.

Table 10-10: Strategies and costs to reduce waterlogging on dairy farms

Action	Capital Costs across whole of production system ($)/ha	Annual Capital Costs ($) assuming 8% interest	Additional Operating Cost per hectare ($/ha/yr)	Total Additional Costs ($/ha/yr)
Installation of surface drainage	100	14		
Installation of sub-surface drainage	833 ($2500/ha over 33% of production system)	90		
Improved grazing management.			5	
Installation of feed pads	100	11		
Adopted combined cost	**$1,033**	**$114.7**	**$5**	**$119.7**

Note: Annual costs for drainage infrastructure assume an average 18 year replacement period.

Capital costs have been determined from working group estimates and RMCG experience. Operating costs have been calculated from the CSHS dairy group's estimates of additional labour requirements.

Timing and use of farm machinery

The primary strategies employed to reduce the impact of machinery on soils are:

- Timing of operations to avoid significant soil impacts; and

- Utilising smaller machinery and/or larger low pressure tyres.

Additional capital costs are assumed to be low and have been estimated by RMCG at $25/ha requiring replacement every seven years. This results in an annual cost of $5/ha/year.

Additional operating costs are difficult to quantify as they result from a number of factors. These are:

- A decreased flexibility in the timing of cropping activities;
- Crop yield reductions from less timely applications of fertilisers;
- Reduction of summer pasture yields due to later sowing times (resulting from restricted cultivation of wet soils); and
- Increased costs for cultivation (smaller rig / higher labour).

These operating costs are assumed to be negligible.

Implement best management practices to reduce nutrient and sediment export to waterways;

Reduce nutrient loss to waterways from dairy farms

On-farm actions that have been identified by the dairy working group to reduce nutrient run-off is the installation of irrigation infrastructure for effluent reuse and conducting soil testing.

An effluent reuse system would typically incorporate the application of effluent to land. It is assumed that there is some existing effluent reuse infrastructure on most properties and that this action only requires additional piping and pumping infrastructure. This enables the effluent to be applied to a large area so that soil nutrient concentrations do not reach excessive levels and cause nutrient run-off.

Costs for an effluent reuse system have been determined through consultation with the CSHS dairy group and RMCG experience and records. Capital costs for the additional piping and pumps are $150/ha. Replacement will be required on an average of twelve years resulting in an annualised cost of $20.7/ha/year.

Reduce sediment loss from dairy farming systems

Reductions of sediment loss on dairy farms are achieved thorough establishing buffer strips along riparian zones. Fencing, revegetation and water trough costs have been estimated by the CSHS dairy group at approximately $7/m.

The cost per hectare is dependent upon the number and density of streams (which is unknown). We have assumed that for each hectare of land adjoining a waterway, 100m of buffer strip will be required (i.e. one boundary). Buffer strips, therefore, cost $700/ha for all hectares adjoining waterways. Assuming waterways only adjoin approximately 10 per cent of the area, the unit on-farm cost of buffer strips is $70/ha (i.e. 10 metres at $7/m).

Buffer strips require replacing approximately every fifteen years resulting in an annual cost for buffer strips of $8.80/ha/year.

Total Private Cost

The sum of the costs for the individual actions amounts to approximately $175/ha/year. The sum of the costs is unlikely to be an effective measure of total costs due to inherent efficiencies in undertaking actions concurrently. Also, in practice it is likely that land managers will implement the actions in stages or only adopt some of the actions. Therefore this study has averaged the costs for each action and adopted this average as a likely combined cost of actions for land managers. The costs and combined adopted cost are presented in Table 10-11.

Table 10-11: Total Private Costs for Dairy

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional annual costs
	$/ha/yr	$/ha/yr	$/ha/yr
Drainage & grazing management	114.7	5	119.7
Fertiliser management	0	3	3
Effluent reuse	20.7	0	20.7
Reduce machinery compaction	5.0	0	5.0
Reduce sediment loss	8.8	0	8.8
Liming	39.8	15	54.8
Adopted combined improved practice			**$35.3/ha/yr**

Private Benefits

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil;

Application of appropriate rates of fertiliser

Substantial improvements in yields can provide for some on-farm economic benefits, although the majority of benefits will be experienced off-farm through improvements in water quality. Additionally, there could be significant cost reductions for those users who are applying excess nutrients currently. A production increase of 0.5 per cent from efficient nutrient management has been adopted for this study.

Liming

The CSHS dairy working group has estimated a 5 per cent increase in production for this action. This is supported by RMCG client records.

Implement best management practices for wet soils on dairy farms to improve soil health

Grazing management waterlogged soils

The practices that have been identified to manage water logged soils are installing surface and subsurface drainage as well as improving grazing management.

Consultation with the CSHS dairy group and RMCG experience has led to the adoption of an overall increase in production of 10 per cent resulting from these practices.

Timing and use of farm machinery

The major benefit of this action is an increase in long-term productivity and pasture growth. This has not been quantified and has been assumed to contribute a benefit of 2 per cent gross margin increase.

Implement best management practices to reduce nutrient and sediment export to waterways;

Reduce nutrient loss to waterways from dairy farms

Kane (2003) has estimated that effluent reuse can yield up to $4000/ML through extra pasture yields. Dairy farms in south western Victoria produce on average 3ML/year of effluent, resulting in a possible benefit of up to $12,000/year.

An average benefit of $2,100/ML or $31.5/ha (assuming an average farm size of 200 hectares) has been adopted as the benefit of effluent application to land. This is equal to a 3 per cent increase in total income.

Reduce sediment loss from dairy farming systems

The on-farm benefits of reducing sediment loss are restricted to minimising production decreases resulting from nutrient and soil loss. These benefits are difficult to quantify and have been assumed to contribute a benefit of 2 per cent gross margin increase.

Combined Private Benefits

The benefits of the strategy action cannot simply be summed as the full benefit of each action may not be realised if other actions have been/are adopted. Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted cost are present in Table 10-12.

Table 10-12: Combined Benefits of CSHS for Dairy Farms

Farm Practice	Current Income	Production Increase	Increase in Income
	$/ha/yr	%	$/ha/yr
Drainage & grazing management	1200	10%	120
Fertiliser management	1200	0.5%	6
Effluent reuse	1200	3%	36.0
Reduce machinery compaction	1200	2%	24
Reduce sediment loss	1200	2%	24
Liming	1200	5%	60
Combined benefits			**$45/ha/year**

Private Cost-Benefits of CSHS Farm Practices

The annual net private benefit of CSHS farm practices for dairy is shown in Table 10-13

Table 10-13: Annualised Cost and Benefit of CSHS Farm Practices for Dairy

	$/ha/year
Combined cost	$35.3
Combined benefit	$45
Net Benefit	$9.7

Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience. Resulting estimates were then checked against likelihood tables produced from the DPI land Use Impact Model (LUIM).

This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil threats presented in section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found. Long term trends in ABS data were used to determine the future total area for dairy.

Assumed adoption rates for the no intervention scenario are presented in Table 10-14. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 10-14: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of cropping area)	% Increase Each Year Given No Intervention	Area (ha)			
			2005	**2015**	**2025**	**2035**
Total area		1.30%	171,004	194,581	221,409	251,936
Drainage & grazing management	30%	0.50%	51,301	53,925	56,682	59,581
Fertiliser management	30%	0.50%	51,301	53,925	56,682	59,581
Effluent reuse	10%	2%	25,651	31,268	38,116	46,463
Reduce machinery compaction	3%	2%	5,130	6,254	7,623	9,293
Reduce sediment loss	3%	1%	5,130	5,667	6,260	6,915
Liming	33%	1%	56,431	62,335	68,857	76,061
Combined	**18%**	**1.2%**	**35,911**	**40,327**	**45,287**	**50,857**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the combined soil health actions are presented in Table 10-15.

Table 10-15: Land Areas of Farm Practices Given Implementation of CSHS

Farm Practice	Strategy adoption Rates (% per yr)	Area (ha)			
		2003	2013	2023	2033
Total area	1.30%	171,004	194,581	221,409	251,936
Drainage & grazing management	2%	51,301	62,536	76,231	92,925
Fertiliser management	2%	51,301	62,536	76,231	92,925
Effluent reuse	6%	25,651	45,937	82,266	147,326
Reduce machinery compaction	10%	5,130	13,306	34,513	89,518
Reduce sediment loss	9%	5,130	12,145	28,751	68,065
Liming	3%	56,431	75,839	101,921	136,974
Combined	**5.30%**	35,911	60,379	101,518	170,688

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of CSHS.

The CSHS is likely to result in a considerable increase in the proportion of the total dairy area that implements the CSHS farm practices. Given assumed adoption rates, the percentage of land on which combined practices occur could increase from 20 per cent given no intervention to 70 per cent with CSHS intervention.

This scenario is considered to be a maximum change scenario; in reality adoption rates are likely to be significantly less than presented above. Refer to Appendix J for a discussion of likely adoption rates.

Total private benefit of soil health

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and net benefits to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 10-16 presents the cost and benefit amounts for the no intervention scenario.

Table 10-16: Benefits of no intervention for dairy

	2005	2015	2025	2035
Total Cost	$1,268,695	$1,814,740	$1,599,949	$1,796,720
Total Benefit	$1,615,995	$1,814,740	$2,037,928	$2,288,565
Net Benefit	**$347,300**	**$390,013**	**$437,979**	**$491,845**

Table 10-17 presents the cost and benefit amounts for the strategy being implemented.

Table 10-17: Benefits of CSHS actions

	2005	2015	2025	2035
Total Cost	$1,268,695	$2,133,121	$3,586,525	$6,030,206
Total Benefit	$1,615,995	$2,717,054	$4,568,321	$7,680,948
Net Benefit	**$347,300**	**$583,933**	**$981,796**	**$1,650,743**

Table 10-18 presents the net cost and benefit amounts for the CSHS for dairy.

Table 10-18: Net Benefit of CSHS Actions

	2005	2015	2025	2035
Total Cost	$0	$318,381	$1,986,576	$4,233,485
Total Benefit	$0	$902,314	$2,530,393	$5,392,384
Net Benefit	**$0**	**$193,920**	**$543,817**	**$1,158,898**

A total on-farm net benefit of over on million dollars may be expected through the implementation of the CSHS.

Table 10-19 shows the net present value of implementing the CSHS for dairy at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 10-19: Net Present Value of CSHS on Dairy

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$7,239
Without CSHS	$4,418
Net Present Value	$2,820

Broad Acre Grazing Production Systems

The CSHS programs relevant are:

- Implement appropriate grazing practices based on land class boundaries to sustain long-term soil health (Action E4)
- Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil (Action E3);

- Strategically establish trees to act as windbreaks to control wind erosion (Action E2); and
- Increase the establishment of perennial pastures, with a preference for direct drilling (Action E5).

Private Costs

Implement appropriate grazing practices based on land class boundaries to sustain long-term soil health

The grazing working group has estimated the on-farm costs for rotational grazing to be $25/ha plus increasing stock numbers.

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil;

The grazing working group has stated that there are no real costs associated with lime and nutrient management and that an open mind is all that is needed.

SGS data suggests that many farmers are not currently testing their soils for nutrient levels. This practice could significantly improve nutrient and lime management.

Soil testing costs of $3/ha/year have been assumed for nutrient management actions. This has been estimated from RMCG client records. This figure is equivalent to the difference in costs between the lowest and highest income earners amongst Victorian wool growers (NRE 1999).

Promote the fencing to allow appropriate grazing of different land classes

The grazing working group has estimated a capital cost of $60/ha for the required fencing (1000m/100ha) which is $7.5/ha/year assuming 8 per cent interest and the need for replacement after 15 years.

Additional operating costs of $5/ha/year can be expected due to water pumping as well as management and labour demands.

Therefore total additional costs for land class fencing are $12.5/ha/year.

Strategically establish trees to act as windbreaks to control wind erosion

The grazing working group has estimated a cost of $35 per hectare for establishing 10 per cent tree cover which is $3.8/ha/year assuming 8 per cent interest and replacement after 20 years.

Increase the establishment of perennial pastures, with a preference for direct drilling

Costs of $125/ha for perennial pasture establishment have been determined from RMCG client records which is $19.73/ha/year assuming 8 per cent interest and replacement after 10 years.

Total Private Cost

The sum of the costs for the individual actions amounts to approximately $64/ha/year. The sum of the costs is unlikely to be an effective measure of total costs due to inherent efficiencies in undertaking actions concurrently.

Also, in practice it is likely that land managers will implement the actions in stages or only adopt some of the actions.

Therefore this study has averaged the costs for each action and adopted this average as a likely combined cost of actions for land managers. The costs and combined adopted costs are presented in Table 10-20.

Table 10-20: Total Private Costs for Grazing

Action	Annual Capital Cost	Additional Annual Operating Cost	Total Additional Annual Costs
	$/ha/yr	**$/ha/yr**	**$/ha/yr**
Rotation grazing	0.0	25	25.0
Lime/fertiliser management	0.0	3	3.0
Land class fencing	7.5	5	12.5
Trees as windbreaks	3.8	0	3.8
Introduce perennials (where absent)	19.7	0	19.7
Adopted combined improved practice			**$13/ha/yr**

Private Benefits

Implement appropriate grazing practices based on land class boundaries to sustain long-term soil health

Southern Grazing Systems (2001) research indicates that significant increases in gross margins can be achieved through the adoption of rotation grazing.

Research in south western Victoria has shown the rotation grazing can allow a 10-15 per cent increase in stocking rates. An increase in production of 15 per cent has been assumed by this study.

Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil;

The SGS program found that less than $0.50/ha/year of P fertiliser equivalent is being lost in surface water runoff. Therefore on-farm benefits resulting from restricting nutrient run off are minor.

Appropriate liming and fertiliser application can significantly increase soil fertility and pasture productivity. This can result in increase in stocking rates.

Benefits of lime and nutrient management are assumed to be a 5 per cent increase in production.

Promote the fencing to allow appropriate grazing of different land classes

Land class fencing can result in significant reduction in soil erosion, soil compaction and impacts from stock camps.

On-farm financial benefits of reduced soil erosion and compaction are difficult to quantify. They are experienced through improved pasture growth and subsequent increased stocking rates. It has been assumed that an improvement of 7 per cent be achieved through land class fencing.

Strategically establish trees to act as windbreaks to control wind erosion

Windbreaks can contribute to on-farm financial benefits by improving pasture and crop production and decreasing the cost of chemical control of pests.

Pasture and crop improvements are likely to contribute to a 2 per cent increase in production. Decreases in chemical costs are considered to be minimal.

Increase the establishment of perennial pastures, with a preference for direct drilling

The introduction of perennial pastures can result in significant increases in production and gross margins. Previous studies by RMCG (2002) indicate increases can be up to 8 DSE/ha when combined with liming and improved grazing management.

Stocking rates are unlikely to increase by more than 6 DSE/ha (50 per cent) and this is only likely from areas of existing low stocking rates.

An increase in production of 10 per cent has been assumed to result from the addition of perennials.

Combined Private Benefits

The benefits of the strategy action cannot simply be summed as the full benefit of each action may not be realised if other actions have been/are adopted.

Therefore this study has averaged the benefits for each action and adopted this average as a likely combined benefit. The benefits and combined adopted costs are presented in Table 10-21.

Table 10-21: Combined Benefits of CSHS for Grazing

Action	Current Gross Income	Production Increase	Increase in Gross Income
Rotation grazing	320	15%	48.0
Lime/fertiliser management	320	5%	16.0
Land class fencing	320	7%	22.4
Trees as windbreaks	320	2%	6.4
Introduce perennials (where absent)	320	10%	32.0
Combined benefits			**$19/ha/year**

Private Cost-Benefits of CSHS Farm Practices

The annual net private benefit of CSHS farm practices for broad acre grazing is shown in Table 10-22.

Table 10-22: Cost and Benefit of CSHS farm practices for broad acre grazing

	$/ha/year
Combined Cost	$13
Combined Benefit	$19
Net Benefit	$6

Adoption rates

Adoption rates have been estimated from CSHS working group estimates combined with RMCG experience.

This checking involved comparison of the spatial distribution of the likelihood of soil degradation processes (equivalent to the soil threats presented in Section 3) that each practice addressed to the area that practices would be adopted given assumed adoption rates. Adoption rates were adjusted if a significant discrepancy was found.

Long term trends in ABS data were used to determine future areas for cropping and dairy. It has been assumed that increases in these land uses result in a decrease in the total area of grazing.

Assumed adoption rates for the no intervention scenario are presented in Table 10-23. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 10-23: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of grazing area)	% Increase Each year Given no Intervention	Area (ha)			
			2005	**2015**	**2025**	**2035**
Total area			732,944	696,902	656,446	611,013
Rotation grazing	33%	0.50%	241,872	254,241	267,243	280,910
Lime/fertiliser management	10%	0.50%	73,294	77,042	80,982	85,124
Land class fencing	3%	0.10%	21,988	22,209	22,432	22,657
Trees as windbreaks	10%	2%	73,294	89,345	108,911	132,762
Introduce perennials (where absent)	20%	1.00%	146,589	161,925	178,866	197,580
Combined	**16%**	**0.80%**	**114,339**	**124,068**	**134,626**	**146,081**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the combined soil health actions are presented in Table 10-24.

Table 10-24: Land Area of Farm practices given CSHS Implementation

Farm Practice	Strategy adoption Rates (% per yr)			Area (ha)			
	2005-15	**2015-25**	**2025-35**	**2005**	**2015**	**2025**	**2035**
Total area				732,944	664,206	570,528	441,048
Rotation grazing	7.50%	0%	0%	241,872	498,505	498,505	493,919
Lime/fertiliser management	22.00%	0%	0%	73,294	535,386	513,475	396,943
Land class fencing	27.50%	0.10%	0.01%	21,988	249,625	252,132	252,384
Trees as windbreaks	5%	2%	1%	73,294	119,388	145,534	160,760
Introduce perennials (where absent)	2.00%	1.30%	0.40%	146,589	178,691	203,328	211,609
Combined	**12.80%**	**0.70%**	**3.20%**	**114,339**	**381,316**	**408,054**	**419,708**

Note: These are estimates based on CSHS working group estimates combined with RMCG experience. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of CSHS.

The above tables highlight the fact that grazing is the one land use in the CCMA that is expected to significantly decrease in size, irrespective of CSHS implementation. The CSHS can be expected to strengthen this decline in area as well as significantly increasing the proportional area of CSHS farm practices being adopted.

Total Private Benefit of CSHS Farm Practices

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and benefits-costs to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 10-25 presents the cost and benefit amounts for the no intervention scenario

Table 10-25: Benefits of no intervention

	2005	2015	2025	2035
Total Cost	$1,464,626	$1,589,255	$1,724,489	$1,871,231
Total Benefit	$2,675,533	$2,903,201	$3,150,243	$3,418,307
Net Benefit	**$1,210,907**	**$1,313,946**	**$1,425,754**	**$1,547,076**

Table 10-26 presents the cost and benefit amounts for the strategy being implemented.

Table 10-26: Benefits of CSHS actions

	2005	2015	2025	2035
Total Cost	$1,464,626	$4,884,473	$5,226,967	$5,376,252
Total Benefit	$2,675,533	$8,922,802	$9,548,460	$9,821,169
Net Benefit	**$1,210,907**	**$4,038,329**	**$4,321,493**	**$4,444,917**

Table 10-27 presents the net cost and benefit amounts for the CSHS for grazing

Table 10-27: Net Benefit of CSHS Actions

	2005	2015	2025	2035
Total Cost	$0	$3,295,217	$3,502,477	$3,505,021
Total Benefit	$0	$6,019,600	$6,398,216	$6,402,862
Net Benefit	**$0**	**$2,724,383**	**$2,895,739**	**$2,897,841**

An on-farm net benefit of just over one million dollars may be expected through the implementation of the CSHS.

Table 10-28 shows the net present value of implementing the CSHS for broad acre grazing at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 10-28: Net Present Value of CSHS on Broad acre Grazing

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	$34,784
Without CSHS	$14,844
Net Present Value	$19,939

Private Plantation and Farm Forestry

The relevant Corangamite Soil Health Strategy actions for block plantations on sloping sites are:

- Implement Codes of Forest Practices related to soil health for all plantations (Action E9).
- Promote farm forestry plantations in areas that benefit soil and catchment health (Action E8); and
- Develop a discussion group to improve the implementation of private forestry BMPs (under Action E8).

Assumptions

Some key assumptions used in the evaluation of the Soil Health Strategy Actions for private and farm forestry are:

- The typical species and rotation mix is 60 per cent Radiata Pine and 40 per cent Blue gum;
- Rotation length for Radiata Pine and Blue gum is 28 years and 20 years respectively; and
- Current annual growth in plantations in the region of 260 hectares of softwood and 500 hectares of hardwood (including farm forestry).

Many of the assumptions concerning the current costs of operations, likely impacts of CSHS actions on production and adoption rates of the best management practices with and without the actions have been formulated by URS in the absence of better information being provided by industry ‘experts’. These assumptions are likely to have considerable influence on private costs and benefits and will need to be reviewed if and when better information becomes available. For more assumptions, see Appendix C.

Private costs

Implement Codes of Forest Practices related to soil health for all plantations.

The Code of Forest Practices formalises the best management practices, from site preparation to post-harvest practices, for forest activities. The Code is enforced on public land, but while it incorporates management practices on private land, it is simply a guideline rather than regulation on this land. For this assessment, the management practices specified in the Code of Forest Practices that have been evaluated are:

- ground preparation (including appropriate ripping and mounding); and
- road design, construction and maintenance.

Ground Preparation

Best management practices for ground preparation which includes contour ripping and mounding is estimated to increase site preparation costs by around 25 per cent. This includes the possible increase in time and labour input, equipment hire and other costs. Assuming an average cost of site preparation of $190 per hectare, the additional cost of best management ground preparation is approximately $47.50 per hectare. This cost will be incurred on new sites or existing site re-establishment for the areas where the action is adopted.

Roading and other costs

Additional private costs identified include code adherence costs of up to $100 per hectare which includes improved road design and construction. This cost is assumed to be incurred once for each rotation.

Table 10-29: Private Cost of Implementing the Code of Forest Practices on private plantation and farm forestry

Action	Average Cost $/ha	Frequency of Outlay
Ripping and Mounding	$47.50	Once at plantation establishment
Additional costs (eg. Roads)	$100	Assume once in year before final harvest
Total Annual Equivalent Cost (calculated over 30 years @ 8%)	$6.41	

Promote plantations in areas that benefit soil and catchment health

Establishing plantations in marginal areas that benefit soil and catchment health are often not the preferred sites for optimal tree growth rates. Private establishment and management costs for plantations located on target sites is estimated to increase by around 50 per cent of the total cost (estimated at $1,200 per hectare), or around $600 per hectare over the first three years of the rotation, giving a total establishment cost of $1,800 per hectare. This translates into an annual private cost of $52 per hectare per year calculated at 8 per cent discount rate.

Table 10-30: Private Cost of establishing plantations on areas that benefit soil and catchment health on private plantation and farm forestry

Action	Average Cost $/ha	Frequency of Outlay
Additional costs	$600	Once every rotation
Annual Equivalent Cost (calculated over 30 years @ 8%)	$52[a]	

[a] Assumes a rotation length of 20 years for hardwood (40%) and 28 years for softwood (60%) plantations

Private benefits

Implement Code of Forest Practices

The private benefits for ripping and mounding include higher product yields and greater seedling success rates. Better seedling success rates will increase the volume of the first thinning and implicitly increase the value of clearfall products by providing greater selection ability at thinning. The average increase in production value was estimated at 15 per cent or $21/ha/year (15% of $140/ha).

Better road design and construction may decrease road maintenance costs by 25 per cent. At a current average annual road maintenance cost of $100 per hectare, the benefit of this BMP is estimated at $25/ha/year.

Future plantation establishment costs (other than road design and construction) may also be reduced through adherence to the Code of Forest Practices. Assuming a current establishment cost of $1,200 per hectare and a reduction in future establishment costs of 10 per cent, the reduction in future establishment costs are $120/ha. This translates to an average annual equivalent saving of around $1.50/ha/year.

Table 10-31: Private Benefit of implementing Code of Forest Practices on private plantation and farm forestry

Action	Average Benefit $/ha/yr
Ripping and Mounding	$21
Better Road Construction	$25
Reduced Future Establishment Costs	$1.53
Annual Equivalent Benefit (calculated over 30 years @ 8%)	$47.53

Promote plantations in areas that benefit soil and catchment health

The private benefits for establishing plantations in areas that benefit soil and catchment health include the opportunity cost of alternative land uses. Although the productivity of plantations are likely to be less than that achievable on more suitable sites for tree growing, the annual equivalent returns on the target land may be in the order of $140 per hectare per year[1]. Sheep grazing in these low production areas are around, say, 10 DSE per hectare[2], which translates into an average gross margin of $120 per hectare (based on a gross margin for sheep grazing of $12 per DSE[3]). The difference between these land uses, $20 per hectare, represents the productivity benefits of this action.

The CSHS Working Group suggested a likely reduction in annual maintenance costs normally associated with inappropriate land use. This reduction may be in the order of 50 per cent of current annual maintenance costs of $50 per hectare. This equates to an annual reduction in maintenance costs of $25 per hectare per year.

Table 10-32: Private Benefit of establishing plantations on areas that benefit soil and catchment health on private plantation and farm forestry

Action	Average Benefit $/ha/yr
Net productivity	$20
Reduced maintenance	$25
Annual Equivalent Benefit (calculated over 30 years @ 8%)	$45

[1] Based on average returns for a combination of softwood and Blue gum woodlots (URS, 2003).
[2] Based on a low Victoria average sheep stocking rate of 1.4 DSE/ha/100mm rainfall and around 700mm rainfall.
[3] Based on a low Victorian average gross income of $20 per DSE and sheep variable costs of around $8 per DSE.

Net Benefits

Table 10-33 shows that Action 7.1 may require Government incentives to encourage landholders to develop woodlots on sites that would benefit soil and catchment health. That is, the additional establishment costs are greater than the private benefits that would result. On the other hand, Action 7.3 is likely to result in a net private benefit and hence, be more readily adopted by landholders.

Table 10-33: Annualised Private Costs and Benefits of the CSHS actions for Private plantation and farm forestry ($/ha/year)

	Action 7.3	Action 7.1
Combined Private Cost	$51.89	$6.41
Combined Private Benefit	-$12.60	$47.53
Net Private Benefit	-$64.49	$41.12

Adoption rates

In estimating the total benefits of the Corangamite Soil Health Strategy, estimates were made for the likely adoption of relevant actions, 'with' and 'without' the soil health strategy.

The benefits associated with Action 7.4 listed above, to develop a discussion group to improve the implementation of private forestry BMPs, has been incorporated into the benefit cost analysis by increasing the rate of adoption of the other actions evaluated in this report. The CSHS Working Group suggested that this action could increase the adoption of actions 7.1 and 7.3 by 0.5 per cent.

Assumed adoption rates for the no intervention scenario are presented in Table 10-34. The current total area of private plantation forestry plus private farm forestry is estimated at 51,350 hectares (URS Forestry, 2003). This area may differ from that presented in Table 2-1 as these have been derived from different sources and the areas of private and public forestry from URS Forestry (2003) were considered to be the most accurate. The no intervention scenario is what we would expect to occur without CSHS. It is the baseline to compare CSHS actions against.

Table 10-34: Land Areas of Farm Practices Given No Intervention

Farm Practice	Current Adoption. (% of private forest Area)	% Increase Each year Given no Intervention	Area (ha)			
			2005	2015	2025	2035
Total area		0.50%	51,350	53,976	56,736	59,638
Planting Marginal Sites	15%	0.10%	7,703	7,780	7,858	7,937
Implement COFP	50%	1.00%	25,675	28,361	31,328	34,606
BMP Discussion Groups	0%	0%	na	na	na	na
Combined		**0.40%**	**16,689**	**17,368**	**18,076**	**18,812**

Note: These are estimates based on CSHS working group estimates. However they are very approximate estimates and ideally would require surveying for verification.

Assumed adoption rates for the soil health actions are presented in Table 10-35.

Table 10-35: Land Area of Farm practices given CSHS Implementation

Farm Practice	Strategy adoption Rates (% per yr)	Area (ha)			
		2005	2015	2025	2035
Total area	0.50%	51,350	53,976	56,736	59,638
Planting Marginal Sites	1.00%	7,703	8,939	10,374	12,040
Implement COFP	5.60%	25,675	46,416	56,736	59,638
BMP Discussion Groups	0.50%	na	na	na	na
Combined	**2.40%**	**16,689**	**22,140**	**29,371**	**38,964**

Note: These are estimates based on CSHS working group estimates. However they are very approximate estimates and depend upon the level of extension, economic conditions and effectiveness of the CSHS.

In the above tables, the future growth in private forestry is assumed to occur at the expense of area currently used for broad acre grazing. The figures highlight the fact that extent of private forestry in the CCMA is likely to increase irrespective of CSHS implementation. The CSHS can be expected to have little or no effect on overall growth in private forestry, but will increase the adoption of best management forestry practices. It should be noted that the adoption of plantations on marginal sites with the CSHS (around 80 hectares per year in the first 10 years) is considered to a high estimate of achievable adoption.

Total Private Benefit of CSHS Farm Practices

The total net benefit of the soil health actions are presented below. These amounts have been calculated by multiplying the per hectare costs and benefits by the area of the relevant production system (hectares). This results in a total dollar figure for the costs, benefits and benefits-costs to be expected for the combined on-farm practices of the strategy.

The baseline no intervention scenario is compared with the predicted amounts calculated for the implementation of the CSHS. This produces the expected costs and benefits that can be attributed solely to the implementation of the CSHS.

Table 10-36 presents the cost and benefit amounts for the no intervention scenario

Table 10-36: Benefits of no intervention

	2005	2015	2025	2035
Total Cost	$973,030	$1,012,659	$1,053,903	$1,096,826
Total Benefit	$582,933	$606,674	$631,383	$657,098
Net Benefit	**-$390,097**	**-$405,985**	**-$422,520**	**-$439,728**

Table 10-37 presents the cost and benefit amounts for the strategy being implemented.

Table 10-37: Benefits of CSHS actions

	2005	2015	2025	2035
Total Cost	$973,030	$1,290,842	$1,712,457	$2,271,780
Total Benefit	$582,933	$773,331	$1,025,916	$1,361,001
Net Benefit	**-$390,097**	**-$517,511**	**-$686,541**	**-$910,779**

Table 10-38 presents the net cost and benefit amounts for the CSHS for grazing

Table 10-38: Net Benefit of CSHS Actions

	2005	2015	2025	2035
Total Cost	$0	$278,182	$658,554	$1,174,954
Total Benefit	$0	$166,656	$394,533	$703,904
Net Benefit	**$0**	**-$111,526**	**-$264,021**	**-$471,051**

Table 10-39 shows the net present value of implementing the CSHS for private forestry at an 8 per cent discount rate over 30 years. This is the difference between the present value of net benefits *with* and *without* the CSHS.

Table 10-39: Net Present Value of CSHS on Private Forestry

	Present Value @ 8% discount over 30 years ($'000)
With CSHS	-$6,003
Without CSHS	-$4,576
Net Present Value	-$1,427

Public Native Forestry

The relevant Corangamite Soil Health Strategy actions are:

- Implement Codes of Forest Practices related to soil health for all plantations (Action E9); and
- Increase awareness and skills in road design construction and maintenance (under Action E8).

Code of Forest Practices is already enforced on Public land. Adherence to the code of practice would ensure that site and temporary road regeneration is undertaken in a manner that maximises future environmental condition. Also, changes in the management of public native forests in the Corangamite Region are proposed over the next 5 years or so. Therefore, the costs and benefits from implementing the soil health strategy have not been evaluated.

Sum of Net Benefits for all Production Systems

Table 10-40 shows the sum of the net benefits for all production systems evaluated in this assessment. The figures show that the total on-farm net benefits can reach just under $3.0 million per year within 10 years and over $4 million per year within 30 years with the implementation of all of the CSHS actions.

Table 10-40: Sum of Net Benefits for all production systems

Production System	2005	2015	2025	2035
Cropping	$0	$116,974	$339,128	$739,976
Dairy	$0	$193,920	$543,817	$1,158,898
Grazing	$0	$2,724,383	$2,895,739	$2,897,841
Private Forestry	$0	-$111,526	-$264,021	-$471,051
Public Native Forestry	Not assessed			
Total		**$2,923,750**	**$3,514,662**	**$4,325,666**

Appendix C

KEY ASSUMPTIONS USED IN THE BENEFIT COST ANALYSIS

GENERAL ASSUMPTIONS

Discount Rate	A 'real' discount rate (based on inflation-free interest rates) of 8 per cent was used.
Existing Farm Assets	Exiting farm assets assumed to be adequate for the implementation of actions unless otherwise costed.
Total Agricultural Area	The total agricultural area will remain unchanged over the investigation period.
Production Systems	Costs, benefits and adoption rates have been determined for each production system, variations within production systems have not been incorporated to this study.

ON-FARM ASSUMPTIONS

Cropping

Growth in Area	Growth in area of cropping will be 1% per year without strategy.
Combined Practices	On farm practices will be adopted as a combination of practices.
Gross Income	Annual income per hectare is $730/ha/year.

Dairy

Growth in Area	Growth in area of dairy will be 1.3% per year without strategy
Combined Practices	On farm practices will be adopted as a combination of practices
Gross Income	Annual income per hectare is $1200 based on 1.5 head/ha at $800/head/year
On farm Management	Practices will increase management costs and reduce flexibility
Property Size	Assumed property size of 200ha
Additional Stock	Costs of additional stock to increase production have not been attributed to costs for on-farm practices

Grazing

Growth in Area	As cropping and dairy areas grow, grazing area will decrease
Combined Practices	On farm practices will be adopted as a combination of practices
Gross Income	Annual income per hectare is $300/ha
On farm Management	Practices will increase management costs and reduce flexibility

Land class fencing	Land class fencing is assumed to require 1km of fencing per 100ha
Additional Stock	Costs of additional stock to increase production have not been attributed to costs for on-farm practices

Farm Forestry

General

Total Area of Private Forestry	51,350 hectares (comprising 46,280ha of private plantation forestry and 5,070ha of private farm forestry) – from URS Forestry (2003), *Socio-Economic Study of the Forest Industries in Central Victoria*, prepared for DSE and CVFPC
Species mix	60 per cent Softwood (Radiata Pine), 40 per cent Hardwood (Blue Gum)
Rotation Length	Softwood 28 years, Hardwood 20 years
Current Industry Expansion	Current annual growth in private plantations in the Region include 260ha/yr for softwood and 500ha/yr for hardwood
Annual equivalent of returns from forestry	Based on a combination of softwood and hardwood rotations, average returns of $140 per hectare per year were assumed for all species

Marginal sites

Plantation establishment costs	$1,200 per hectare
Change in establishment costs	Establishing plantations on marginal sites to increase establishment costs by 50 per cent (or $600 per ha)
Sheep Carrying Capacity	1.4DSE/ha/100mm rainfall - based in low Victoria average sheep stocking rate
Average Annual Rainfall	700 mm
Sheep Gross Margin	$12 per DSE – based on low Victoria average gross income of $20 per DSE and variable costs of $8 per DSE
Current Adoption	10 per cent of total area planted
Current adoption rate (with no intervention)	0.1 per cent per year
Expected adoption (with CSHS)	1.0 per cent per year

Implement Code of Forest Practices

Management practices encouraged by action	Ground preparation (ripping and mounding) and road design, construction and maintenance
Site preparation	Average site preparation costs assumed to be $190 per hectare
	Contour ripping and mounding to increase site preparation costs by 25 per cent
	15 per cent increase in production value due to improved site preparation
Road design and construction	Additional cost of adhering to Code of Forest Practices, which includes improved road design and construction is assumed at $100 per hectare planted
Road maintenance cost	Current average annual road maintenance cost of $100 per hectare
Change in Road maintenance cost	25 per cent decrease in road maintenance costs
Future establishment costs	Adherence to COFP assumed to reduce future establishment costs by 10 per cent (currently assumed at $1,200 per hectare)
Current Adoption	30 per cent of total planted area
Current adoption rate (with no intervention)	1.0 per cent per year
Expected adoption (with CSHS)	5.6 per cent per year

Develop Discussion Groups

Effect on implementation of land practices	Assumed to increase the adoption of other CSHS actions by an additional 0.5 per cent

OFF-FARM ASSUMPTIONS

Gully & sheet erosion

Rate of expansion	The area of gully and sheet erosion will expand by 2 percent per annum in the absence of the strategy
Location of sites	All gully and sheet erosion sites are on private agricultural land.

Landslides

Magnitude of the Consequences	The value of damages to Municipal infrastructure for a range of landslides that occurred over the past 50 years have been used to estimate the magnitude of various levels of consequence
Likelihood of Landslides occurring	Strategy will reduce likelihood of various consequences associated with landslides by half
Realisation of benefits	Benefits are progressively realised over 10 years

Appendix D

DETAIL OF COSTS AND BENEFITS OF SHEET AND GULLY EROSION

In this Section the costs and benefits of gully, tunnel, and sheet and rill erosion are assessed. Because tunnel erosion results in gully erosion, the estimated impacts of tunnel erosion are therefore assessed within the section for gully erosion. Similarly, sheet and rill erosion have been combined and will be hereafter be referred to as "sheet erosion".

The relevant actions in the Corangamite Soil Health Strategy for soil erosion are:

- To implement best management practices to reduce nutrient and sediment export to waterways in all agricultural industries (E2).
- To develop and implement a soil health incentives plan (G1).
- Co-invest with municipalities to develop Erosion Management Overlays (EMOs) (F2).
- To map all soil health threats (C2), specifically to complete erosion mapping by 2006.

Assumptions

To calculate the cost of ameliorating soil erosion, typical unit costs were used (Table 10-41).

Table 10-41: Unit costs of control works for the stabilisation and renovation of sheet and gully erosion sites.

Works	Cost of works	Per unit
Fencing	$5	metre
Tree planting	$2,000	hectare
Pasture establishment	$400	hectare
Battering, ripping, edging	$7	metre
Earth levelling, diversion bank	$3	metre
Head structure, rock chute	$11,000	each

*these costs include labour and materials

Appendix D

Sheet erosion – Works

Costs

The costs of stabilising and renovating sheet erosion sites depend on the characteristics of each site. Table 10-42 categorises sheet erosion sites by their severity. These categories were used to calculate costs of control and to assess the impact of ameliorating these sites.

Table 10-42: Categorisation of sheet erosion sites by their severity.

Category (based on work required for amelioration)	Attributes	Specific actions appropriate for achieving stabilisation
Small	The site is capable of stabilising itself if it is protected.	Pasture establishment.
Medium	Erosion will require some additional work to achieve revegetation.	Fence off and establish pasture
Large	There is significant potential for the sheet erosion to turn into rill and gully erosion.	Fence off, establish pasture, and install diversion banks.

The costs of treating small, medium and large sheet erosion sites were estimated based on typical works that would be required at each site and the typical dimensions of each site. Data provided by Feltham (2005) was used as a guide to estimate typical dimensions of small, medium and large sites. These dimensions are presented in Table 6-1.

For a small site, it is assumed that the works required are pasture establishment only. It was also assumed that a small site had an average area of one hectare on which to establish pasture. The cost of treatment is therefore estimated at $400 per site (calculated as 1 hectares of pasture establishment at $400 per hectare).

For medium sheet erosion sites it was determined that treatment involves fencing and pasture establishment. Medium sites were assumed to require 1.5 hectares of pasture establishment and 490 metres of fencing. Fencing and pasture establishment is therefore estimated at $3,049 per site (calculated as 1.5 hectares times $400 per hectare plus approximately 490 metres of fencing at $5 per metre).

Large sheet erosion sites are those where management requires pasture establishment, fencing and the installation of diversion banks. Large sites were assumed to require 2 hectares of pasture establishment, 566 metres of fencing and 424 metres of diversion banks. The cost of treatment is therefore estimated at $4,760 per site (calculated as 2 hectares of pasture establishment at $400 per hectare plus 566 metres of fencing at $5 per metre and 424 metres of diversion banks at $3 per metre).

The development and implementation of a soil health incentives plan is expected to lead to the stabilisation and renovation of 31 sheet erosion sites over the 5 years of the strategy. Of these, sites, 21 are expected to be "small", eight "medium" and two "large", according the categories presented in Table 10-42.

With the treatment of sites, production will be foregone on fenced sites. It was assumed that 50 per cent of production would be lost, which was valued based on a gross margin of $165 per hectare. This gross margin reflects land use in gully-prone areas which has been calculated as a weighted average of 75 percent grazing and 25 percent cropping.

Based on this, the total costs of sheet erosion site control were estimated (Table 6-1). It was assumed that this work would be conducted evenly over 5 years.

Table 10-43: Costs of sheet erosion site amelioration.

	Small	Medium	Large	Total
Number of sites treated	21	8	2	31
Unit costs for treatment	$400	$3,049	$4,760	
Total Cost	$8,400	$24,396	$9,520	$42,316
PV Costs	$6,708	$19,481	$7,602	$33,791
PV Foregone production	$21,382	$12,218	$4,073	$37,673
PV Total Cost	$28,090	$31,699	$11,675	$71,464

Benefits

Benefits from treating gully erosion sites were estimated in the following areas and are presented in Table 6-2:

Reclaiming agricultural production on these areas. It was assumed that production would be regained within two years of treatment. For small sites a complete recovery to the typical gross margin of $165 per hectare was assumed. A recovery of 75 percent was assumed for medium sites; and 50 percent for large sites. This is based on practical experience in assessing the impact of sheet erosion of production in the region.

Preventing the loss of productive land through further erosion of these sites. It was assumed that in the absence of treatment the sites would increase in area by 2 percent per annum, but if treated, this future expansion would be totally prevented.

Table 10-44: Benefits from the amelioration and renovation of sheet erosion sites.

	Small	Medium	Large	Total
Number of sites treated	21	8	2	31
Avoided land lost	$5,400	$3,086	$1,029	$9,514
Reclaimed Production	$19,504	$8,359	$3,715	$31,578
PV Total private benefit	$24,904	$11,444	$4,744	$41,092

The present value of costs from addressing sheet erosion ($71,464) is about double the present value of benefits ($40,072) (discounted at 8 per cent over 30 years).

Gully erosion – Works

Costs

As for sheet erosion, the costs of stabilising and renovating gully erosion sites depend on the characteristics of each site. Gully erosion sites are categorised by their severity in Table 10-45.

Table 10-45: Categorisation of severity of gull erosion sites by appropriate stabilisation actions.

Category (based on work required for amelioration)	Attributes	Specific actions appropriate for achieving stabilisation
Small	The site is capable of stabilising itself without structural works if it is protected.	Fence off and revegetate with trees.
Medium	Some earthworks required, but no structural works.	Gully battering (ripping) works. Fence off and revegetate with trees.
Large	Structural works, earthworks and revegetation required to stabilise the gully. High level of sediment load.	Installation of rock chutes (or other structures) at the head of the gully. Battering or edging and the installation of diversion banks. Fence off and revegetate with trees

To calculate the cost of ameliorating these sites, the typical unit costs, noted earlier in Table 10-43 were used along with recommendations of typical works that would be required at each site and the typical dimensions of each site. An indication of average site area is provided by Feltham (2005). This was used as a guide to estimate typical dimensions of small, medium and large sites (Clarkson and Dahlhaus pers.com. 2005). These estimates are presented in Table 6-3.

For a small gully, it is assumed that the works required are fencing and revegetation only. It was also assumed that a small gully has an average length of 200 metres and a width of 1 metre; however, a 20 metre strip would need to be fenced-off. Therefore the area to be revegetated is estimated at 0.4 hectares. The cost of fencing and revegetation is therefore estimated at $3,000 per gully (calculated as 0.4 hectares times $2,000 per hectare plus 440 metres of fencing at $5 per metre).

For medium gullies it was determined that treatment involves earthworks, fencing and revegetation. It was assumed that a medium gully is 500 metres in length and has a width of 5 metres; however, a 25 metre strip would need to be fenced off. Therefore the area to be revegetated is 1.25 hectares. The cost of earthworks has been estimated at $3,333 per gully (500 metres gully battering times $7 per metre). Fencing and revegetation is therefore estimated at $8,300 per gully (calculated as 1.5 hectares times $2,000 per hectare plus approximately 1.5 kilometres of fencing at $5 per metre).

Large gullies are those where management requires structural works including headwork structures and silt traps to minimise downstream impacts. We have assumed that a large gully is 750 metres in length and has a width of 10 metres; however, a 40 metre strip would need to be fenced off. Therefore the area to be revegetated is 3.0 hectares. It is assumed that 2 head structures are required per gully at a cost of $11,000 each. The cost of earthworks has been estimated at $4,667 per gully (500 metres gully battering times $3 per metre plus 500 metres of diversion banks times $7 per metre). The cost of fencing and revegetation has been estimated at $13,900 per gully (calculated as 3.0 hectares times $2,000 per hectare plus approximately 1.5 kilometres of fencing at $5 per metre).

The development and implementation of a soil health incentives plan is expected to lead to the stabilisation and renovation of 36 gully sites over the 5 years of the strategy. Of these, fourteen are expected to be "small", thirteen "medium" and nine "large", according the categories presented in Table 5-2.

With the treatment of sites, production will be foregone on fenced areas. It was assumed that 50 per cent of production would be lost, which was valued based on a gross margin of $165 per hectare. This gross margin reflects land use in gully-prone areas which has been calculated as a weighted average of 75 percent grazing and 25 percent cropping.

Based on this, the total costs of gull erosion site control were estimated Table 6-1. It was assumed that this work would be conducted evenly over 5 years.

Table 10-46: Costs of gully erosion stabilisation and renovation.

	Small	Medium	Large	Total
Number of gullies treated	14	13	9	36
Unit costs for treatment	$3,000	$11,633	$40,567	
Total Cost	$42,000	$151,233	$365,100	$558,333
PV Costs	$33,539	$120,766	$291,548	$445,853
PV Foregone production	$11,404	$39,709	$43,315	$94,428
PV Total Cost	$44,943	$160,476	$334,862	$540,281

Benefits

Benefits from treating gully erosion sites were estimated in the following areas and are presented in Table 6-4:

Reclaiming agricultural production on these areas. A recovery to the typical gross margin of 75, 50 and 0 per cent was assumed for small, medium and large sites respectively.

Preventing the loss of productive land through further erosion of these sites. As for sheet erosion.

Achieving better farm access. Based on best estimates of on-farm impacts, it was assumed that 0.5 hours per year in farm operations would be saved per annum for small gully sites, 2 hours for medium sites and 5 hours for large sites.

Benefits are also likely to be realised through a reduction in pest plant and animals, particularly rabbits and foxes. However these benefits were not quantified due to the high level uncertainty in making estimates.

Table 10-47: Benefits from gully erosion amelioration and renovation.

	Small	Medium	Large	Total
Number of gullies treated	14	13	9	36
Avoided land lost	$288	$1,671	$3,471	$5,431
Reclaimed Production	$7,174	$4,783	$0	$11,956
Better Farm Access	$1,576	$5,854	$0	$7,430
Pest Plants & Animals	Not Quantified			
PV Total benefits	$9,038	$12,308	$3,471	$24,817

For gully erosion the present value of costs ($537,937) are substantially greater than the present value private benefits ($24,385).

Appendix E

BENEFIT COSTS ANALYSIS OF THE CORANGAMITE NUTRIENT MANAGEMENT STRATEGY

An economic assessment was completed of Corangamite's Nutrient Management Strategy in 1998 by the former Read Sturgess and Associates. The quantitative analysis of the benefits of nutrient management was limited to evaluating the reduction in expected value of damages from toxic blue-green algal blooms. These benefits included both priced and unpriced use values, where the latter involved recreational benefits. It is important to note that unpriced non-use values, such as improvements in wildlife habitat due to improved water quality were not quantified in that analysis. These benefits have the potential to be large (Read Sturgess and Associates 1998).

The impacts were quantified for all those who enjoy values associated with the water bodies and waterways; namely:

- visitors to water bodies and waterways for recreation;
- farmers relying on stock water;
- users of domestic water;
- industrial users of water;
- urban users of water;
- irrigators;
- fishermen; and
- home owners with amenity values.

The benefits of nutrient management were estimated by:

1. determining the expected impacts of blooms without a nutrient management strategy; then
2. multiplying by the expected percentage reduction in the number of blooms that would be achieved by implementing each nutrient management activity.

The expected impact of blooms without a nutrient management plan was estimated at between $5.7 and $9.2 million annually. With the nutrient management plan it was estimated that the occurrence of toxic algal blooms could be reduced by 46 per cent. For more information on the estimation of impacts and benefits for the Corangamite Regional Nutrient Management Strategy, readers are directed to the full economic report (Read Sturgess and Associates 1998).

The quantified annual benefits of nutrient management within the Corangamite region are shown in Table 10-48.

Table 10-48: Benefits and Costs of the Corangamite Regional Nutrient Management Strategy ($ million)

	Present value (8 per cent over 30 years)	
	Low Estimate	**High Estimate**
Benefits $M	$40	$80
Costs $M	$40	$40
Net Present Value	$0	$40
Benefit Cost Ratio	1	2

The management actions included within the nutrient management strategy were:

- fencing off streams to provide filter strips that would intercept nutrient laden runoff;
- effective dairy waste management; and
- soil stabilisation measures to minimise nutrient loss.

Under the CSHS the actions of liming acid soils, applying gypsum, establishing deep rooted pasture species, and improving grazing management are all likely to reduce erosion and, therefore, reduce the amount of nutrient exported from agricultural land in the Corangamite region. Addressing gully, sheet and rill erosion will also reduce nutrient export. Any increase in rates of adoption for these management actions due to the CSHS will therefore have economic benefits for the region.

FRAMEWORK FOR ESTIMATING WATER QUALITY & RIVER HEALTH BENEFITS

1. Location of waterways where water quality/algal blooms are a threat.

The first step of the framework is to determine the location of gully and sheet erosion sites. Recently the CCMA has spatially mapped the location of gullies, sheet erosion and landslides throughout the CCMA region. This data should be used to determine potential sites for work. Greater benefits are more likely from works on soil erosion sites that are in close proximity to priority waterways and/or reaches of waterways where water quality is an issue. The waterways and reaches of waterways where water quality is a threat are noted in Table 10-49.

Table 10-49: Corangamite waterways where water quality and/or algal blooms are a threat

Landscape Zone	Waterway
Aire	Aire River (O27)
Bellarine	Barwon River (B1)
	Waurn Ponds Creek (B8)
Curdies	Curdies River (O1)
Gellibrand	Gellibrand River (O12)
	Gellibrand River (O13)
	Gellibrand River (Sth Otway) PWSC
	Gellibrand River PWSC
Leigh	Leigh River (B12)
	Ballarat PWSC
Lismore	Gnarkeet Chain of Ponds (C16)
Mid Barwon	Barwon River (B2)
	Barwon River (B3)
Moorabool	Lal Lal Reservoir PWSC
	Moorabool River (Sheoaks) PWSC
	Stony Creek (Geelong WWT) PWSC
Otway Coast	Barham River (O30)
	Barham River East Branch (B31)
	Erskine River (O33)
	Wye River (O46)
	Kennett River (O47)
	Skenes Creek (O51)
	Wild Dog Creek (O52)
	Lorne PWSC
	West Barham River PWSC
Thompson	Anglesea River (O34)
	Thompson Creek (O36)
	Painkalac Creek (O42)
	Painkalac PWSC
Upper Barwon	Pennyroyal Creek (B23)
	Upper Barwon PWSC
	Gosling PWSC
	Matthews PWSC
	Pennyroyal PWSC
Woady Yaloak	Woady Yaloak River (C4)

2. Determine sediment export to waterways

Step two requires an analysis of the volume and nutrient content of sediment discharged to waterways. Data for step two is likely to be transferred from research findings. Information would need to be obtained on the volume of eroded soil exported from the sites, but more importantly, the amount of exported soil that actually enters waterways.

There is limited data on typical sediment loads of sheet and gully erosion sites in the Corangamite region. From broader Australian perspective, Hughes et al, based on limited studies across Australia, estimated that the average sized gully was approximately five metres wide and two metres deep. From this average it was estimated that one kilometre of gully would produce 10,000 cubic metres (around 15,000 tonnes) of sediment per square kilometre of land. Assuming an average gully age of 100 years, the mean annual rate of erosion was estimated at 1.5 tonnes per hectare per year.

A key driver of sediment load will be the soil type on which the erosion site is located as some soils erode more readily than others. Another key driver will be the severity of the erosion at the site. The ratings of "small", "medium" and "large" used earlier in determining sheet and gully erosion costs provide a guide to this.

An important source of uncertainty in making estimates in this area is the episodic nature of weather. For example, a 100mm downpour of rain will have a greater impact on sediment load than if it was received evenly over a month.

A 'well connected' catchment, where sediment will move directly into the stream network, was noted in Davis (1997) as one where a stream is in close proximity and slope is $>10^o$ adjoining a stream. In poorly connected streams (where streams and slopes are separated by flatter areas and/or long distances) sediment will deposit before reaching the stream and thus sediment supply is effectively cut off (Davis, 1997). However sediment exported from more distant streams may still reach waterways, but merely take more time to do so. The sediment may be washed into "banks" that will take an unpredictable time to reach waterways. This will be highly dependant on episodic climatic events, such as floods. Another influence is riparian vegetation and vegetation between the area of erosion and the waterways.

Standard exports rates could be determined for small, medium and large erosion sites. Data on the connectedness of a site could be simulated with topographical data by taking into account slope and distance from waterways. This data could then be combined to simulate sediment exports to waterways.

3. Impact on water quality (with and without management)

The third step is probably the most difficult step of the framework and the point where scientists are not willing to speculate on water quality changes with and without management given the current availability of information.

To be able to quantify the impact on water quality, it is necessary to understand the total sediment load of a waterway and the relative importance of the erosion site that is to be managed.

Consider for example that a gully is contributing only 20 per cent of the total sediment to a specific waterway. Therefore, by managing the gully, the potential benefit of the work is only a 20 per cent improvement in water quality. To quantify the benefits of this change in water quality, it will be necessary to know how consumptive and non consumptive uses will change.

4. Determine the economic value of water quality events

The fourth step in the process requires an analysis of the type of use consumptive and non-consumptive uses that will be affected by the change in water quality due to soil erosion.

For example, if a river supplies potable water, a reduction in sediment load will result in lower water treatment costs. This represents a benefit of erosion management. Alternatively, if water is directed to domestic and stock use then improved water quality results, providing increased livestock consumption and improved production. The types of use values for the site in question will need to be quantified during this step.

The benefits noted above regarding water quality relate directly to impacts on the use of rivers (i.e. they are "use values" as defined in section 4.3.1). In addition to this there are also benefits that are largely non-use values. That is because people associate with such things as the landscape, or waterways and water bodies even though they do not make use of them. These non-use values reflect, for example, the value people might derive from knowing that improved habitat for native fish or wildlife exists because of improvements in water quality even if they never visit or use the habitats.

These non-use values are not provided by the market (as discussed in section 4.3.2). However, methods exist to impute values for these types of benefits. An assessment can be made of a community's willingness to pay to gain an attribute of a river, such a river water quality. Similarly an assessment can be made of a community's willingness to accept compensation for the loss of an attribute of a river, as would be the case if the river were not to be persevered or maintained (URS 2005).

For example, Bennet and Morrison (2001) estimated values for river quality attributes for northern coastal rivers in New South Wales (Table 10-50).

Table 10-50: Attribute value estimates for northern coastal rivers from Bennett and Morrison (2001)

Attribute	Unit of improvement	Value estimate($) per household inside catchment	Value estimate($) per household outside catchment
Native Vegetation[a]	One per cent increase in river length with healthy vegetation and wetlands	2.02	2.61
Native Fish[b]	Unit increase in the number of native fish species present	2.02	2.02
Fauna[c]	Unit increase in the number of waterbird and other fauna species present	1.86	0.87
Water Quality:Boatable to Fishable[d]	Increase in water quality from boatable to fishable across the whole river	47.92	30.10
Water Quality:Fishable to Swimmable[e]	Increase in water quality from fishable to swimmable across the whole river	24.73	38.74

Estimates provided by Bennett and Morrision (2001) for New South Wales catchments which are representative of Corangamite catchments were applied by URS (2005) in analysing benefits and costs of the Corangamite River Health Strategy. This approach could also be used to asses the impact of the CSHS on river quality in the region.

To provide an indication of how this information is used, let us assume that works on a particular reach are sufficient to change the water quality of the waterway from fishable to swimmable. The reach represents 20 per cent of the waterways entire length. The waterway is important to 5,000 households located within the catchment and 100,000 households located outside the catchment.

The benefit is calculated as:

- Proportion of the river (20%) x No households (5,000) x estimated value/ household ($24.73), plus

- Proportion of the river (20%) x No households (100,000) x estimated value/household ($38.74),

which is equal to a present value of about $800,000.

5. Estimates of the economic impact of this reduction in water quality

The final step is a comparison of the benefits of management with the costs of management. For the example provided above, if the present value of costs for management is less than $800,000, then the management would be considered economic.

COSTS TO IMPLEMENT THE CSHS

The costs to implement the CSHS have been quantified by the project technical group. These costs have been calculated for:

- Broad acre Grazing Farming Systems (see Table 10-51),
- Cropping Farming Systems (see Table 10-52),
- Dairy Farming Systems (see Table 10-53),
- Private Forestry (see Table 10-54), and
- Landslides (see Table 10-55).
- Other threats with off-farm impacts (see Table 10-56).

The remaining programs (1, 2, 3 and 9) were unable to be calculated as program resource requirements have not been provided by the project technical group.

Table 10-51: Implementation costs associated with grazing land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
E4	Implement appropriate grazing practices based on land class boundaries to sustain long-term soil health	$37,815	$425,714
E3	Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil	$37,815	$425,714
E4	Promote the fencing of different land classes	$153,176	$1,724,417
E2	Strategically established trees to act as windbreaks to control wind erosion	$96,065	$1,081,477
E5	Increase the establishment of perennial pastures, with a preference for direct drilling	$151,177	$1,701,914
TOTAL		**$476,047**	**$5,359,236**

Table 10-52: Implementation costs associated with cropping land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
E6	Adopt bed farming in accordance with BMP as a means to improve soil health in wet environments	$93,053	$1,047,567
E3	Apply appropriate rates of fertiliser in production systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil	$60,094	$676,523
E5	Increase the establishment of cros through direct drilling and retain stubble, including:		
"	Investigate alternative practices for stubble management to encourage stubble retention.	$4,578	$51,542
"	Promote the adoption of minimal tillage and no-till practices.	$44,775	$504,072
"	Support research into no-till practices.	$7,930	$89,269
TOTAL		**$210,430**	**$2,368,973**

Table 10-53: Implementation costs associated with dairy land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
E3	Apply appropriate rates of fertiliser in produciton systems to sustain or improve soil fertility and reduce long-term nutrient decline in the soil	$60,612	$682,361
E7	Implement best management practices for wet soils on dairy farm to improve soil health	$23,547	$265,090
E2	Implement best management practices reduce nutrient and sediment export to waterways	$37,065	$417,271
TOTAL		**$121,225**	**$1,364,722**

Table 10-54: Implementation costs associated with forestry land uses

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
E9	Implement Codes of Forest Practices related to soil health for all plantations	$20,000	$225,156
E8	Increase awareness and skills on road design, maintenance and construction to reduce sediments and nutrients entering waterways.	$4,524	$50,926
E8	Establish farm forestry plantations in areas that benefit soil and catchment health.	$11,446	$128,855
E8	Support the delivery of specialist technical advice in Farm Forestry to increase the implementation of best practices in site establishment and harvesting operations.	$23,836	$268,345
TOTAL		**$59,806**	**$673,281**

Table 10-55: Implementation costs associated with landslides

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
F2	National guidelines on Landslide Risk Management	$28,737	$323,512
F2	Implementation of uniform standards for landslide risk management	$27,334	$307,717
F2	Landslide stabilisation activities	$5,516	$62,102

Table 10-56: Implementation costs associated with other threats with off-farm impacts

Action No.	Program Requirements	Annualised Program Costs ($/year)	Present Value @ 8% Discount ($)
F2	Development of Erosion Management Overlays	$42,559	$479,125
C3	Acid sulphate soil mapping and updating municipal strategic statements	$23,090	$259,945
F1	Develop a Soil Health Action Plan for each municipality	$17,733	$199,636

COST SHARING PRINCIPLES

Cost-sharing negotiations should proceed only after a proposed management project has passed the benefit-cost test. There is little point arguing about sharing of costs for inefficient projects. The benefit-cost methodology for ranking projects essentially tells us whether or not a particular project is likely to increase community welfare. This is the critical first step and should not be overtaken by undue emphasis on how the project should be paid for, and by whom. The benefit-cost analysis will also assist in identifying the stakeholders between whom costs should be shared.

Three sources of funding can be considered:

1. Private entities or local agencies whose actions are causing the degradation that creating the need for the implementation of the plan (i.e. the ‘polluters pay’ principles);

2. Private entities or local agencies who would benefit from the implementation of the plan (i.e. the ‘beneficiaries pay’); and

3. Government.

POLLUTERS PAY

It has been a long-standing code of human conduct that if you make a mess you clean it up. This notion has been enshrined in the ‘polluter-pays’ principle for environmental protection. Demanding that polluters pay is often society’s policy of first choice because it is regarded as being the fairest and most equitable policy. It is also the most efficient policy when the principle can be applied to stop pollution before it occurs, or to control and keep it within acceptable limits.

Therefore, where the polluter-pays principle is appropriate and the polluters can be identified and their pollution measured, monitored and levied, it is sensible that that polluter-pays principle should take precedence over the beneficiary-pays principle for sharing the funding of management measures. To do otherwise runs the risk that the pollution may continue unabated.

The principle may be made operational in a variety of ways, including:

- a tax to discourage pollution;
- requirements for those causing damage to pay for fixing it up; or
- requirements to pay compensation to affected parties after causing a polluting event.

The polluter-pays principle, therefore, is a principle which provides an economic disincentive to pollute (Read 1984 and OECD 1989). While full adherence to the polluter-pays principle would require that the polluters bear the full cost of pollution control measures, a degree of flexibility has arisen in application of the principle. In some circumstances, if the cost to the polluter of full adherence is very high, ‘compatibility’ with the principle may be all that is required.

There are difficulties in applying the polluter-pays principle, which concern the identification of the polluters. It may be readily applicable when the source of pollution can be traced to a particular entity (so-called point-source pollution). It is much more difficult to apply when there are high costs of identifying the polluters and monitoring the damage they cause. This is particularly the case for 'non-point' pollution arising from broad acre activities that may be damaging soil health. However, the scope for converting a non-point source problem into a point source problem by dealing with an agricultural community on a catchment basis should not be ignored. For example, farmers in the sub-catchment might be held collectively responsible for meeting standards of practice and if those standards are not met pollution levies may be charged against them. This may encourage individuals to monitor each other's behaviour so that serious offenders are isolated.

However, a major consideration against using the polluter-pays principle is the likelihood that soil degradation is, in part, the result of past activity which was sanctioned by governments. Clearly, there is no way that past generations of farmers or governments can be brought to account. With improved present knowledge about the processes involved, the practical action is to wipe the slate clean and set about managing for the future. In such situations there is probably no alternative other than for the present beneficiaries to pay for the improvements they will receive.

In the future, however, as progress is made convincing farmers that they have a 'duty of care' rather than a right to do what they wish, the government may be in a position to provide clear guidelines as to which practices are considered acceptable, and any subsequent adoption of 'poor' practices could be viewed as damaging. Those responsible could fairly be asked to cease those practices or to compensate those suffering the impacts.

BENEFICIARIES PAY

The main convention by which commercial affairs are conducted is that the 'user' or 'beneficiary' of some service pays for that service. By paying prices that reflect the social value of these goods and services, an economically efficient allocation of resources can be ensured. Governments and public authorities have come to realise that it is important for the efficient use of scarce resources that the services provided by public authorities also be paid for by the users or beneficiaries of those services. Thus, the beneficiary-pays principle has been adopted by many authorities for determining who should meet the costs of the works undertaken as part of land and water planning.

Marsden (1996) postulated 'strong' and 'weak' versions of the beneficiary-pays principle, which the MDBC (1996) termed the 'user-pays' principle and the 'beneficiary-compensates' principle respectively.

Strong beneficiary-pays principle ('user pays')

Anyone who derives a direct benefit from management actions should contribute to the cost of the actions in direct proportion to their share of the total benefits.

When the bulk of benefits are private benefits and can be valued in markets, application of the user-pays principle presents few problems. The following steps are required to put the 'strong' version of the beneficiary-pays principle into effect.

- Identify all the beneficiaries of the management proposal.
- Measure the benefits they receive.
- Charge the beneficiaries the full cost in proportion to the benefits received.

If all the benefits were priced in competitive markets this process would help society pursue the goal of an efficient allocation of resources.

Unfortunately, this simple mechanistic process can seldom, if ever, be put in place because, amongst other problems, not all the benefits are priced in markets. Suppose, for example, that an action produces a mix of public benefits and private benefits. If the dollar value of public benefits cannot be determined, the proportion of total benefits accruing as public and private goods cannot be determined. Therefore, in such a situation, the strong version of the beneficiary-pays principle cannot be implemented. Thus:

> *we must recognise the dilemma that the principle of distributing costs in proportion to the share of the benefits is least feasible in precisely those cases where the principle is most likely to be sought to be applied (Marsden 1996 p.9).*

The precision and simplicity of the strong version may encourage the valuing of unpriced benefits using stated preference methods, such as contingent valuation or choice modelling. However, despite the considerable advances that have been made in these techniques in recent years, they remain controversial and difficult to apply. They are also sparsely applied, so that the probability that suitable valuations will be available for any given problem is very low.

Another way of coping with this situation is to propose a mild version of the beneficiary-pays principle – the beneficiary-compensates principle.

Weak beneficiary-pays principle ('beneficiary compensates')

All identified beneficiaries meet some portion of the costs and together the beneficiaries cover all the costs associated with the works or activity[1].

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1 Earlier, the OECD (1989) had put forward a similar view when it noted that paying the full cost for the quantity of benefit received may not be required; that is, 'compatibility' with the beneficiary-pays principle may be required rather than full adherence. For example, in some circumstances where beneficiaries do not have the ability to pay, the notion of compatibility may be invoked. The government or authority in this situation must exercise extreme caution, however, lest an inappropriate subsidy results. The share of the full cost paid and the proportionality between the benefits received and the payment might be used to assess compatibility.

This principle has tended to be applied where a public conservation good is supplied jointly with a private good (Marsden 1996, Marshall 1998). For example, protection of remnant native vegetation provides private benefits to a farmer in the form of shelter for livestock and public benefits, such as the preservation of habitat for native birds and animals. Under the beneficiary-compensates principle, people who are beneficiaries of the conservation good pay for the additional costs to the landholders of maintaining that good.

The weak version of the beneficiary-pays principle reflects a particular view of fairness that is not based on any rigorous theory. As Musgrave (1996) points out, other positions are possible including one (as a variant of the weak version):

> *which would restrict the government's share of costs to that which is sufficient to induce the private beneficiaries to produce the desired level of public benefits. While appearing to discriminate against the private beneficiaries, this helps to maximise the spread of the government's budget and be fair to the taxpayer. In fact, an array of positions exist and selection between them would seem to call for some form of negotiation.*

This aspect of the beneficiary-compensates principle is a key issue when attempting to minimise government's payment to achieve a result and be fair to the taxpayer. In the extreme, if the action is profitable to the private beneficiaries, no government share would be required unless government wished to increase the rate of adoption.

GOVERNMENT PAYS

Government contributions to the funding of on-ground works can be justified in situations where there would be too little investment in preventing soil degradation if it were left entirely to the free market. The reasons for this proposition are:

- the polluters are unaware of the effects of their actions on other parties ('externalities');
- enjoyment of the benefits cannot be restricted to a particular group of private entities (that is, the benefits represent 'public goods'); and
- the costs of collecting contributions from each private beneficiary or polluter would be too large relative to the contributions required from those entities (that is, the 'transaction costs' are excessive when collecting contributions from the private entities). For example, the off-site benefits to recreationists and future generations.

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SUMMARY OF PRIVATE NET BENEFITS AND COSTS AND IMPLEMENTATION COSTS (at 8 per cent discount)

($'000)	Present value		On-farm	Present value	Program
Management Actions	**Net on-farm benefits**	**Net on-farm costs**	**NPV**	**Program Implementation costs**	**NPV**
Broadacre Grazing					
Graze and spell rotation	$79,091	$43,939	$35,151	$426	$34,726
Fertiliser management	$46,081	$9,216	$36,865	$426	$36,439
Land Class fencing	$31,604	$18,871	$12,733	$1,724	$11,008
Trees as wind breaks	$1,424	$896	$528	$1,081	-$554
Direct drill pastures (introduce perennial pastures)	$4,305	$2,832	$1,474	$1,702	-$228
Combined	$44,056	$24,117	***$19,939***	***$5,359***	***$14,580***
Cropping					
Controlled traffic	$8,262	$7,201	$1,060	$1,048	$13
Lime & fertility	$5,587	$3,980	$1,607	$677	$931
Stubble retention				$52	-$52
Minimum Till	$4,451	-$20	$4,471	$593	$3,878
Combined	$5,473	$3,729	***$1,744***	***$2,369***	***-$625***
Dairy					
Fertiliser Management	$11,257	$10,010	$1,247	$682	$564
Reverse wet soils	$16,099	$13,489	$2,610	$265	$2,345
BMP reduce nutrient export	$10,871	$5,684	$5,187	$417	$4,769
Combined	$13,123	$10,303	***$2,820***	***$1,365***	***$1,456***
Forestry Production					
Implement code of practice	$7,838	$1,057	$6,780	$225	$6,555
Better road construction				$51	-$51
Forestry to improve catchment health	-$176	$726	-$902	$129	-$1,031
Support delivery of specialist technical advice				$268	-$268
Combined	$2,133	$3,560	***-$1,427***	***$673***	***-$2,101***
Total on-farm	$64,785	$41,709	***$23,076***	***$9,766***	***$13,310***

SUMMARY OF OFF-FARM BENEFITS AND IMPLEMENTATION COSTS (at 8 per cent discount) Continued

($'000)	Present value		On-farm	Present value	Program
Management Actions	Net on-farm benefits	Net on-farm costs	NPV	Program Implementation costs	NPV
Off-farm impact				$0	
National guidelines on Landslide Risk Management				$324	-$324
Implementation of uniform standards for landslide risk management				$308	-$308
Landslide stabilisation activities				$62	-$62
Combined	$508		**$508**	**$693**	**-$185**
Development of Erosion Management Overlays				$479	-$479
Soil health incentives program					
Develop a Soil Health Action Plan for each municipality				$200	-$200
Combined	$833	$612	**$221**	**$679**	**-$457**
Acid sulphate soil mapping and updating municipal strategic statements	$541		$541	$260	$281
Total off-farm	$1,882	$612	**$1,271**	**$1,632**	**-$361**
TOTAL	$66,668	$42,321	**$24,347**	**$11,398**	**$12,949**

Appendix J

CSHS ADOPTION AND IMPLEMENTATION ISSUES

Benefits and beneficiaries from implementing the CSHS

The CSHS aims to help improve the practices by a number of stakeholders to address soil related threats to the region's assets. The aggregate economic effects on society would be improved if the total benefits from reduced soil degradation, that is, the sum of the benefits to farmers and benefits to other members of the community stemming from avoiding off-site damages, exceeded the costs of actions to reduce soil degradation.

Achievement of such an improvement in economic welfare, however, requires that all parties are fully informed about the relevant causes and effects of soil degradation. This is not usually the case when off-site effects are involved because there are no direct signals that transmit information to farmers about the damage they cause in other places. Therefore, farmers do not account for the cost of these damages in their decision making. Conversely, they do not account for the off-site benefits from practices that reduce soil degradation.

In these circumstances, a damaging practice may be profitable for a land manager but not to society, while improved practices may be profitable for society but not for individuals. This may create a case for government involvement either to impose a cost on farmers (a 'pollution' charge) or to contribute in some way on behalf of the off-site beneficiaries of reduced damage to help farmers ameliorate the causes of soil degradation. Actions of this nature, in the form of incentives such as cost-sharing arrangements for some practices are envisaged as part of the CSHS. The relevant principle here is the 'beneficiary pays' principle that the 'user' or 'beneficiary' of some service should pay for that service. On this basis the public (government) should only invest in services where the public is the major beneficiary of these services.

A closely related situation is where the new practice is not 'sufficiently' profitable for farmers to embrace it. This situation may also create a case for government intervention in the form of an incentive that attempts to overcome the 'threshold' of profitability. A strong case would only exist where the benefits to the public will exceed the costs of undertaking the work.

At the opposite end of a continuum is the situation where a change in farming practice to reduce soil degradation, say soil erosion, is sufficiently profitable to farmers for them to adopt it without government intervention. By reducing the on-site damages in a way that was sufficiently profitable to them, farmers would also reduce the impacts soil erosion is causing to others, such as users of the river into which sediment from erosion sites is being transported. In this situation there would be no need for government intervention to improve the welfare of society.

In other circumstances, however, it may be feasible and less costly to increase farmers' awareness of the off-site effects of their actions and attempt to persuade them to change their behaviour, say, through community education or extension programs. The principle of intergenerational equity: that consideration be given to maintaining environmental quality for future generations is also important. In this regard, education of the next generation of landholders while still at school might also be appropriate.

This form of action is a major feature of CSHS through the community education program, which aims to increase community awareness and understanding of the impact of soil health on catchment health and of the processes of soil degradation and remedial actions.

Another case in which community education and extension would be important is where farmers' knowledge about the profitability of an improved practice or confidence in its use and effects may be deficient. Here the extension program would aim to inform farmers about profitability and/or to increase their confidence and skills.

Given that the problem of soil degradation could be tackled by different means, it is appropriate to examine some of the many factors that might influence farmers' decisions to adopt a change that would reduce soil degradation.

Adoption of practices to reduce soil degradation

The adoption of land management practices that are designed to reduce soil degradation is a key issue influencing the achievement of the potential benefits of the CSHS. Unfortunately, there is no formula for predicting the rate and ultimate level of adoption of any new agricultural practice. Instead, we must rely on the best guess estimates of experts to make such predictions, however, for obvious reasons, these estimates will be surrounded by considerable uncertainty.

The adoption by farmers of soil conservation actions appears to be influenced by a number of general matters related both to the action itself and to the landholder. These include:

- recognition that an environmental problem exists;
- a perception that the problem could be rectified by a technically feasible change in farming practices;
- the farmer’s perception of the profitability of the change in practice (that is, net returns greater than for current farm practices); and
- the presence of psychological motivations to act (these may be related to concerns for the environment as well as profit) (Sinden and King 1990, Cary and Wilkinson 1997).

Some of the more detailed factors embodied in the above might be:

- time to achieve benefits and the farmer’s rate of time preference for income;
- the farmer’s skills in relation to the new practice;
- the degree to which the change permits the achievement of landholders’ non-profit, non-environmental goals;
- compatibility with cultural values and beliefs;
- the complexity of the change;

- uncertainty about future outcomes in an unfamiliar form of production;
- the landholder’s aversion or otherwise to uncertainty;
- the availability of funds and the cash flows produced; and
- the opportunity to conduct trials or observe potential outcomes.

In RMCG’s experience adoption of practices tends to be faster for those practices that:

- reduce labour requirements;
- have a low capital requirement;
- provide a margin of $2 income for every $1 in operating expenses; and
- create a readily saleable asset.

In the case of many of the actions proposed under the CSHS the outcomes can be more labour, more capital, uncertain margins and not necessarily the creation of a readily saleable asset.

The main barriers are seen to be:

- Financing the capital required to convert to improved practices and finance an increase in stocking rate at the same time.
- Financing of practices that provide minimal on farm benefits, such as reducing nutrient runoff from dairy farms.
- The large change in labour, machinery and skill requirements in changing from a grazing system to a bed farming system.
- Loss of feed when converting existing paddocks. There is a need to increase stocking rates to utilise the extra feed after the perennial pastures are established.
- Inherently higher risk position of adopting higher stocking rates both from a drought perspective (need to feed or de-stock earlier)and debt load perspective.
- Many of the recommended on farm practices have costs which are constant over time while the benefits are very variable over time. In order minimise risk land managers often avoid practices that have benefits that are very variable over time.

The fact that current adoption rates of the practices are low (30% for cropping, 18% for dairy and 18% for grazing) infers that there are significant barriers to adoption.

Therefore, the adoption rates for the CSHS must be set at realistically low levels.

It is not the purpose of this evaluation of the CSHS to consider all aspects of the adoption process in detail. Rather, we focus on some aspects that might be influenced by incentive mechanisms, and by community education and extension programs.

Incentive mechanisms

Healthy soil can be considered as a 'stock' asset that provides 'flows' of benefits. Property rights (i.e. the ability to own land) give landholders access to both the stock and flow of the soil asset. This gives landholders the option of using these flows of benefits to maintain, degrade or improve the stock asset. The price of a piece of land should therefore be a combination of the 'stock' and expected 'flows' of benefits. The degree to which soil health is reflected in land prices (i.e. the combination of stock and flows) will determine the financial rewards (incentives) that exist for landholders to avoid soil degradation. Clearly if the value of a piece of land falls markedly when its soil is degraded, this will create a significant financial incentive for the landholder to manage the health of the soil.

In cases where the total economic benefit realised by the landholder (both priced and unpriced) of reducing soil degradation are greater than the costs of reducing degradation, government intervention is not required. However, government may consider the provision of economic incentives in situations where the private benefits of measures to ameliorate degradation are less than the private costs but the total benefits (private plus public) exceed the on-farm (private) costs. This condition is taken to include situations where farmers' profits are less than the 'sufficient' level of profit at which adoption levels acceptable to government would occur.

Clearly, the costs of any incentive mechanisms that might be used should not cause the total social costs of an action to exceed the total social benefits. In this respect, care must be exercised to guard against the use of subsidies that lower the private costs of correcting soil degradation so that more degrading methods of farming become profitable.

Community education and extension

Several previous studies of adoption of conservation practices have shown the importance of a number of variables in farmers' adoption decisions that can be influenced by education and extension. To the extent that the findings of those studies can be extrapolated to soil degradation threats in the CCMA region of Victoria, they confirm that it is appropriate for the CSHS to attempt to influence:

- landholders' perceptions about the profitability of changes in farming practice;
- landholders' recognition of an environmental problem; and
- the environmental orientation of landholders.

It is also clear from these studies that the effort expended on extension has an important role to play bringing about change in farmers' behaviour toward conservation practices. A significant proportion of the CSHS budget is devoted to extension effort.

Appendix A
Benefit-Cost Analysis

Appendix B
Detailed Analysis of On-farm Benefits

Appendic C
Key Assumptions Used in the Benefit Cost Analysis

Appendix D
Detaill of Benefits and Costs of Sheet and Gully Erosion Control

Appendix E
Corangamite Nutrient Management Strategy

Appendix F
Framework for Assessing Benefits to Waterways

Appendix G
CSHS Implementation Costs

Appendix H
Cost-Sharing Principles

Appendix I
Summary of Benefits and Costs and Implementation Costs

Appendix J
CSHS Adoption and Implementation Issues