6.4 Irrigation Salinity Management

The actions and projects outlined below apply to the Salinity Management Areas showing predominantly irrigation-induced salinity impacts including Clydebank, Nambrok, Heyfield, Maffra, Boisdale and Wellington. As shown in Figure 1, these areas cover the Macalister Irrigation District and surrounding dryland areas plus Lake Wellington. The programs outlined in this section also apply to the small pockets of irrigation outside the Macalister Irrigation District including the area around Yarram and the Red Gum Plains in the Bengworden/Meerlieu area.

6.4.1 Management Actions and Resource Condition Targets

The management actions to address irrigation salinity are summarised in Table 20 including the asset being protected and the prioritisation. More details on each of the management actions are provided in the following sections.

The changes in resource condition which the identified management actions are expected to achieve are shown in Table 21.

Table 20: Management Action Targets for the Irrigation Salinity Management Areas

Management Action	MAT Number	5 Year Management Action Targets	Salinity Management Program						Asset class being protected							Priority
			Irrigation	Vegetation	Sub-surface	Surface	Living w. salt	Mon, eval, rep	Water	Land	Biodiversity	Atmosphere	People	Infrastructure	Production	
Improve irrigation efficiency	**IA1**	Additional 10,500ha irrig area covered by WFPs (approx 20 to 30 WFPs per year)	●	●	●	●	●	○	●	●	●	○	●	●	●	Priority 1
Improve irrigation efficiency	**IA2**	To convert 800 Ha/year of flood irrigation to spray irrigation	●	○	○	○	○	○	●	●	○	○	○	●	●	Priority 1
Improve irrigation efficiency	**IA3**	50 Ha/year of flood irrigation converted to high flow rate flood irrigation = 250ha over 5 years	●	○	○	○	○	○	●	●	○	○	○	●	●	Priority 1
Improve irrigation efficiency	**IA4**	All new irrigation developments using efficient irrigation techniques with minimal off-site impact	●	○	○	○	○	○	●	●	○	○	○	○	●	Priority 1
Prevent saline irrigation	**IA5**	'Safe salinity' model investigation work completed and extension program begun (50ha/yr)	●	○	○	○	○	○	●	●	○	○	○	○	●	Priority 2
Establish additional perennial pasture and trees	**IB1**	All research and investigation work completed and extension program commenced into perennial pasture and tree establishment	○	●	○	○	○	○	○	●	●	○	○	○	●	Priority 3
Plant trees	**IB3**	Existing extension programs provided with target areas for tree planting for salinity control	○	●	○	○	○	○	○	●	●	○	○	●	○	Priority 1
Continue public groundwater control pumping	**IC1.1**	Continue operation and maintenance of existing pumps on an as needs basis	○	○	●	○	○	○	●	●	○	○	●	●	●	Priority 1
Additional public groundwater control pumping	**IC1.2**	Install 2 new Groundwater Control Pumps and continue investigating pump viability at 5 additional sites	○	○	●	○	○	○	●	●	○	○	●	●	●	Priority 2
Additional public groundwater control pumping	**IC1.3**	Investigate 5 sites for additional public groundwater pumps, review alternative disposal options for existing pumps and investigate the potential for use of alternative power sources	○	○	●	○	○	○	●	●	○	○	●	●	●	Priority 2
Additional private pumping	**IC2**	3 TEDS investigations and 3 Capital Grants Scheme per year starting 2005/06	○	○	●	○	○	○	●	●	○	○	●	●	●	Priority 2
Review additional free flowing bores	**IC3**	Free flowing bores reviewed and recommended actions implemented	○	○	●	○	○	○	●	●	○	○	○	●	●	Priority 4
Review additional tile and mole drains	**IC4**	Tile and mole drains reviewed and recommended actions implemented	○	○	●	○	○	○	●	●	○	○	○	●	●	Priority 4

Management Action	MAT Number	5 Year Management Action Targets	Salinity Management Program						Asset class being protected							Priority
			Irrigation	Vegetation	Sub-surface	Surface	Living w. salt	Mon, eval, rep	Water	Land	Biodiversity	Atmosphere	People	Infrastructure	Production	
Review additional surface drainage	**ID1**	MID Drain management plan complete and implemented	○	○	○	●	○	○	●	○	○	○	○	○	○	Priority 4
Assess viability of community drains	**ID2**	Research into viability of community drains complete	○	○	○	●	○	○	●	●	○	○	○	○	●	Priority 4
Rehabilitate once saline land	**IE1**	All landowners around operating Groundwater Control Pumps provided with advice on rehabilitation of salinity affected land	○	○	○	○	●	○	●	●	○	○	○	○	●	Priority 2
Plant salt tolerant crops in saline areas	**IE2**	Review of suitable salt tolerant crops and pastures complete and extension program in place	○	○	○	○	●	○	○	●	○	○	●	○	●	Priority 3
Review other saline land & water uses	**IE3**	Review of alternative uses of saline land and water complete and recommendations implemented	○	○	○	○	●	○	●	●	○	○	○	○	●	Priority 4
Groundwater monitoring	**IF1.1**	Continuation of current observation bore monitoring	○	○	○	○	○	●	●	●	○	○	○	●	●	Priority 1
Watertable depth mapping and reporting	**IF1.2**	Create yearly watertable depth maps for all irrigated SMAs, analyse and report to stakeholders, 5 yearly reports on trends	○	○	○	○	○	●	●	●	○	○	○	●	●	Priority 1
Sale watertable mapping and reporting	**IF1.3**	Create annual watertable depth map for Sale township	○	○	○	○	○	●	●	●	○	○	○	●	○	Priority 1
Soil salinity monitoring	**IF2.1**	Continue program of soil salinity monitoring around Groundwater Control Pumps	○	○	○	○	○	●	●	●	○	○	○	○	●	Priority 1
Soil salinity reporting	**IF2.2**	5 yearly reports on soil salinity around Groundwater Control Pumps	○	○	○	○	○	●	●	●	○	○	○	○	●	Priority 1
Multi-benefits for vegetation establishment	**IF3**	New vegetation establishment to be compared to areas identified for salinity action	○	○	○	○	○	●	●	●	●	○	○	●	●	Priority 1

▪ Table 21: Resource condition targets for the Irrigation Salinity Management Areas

Asset Class	Asset	Salinity Management Area	Resource Condition Target (RCT)	Time frame for RCT	Assumptions for RCT	MATs contributing to RCT
Land, Production, Infrastructure, Biodiversity	Agricultural land, rural roads and other in-ground infrastructure, native vegetation	Clydebank	RCTI1: Less than 2% increase in the area of <2m depth to watertable from Jan 2003 levels	16 years	Based on groundwater modelling results presented in Sinclair Knight Merz (2004b)	0.02 * MAT IA2 + 0.02 * MAT IA3 + 0.56 * MAT IC2.1 + 0.12 * MAT IC2.2 + 0.19 * MAT IC2.3 + 0.09 * MAT IC3.1
		Nambrok	RCTI2: Greater than 11% decrease in the area of <2m depth to watertable from Jan 2003 levels	16 years		0.02 * MAT IA2 + 0.01 * MAT IA3 + 0.53 * MAT IC2.1 + 0.23 * MAT IC2.2 + 0.12 * MAT IC2.3 + 0.09 * MAT IC3.1
		Heyfield	RCTI3: Greater than 7% decrease in the area of <2m depth to watertable from Jan 2003 levels	16 years		0.10 * MAT IA2 + 0.08 * MAT IA3 + 0.33 * MAT IC2.2 + 0.49 * MAT IC3.1
		Maffra	RCTI4: Greater than 23% decrease in the area of <2m depth to watertable from Jan 2003 levels	16 years		0.15 * MAT IA2+ 0.02 * MAT IA3 + 0.33 * MAT IC2.2 + 0.50 * MAT IC3.1
		Boisdale	RCTI5: Greater than 23% decrease in the area of <2m depth to watertable from Jan 2003 levels	16 years	Assumes that flood to spray conversion will have a similar effect in Boisdale as the modelled result in the Heyfield subregion given the similar distribution of soil permeability	MAT IA2 + MAT IC3.1
		Clydebank, Nambrok, Heyfield	RCTI6: Greater than 50% reduction in soil salinity around existing and new Groundwater Control Pumps	15 years from pump commencement	Assumes average or above average rainfall	MAT IC2.1 + MAT IC2.2 + MAT IC2.3
Infrastructure	Urban infrastructure	Clydebank	RCTI7: No increase in the area of 2m depth to watertable within the Sale urban boundary (assumed to be negligible)	15 years	Currently only a minor threat of urban salinity in the Sale area	MAT IA2 + MAT IA3 + MAT IC2.1 + MAT IC3.1
Biodiversity	Existing native vegetation	All irrigated Salinity Management Areas	RCTI8: No net loss of native vegetation	5 years	Assumes that the current policy of "net gain" of native vegetation continues to be implemented	MAT IB2

6.4.2 Strategy

The strategy to address irrigation salinity in both irrigated areas and adjacent dryland areas is summarised in the following general principles:

- Irrigation induced salinity will be primarily addressed by reducing groundwater recharge wherever practically and economically feasible.
- Engineering options to reduce the watertable in saline areas such as groundwater pumping will be implemented where:
  - protection of high value assets will take too long via recharge control methods; or
  - high value assets will not be protected through recharge control methods.
- Groundwater pumping options where the pumped water is used on farm (including private pumps and Groundwater Control Pumps disposing to channels) will be given preference to options where the water is disposed directly to rivers and lakes.
- Any groundwater pumping disposing to rivers and/or lakes will ensure that:
  - there will be no significant adverse environmental impacts on receiving waters; and
  - there will be no adverse impacts on downstream diverters.
- Where reducing the watertable through recharge control or engineering options in saline areas will take significant time or is impractical, then salt tolerant crops and pastures will be used to improve productivity and reduce soil erosion.
- The decision to implement specific salinity control measures will take into account the social, economic and environmental costs and benefits and include the impacts on other natural resource management issues such as nutrient reduction, river health and water conservation.
- The plan will build the capacity of landowners and the community to recognise and understand the problem and aid in implementing cost-effective solutions.

History has shown that sustainable irrigation generally requires salt export and surface drainage to ensure salinity and waterlogging do not adversely affect key assets. Though it is preferable to mitigate irrigation salinity by addressing the cause of the problem through the adoption of more efficient irrigation, a degree of salt and groundwater export through engineering intervention will be more effective in the short term. More efficient irrigation is still the primary goal and is likely to reduce the volume of groundwater required to be pumped and disposed of into the Gippsland Lakes.

The principles above are very similar to those currently employed through the Lake Wellington Catchment Salinity Management Plan and have proved very successful in reducing the effects of irrigation induced salinity. The key difference in this plan is the slightly stronger focus on recharge control methods as a priority over groundwater pumping methods. Although groundwater pumping has been extremely successful in reducing the effects of salinity in the Macalister Irrigation District and surrounds, this method addresses the symptoms and does not encourage farmers to address the main cause of the problem of groundwater recharge from irrigation. Also, increasing irrigation efficiency has additional benefits that have not been formally acknowledged in the salinity program including reducing nutrient loads to rivers/lakes and water savings. This slight change in emphasis towards recharge control has been a result of the review of the Lake Wellington Catchment Salinity Management Plan combined with community and agency consultation.

Also, the principles outlined here place a greater importance on improving the productivity of saline land through the establishment of salt tolerant crops and pastures than is the case in the current program. Although the Lake Wellington Catchment Salinity Management Plan also placed a high priority on this task, the implementation phase of the plan did not reflect this priority with little work being conducted in this area.

Justification for the management actions presented in the irrigation salinity program is the mitigation of wetland salinity especially in the Clydebank area. As discussed in Section 4.3.2, there are a number of high value wetlands down-gradient of irrigated areas that are affected by irrigation salinity. The irrigation management program will aid in reducing the salt load input to wetlands from the catchment by:

- Reducing the amount of saline land in the catchment area of the wetlands and therefore, reducing the salinity of the overland flow discharge; and
- Reducing the volume of saline groundwater discharge to the wetlands.

6.4.3 Irrigation Management Program

On-ground works

The irrigation management program will increase irrigation efficiency through the following on-ground works:

- Irrigation Farm Planning to ensure irrigation is properly planned and efficient;
- Conversion from flood irrigation to spray irrigation – best suited to the higher permeability soil types in the Macalister Irrigation District which have not been previously laser graded and where there is no re-use system installed;
- Increased efficiency of flood irrigation through:
  - Laser grading of irrigation bays to ensure an even topographic grade (many irrigation layouts in the MID are already laser graded but the proportion and distribution are unknown) – best suited to the lower permeability soils in the Macalister Irrigation District
  - Increasing flow rates to the tops of bays – best suited to the higher permeability soil types in the Macalister Irrigation District that have been previously laser graded and/or where a re-use system has been installed;
- Appropriate planning of new irrigation developments to minimise impact on the watertable – most applicable to the expanding irrigation occurring in the Bengworden and Port Albert Salinity Management Areas; and
- Ensuring the salinity of water applied by irrigation is suitable for the soil type and application rate to avoid salt build up in the soil – most applicable to the groundwater based irrigation occurring in the Macalister Irrigation District and the Bengworden Salinity Management Area.

It is important to note that increasing the efficiency of irrigation reduces the leaching fraction and therefore, the ability to flush salt through the soil profile. This is not an issue when irrigating with fresh channel water. However, if using more saline groundwater for irrigation, the reduced downward flushing has the potential to increase salt levels in the soil to levels that may affect pasture growth. Therefore, it is important that the right advice on water quality issues is sought when improving the efficiency of groundwater based systems. In most cases, this issue can be addressed through the conjunctive use of groundwater and surface water in the right proportions. Although this is an issue that requires consideration, it should not be seen as a significant barrier to the adoption of more efficient irrigation (eg conversion from flood to spray irrigation).

Implementation Mechanisms

Irrigation Farm Planning

"Irrigation Farm Planning" will be the key overarching planning tool to ensure the adoption of more efficient irrigation. In the MID, "Irrigation Farm Plans" involve the planning of farm infrastructure including irrigation layout, water supply, drainage, management of dairy shed effluent and fencing. They do not provide any economic analysis of the costs and benefits of the recommended changes nor provide any detailed recommendations on irrigation scheduling. Therefore, Irrigation Farm Plans are an excellent tool for ensuring that irrigation infrastructure are as water efficient as possible but follow up extension is required to ensure irrigation practices are also efficient. Irrigation Farm Plans are usually compiled by a specialist contractor and involve consultations with the landowners, detailed topographic surveys of the farm and the drafting of a map showing the recommended changes to farm layout. These plans are often referred to as "Whole Farm Plans". However, "Irrigation Farm Plans" do not generally include issues such as vegetation and stock planning nor address other natural resource management issues such as biodiversity and soil erosion as would be normally expected of a "Whole Farm Plan". Therefore, the term "Irrigation Farm Plans" is preferred in this plan.

There are currently financial incentives available to farmers to undertake Irrigation Farm Planning in irrigated areas over the whole West Gippsland CMA region. The current landowner rebate is 75% of the cost to a maximum of $82.50 per hectare plus GST.

Currently, Irrigation Farm Plans have been developed on approximately 158 farms covering 16,100ha, which is equivalent to 35% of the Macalister Irrigation District (GHD, 2004 in prep). This plan has a 10 year target of a total of 75% of the Macalister Irrigation District covered by Irrigation Farm Plans (an additional 21,000 ha). This is equivalent to approximately 2,100ha/yr or approximately 20 to 30 plans per year. This is very similar to the current uptake rate and target for the program offering incentives to landowners to compile Irrigation Farm Plans.

This plan recommends that:

- Irrigation Farm Planning continue to be recommended to farmers as being the best method of ensuring cost and water efficient irrigation;
- The current financial incentives for Irrigation Farm Plans continue at their current levels including being a prerequisite for other financial incentives offered for the development of spray irrigation and re-use systems; and
- The incentives for Irrigation Farm Planning continue to be funded outside the salinity management plan but that extension services funded through the plan be used to ensure landowners undertake Irrigation Farm Planning.

Financial incentives to convert to spray irrigation

Modelling results suggest that a conversion rate of 800 ha/yr over 30 years will result in a reduction of approximately 2,580 ha of less than 2 metres depth to watertable in the five salinity management areas which cover the Macalister Irrigation District. This represents a decrease of 11% relative to the base case of no additional spray irrigation. The remaining area of flood irrigation on the moderate to very high permeability soils (see Appendix G) is approximately 26,300 ha. The aspirational target in this plan is to convert 90% of the remaining flood irrigation on the moderate to very high permeability soils to spray irrigation over 30 years which amounts to 23,700 ha or 800 ha/year. The 5 year target is to convert 15% of the remaining area of flood irrigation on the moderate to very high permeability soils to spray irrigation which equates to 3,950 ha or 800 ha/year.

This plan supports the continuation of the current incentives program offered to landowners to convert from flood to spray irrigation across the West Gippsland CMA region. The current financial incentive provided to irrigators is 15% of the capital costs to a maximum of $410/ha (plus GST) indexed annually for inflation. Analysis of the private and public benefits of flood to spray irrigation conversion detailed in SKM (2004d) and Appendix F suggest that an incentive of 15% is consistent with the proportion of public to private benefit provided water savings, nutrient and salinity benefits are achieved. Further justification for the current level of incentives is provided in Appendix F.

This plan recommends that the financial incentives be available only in areas where the flood to spray irrigation conversion will provide nutrient benefits to the Gippsland Lakes, salinity benefits and water savings. Without any one of these three public benefits, the justification of public investment is weakened. Such a policy would allow the incentives to be provided in all irrigated areas within the West Gippsland part of the Gippsland Lakes Catchment that are vulnerable to salinity (all salinity management areas except Port Albert, Foster and Trafalgar). These incentives are currently being funded through the implementation of the MID Nutrient Reduction Plan and the Gippsland Lakes Future Directions and Action Plan. No additional funds are required to be provided through the implementation of the salinity plan except for provision of extension services to promote the incentives program (see ‘extension’ below).

Over the last 3 years, the average rate of conversion from flood to spray irrigation through the current Government incentives scheme was approximately 350 ha/year. This is a lower rate than originally planned due to the focus on irrigators developing irrigation farm plans, the lack of water access over the last few dry years and the relatively low milk prices. The rate of flood to spray irrigation conversion is expected to increase in the next few years to approximately 800 ha/year as irrigators who were previously developing irrigation farm plans now turn their attention to upgrading their irrigation systems (A. Christie, DPI, *pers. comm.*, 2004). This 800 ha/year is estimated to consist of:

- A base rate of 200 ha/year that would have been converted irrespective of the financial incentives offered;
- A rate of 450 ha/year encouraged by the financial incentives currently on offer by other programs (ie funding not supplied through the current salinity program); and

- A rate of 150 ha/year encouraged through the various extension programs (currently funded through the salinity program).

Given that the expected uptake of flood to spray conversion is expected to reach the target rate of 800 ha/yr, this plan does not recommend any changes to the current financial incentives program offered to farmers to convert from flood to spray irrigation except for a review of the cost sharing arrangements (see Section 6.9.2 and Appendix F). However, the economic analysis indicates that conversion to fixed sprinkler irrigation for dairy enterprises is not likely to be economically viable and therefore, this plan recommends that conversion to fixed sprinkler irrigation should not be encouraged through extension programs. For higher output enterprises such as horticulture, the economics has not been determined. However, conversion of flood irrigation to fixed sprinklers for irrigating horticulture is likely to be much more economic than for irrigating for dairy.

To ensure there is no build up of salt in the soil from the introduction of more efficient irrigation, the provision of incentives for flood to spray irrigation should be accompanied by appropriate advice on irrigation salinity issues (see discussion above under "on-ground works"). Such advice is only likely to be required for irrigation systems sourced from groundwater.

Development of New Irrigation Development Guidelines

New irrigation developments have the potential to adversely affect environmental, cultural and social assets (both on and off-site) as well as compromising the sustainability of groundwater and surface water resources. The current process for assessing and approving licences for new irrigation developments in West Gippsland addresses some of these issues but fails to formally address others. New Irrigation Development Guidelines need to be developed to ensure the process for assessing and approving licence applications for new irrigation developments addresses all of these issues in an equitable, consistent and pragmatic fashion.

The guidelines need to be suitable for use by proponents, licensing authorities and referral bodies. A key component of the guidelines will be that new irrigation developments must follow Best Management Practices to ensure that there are no negative impacts on biodiversity and vegetation. The guidelines will provide a framework for implementation utilising existing mechanisms wherever possible such as the Water Act, Local Government Planning Schemes and the Victorian Native Vegetation Framework.

The guidelines should apply to the issuing of new surface water and groundwater irrigation licences or the transfer of surface water or groundwater entitlements. The guidelines should cover:

- Environmental impacts of irrigation including:
  - Impact on watertable level and associated salinity risk;
  - Impact on off-site nutrient discharge;
  - Impact on existing native vegetation (especially any clearing activities required and the requirement of 'Net Gain' under the Draft Native Vegetation Plan); abd
  - Impact on in-situ soils (eg salinity and sodicity of water may adversely impact on agricultural production).

- Water efficiency and sustainability issues including:
  - Ensuring water use is within acceptable limits for the crop type, rainfall, soil type and irrigation method;
  - Ensuring the volume applied for can be extracted sustainably; and
  - Ensuring groundwater extractions do not adversely affect surface water resources and vice versa for surface water extractions.
- The interference of new irrigation bores with neighbouring bores; and
- Cultural impacts especially the impact on indigenous places, objects and archaeological sites.

The guidelines will also outline the most appropriate implementation mechanism utilising the existing legislation wherever possible (eg Water Act, Local Government Planning Overlays etc.). The roles and responsibilities for each of the key government agencies and other referral bodies will be clearly identified.

Avoiding salt build up in the soil from the use of saline irrigation water

The increase in groundwater based irrigation in the Macalister Irrigation District and other areas has increased the risk of salt build up in the soil from the use of saline irrigation water (see Section 2.3). A technique has been developed to predict the approximate soil salinity content from the prolonged use of saline irrigation water (SKM, 2003a). This method needs to be verified under field conditions (see Knowledge gaps). Once verified, the method should be used to aid landowners to plan irrigation developments to ensure long term sustainability.

Extension

An extension program to ensure the adoption of more efficient irrigation and farm planning is critical to achieving on-ground outcomes. The types of extension activities that are likely to be undertaken in this role include:

- promoting Irrigation Farm Planning as a tool to increase irrigation efficiency, ensure sustainable practices and minimise off-site impacts;
- promoting flood to spray irrigation conversion - especially on the higher permeability soils and advising on the potential effects on soil salinity associated with irrigation water quality issues (see discussion under "on-ground works");
- promoting greater flood irrigation efficiency;
- promoting the financial incentives offered to landowners to compile irrigation farm plans, convert from flood to spray irrigation and upgrade electricity infrastructure;
- ensuring developers of new irrigation enterprises minimise off-site impacts; and
- providing advice to farmers on the suitability of water salinity for a given soil type and application rate to avoid salt build up in the soil.

Conversion to high flow flood irrigation

Higher flow rates to irrigation bays reduces the opportunity for water to infiltrate below the root zone, potentially reducing overall water use and groundwater recharge. This method was recently trialed on two separate properties in the Macalister Irrigation District and is documented in DNRE

(2002c). The method involves increasing the bay outlets to allow a greater flow to the tops of bays, combined with electronic timers to allow more bays to be irrigated at once.

Increasing flow rates for flood irrigation is not possible in all areas of the Macalister Irrigation District due to poor channel delivery systems. The State Government's paper on water reform, *Our Water Our Future* (DSE, 2004a) highlights the need for water delivery system upgrades in the Macalister Irrigation District. This recommendation is being implemented through a major channel automation project in the Macalister Irrigation District. Provision of channel automation, improved channel infrastructure and improved channel delivery will provide a greater opportunity for farmers to become more water efficient. In particular, the opportunities for high flow flood irrigation will increase.

The implementation of high flow flood irrigation is an excellent alternative to spray irrigation conversion on high permeability soils especially where landowners are keen to use pre-existing laser graded bays and re-use systems. There are currently no financial incentives available for landowners to convert to high flow flood irrigation. However, before incentives can be legitimately supplied, more information is required on the costs and benefits of high flow flood irrigation. Although there have been a few documented trials, more information is required on the water savings, recharge and nutrient benefits in addition to a financial analysis from the landowner's perspective. Also, landowners' perception of high flow flood irrigation needs to be assessed against the other alternative of spray irrigation. This could be incorporated into the investigation of the barriers to the adoption of spray irrigation (see discussion above under spray irrigation conversion). While this information is being collected, extension can be undertaken to raise awareness of the potential advantages of high flow flood irrigation as an alternative to the conversion to spray irrigation. Such extension should be targeted towards farmers with laser graded flood irrigation layouts and/or re-use systems on high permeability soils.

Policy, pricing and regulation

Policy and regulation could be used to encourage greater irrigation efficiency. Examples include:

- The "unbundling" of irrigation entitlements into a water share, a share of delivery capacity and a site use license as recommended in the State Government's paper on water reform, *Our Water Our Future* (DSE, 2004a).
- Unbundling will be accompanied by the introduction of Water Use Licences. A licence will permit the use of a set amount of water on a given area of land. The licence will outline standards relating to the use of water on the area of land. Different standards will apply to: Existing Irrigation – based on minimum standards or current standards associated with diversion licences or traded water and New/redeveloped Irrigation – Best practice standards outlined in Irrigation Development Guidelines.
- The Government will create a register of irrigation water rights, licences and bulk entitlements for all water in Victoria. The register is an integral part of the unbundling of water entitlements. The register will provide information such as ownership of the water share, where the water can be used, how much can be used at any one time and how much water was used.
- Development and implementation of guidelines to ensure new irrigation developments are appropriate, efficient and minimise off-site impacts.

- Pricing policies for water that encourage greater water conservation. Such pricing policies are currently being discussed as part of the State Government's current water reforms.
- The introduction of pricing policies that discourage the environmental impacts of irrigation as discussed in DSE's policy paper (*Our Water Our Future*, 2004) on water reform. Such policies could include:
  - Pollution charges;
  - Tradeable pollution permits; and
  - Regulation to set limits on the environmental impacts.

The examples above need to be properly investigated prior to implementation. Some of these examples require investigation at a Statewide level while others can be investigated at a local level.

Economic analysis

Flood to spray irrigation conversion

An economic analysis of flood to spray irrigation conversion was conducted for three different spray irrigation types and for high and low permeability soils. The assumptions and inputs for the analysis are documented in SKM (2004d). The various costs and benefits quantified are shown in Table 22 for lateral spray systems and in Table 23 for centre pivot systems per unit area converted along with the cost benefit ratio and net present values for the overall target rate of 800 ha/year conversion over 30 years.

Table 22: Benefit cost analysis for flood to spray conversion on high permeability soils using a lateral spray system per unit area converted

Item	**Present value of 1 ha conversion (only)**	
	4% discount rate	**8% discount rate**
Benefits		
Water savings (based on temporary water trade value) ($/ha)	$4,200	$2,800
Production ($/ha)	$3,400	$2,200
Nutrients ($/ha)	$300	$200
Salinity ($/ha)	$100	$100
Total benefits ($/ha)	$8,000	$5,300
Costs		
Capital ($/ha)	$3,600	$3,300
Operation ($/ha)	$1,900	$1,300
Labour ($/ha)	$200	$100
Fertiliser ($/ha)	$100	$100
Maintenance($/ha)	$200	$100
Administrative ($/ha)	$200	$200
Total costs ($/ha)	$6,200	$5,100
Net Present Value (benefits minus costs) ($/ha)	**$1,800**	**$200**
Benefit Cost Ratio	**1.3**	**1.0**

The average annual cost to landowners for conversion from flood to spray irrigation using lateral spray systems on high permeability soils is expected to be between $5,100 and $6,200 per hectare based on conversion of 800 hectares per year over 30 years.

- **Table 23: Benefit cost analysis for flood to spray conversion on high permeability soils using a centre pivot system per unit area converted**

Item	Present value of 1 ha conversion (only)	
	4% discount rate	8% discount rate
Benefits		
Water savings (based on temporary water trade value) ($/ha)	$4,800	$3,200
Production ($/ha)	$3,000	$1,900
Nutrients ($/ha)	$300	$200
Salinity ($/ha)	$100	$100
Total benefits ($/ha)	$8,200	$5,400
Costs		
Capital ($/ha)	$4,800	$4,500
Operation ($/ha)	$200	$100
Labour ($/ha)	-$300	-$200
Fertiliser ($/ha)	$100	$50
Maintenance($/ha)	$700	$500
Administrative ($/ha)	$200	$200
Total costs ($/ha)	$5,700	$5,150
Net Present Value (benefits minus costs) ($/ha)	**$2,500**	**$250**
Benefit Cost Ratio	**1.4**	**1.0**

The average annual cost to landowners for conversion from flood to spray irrigation using centre pivot systems on high permeability soils is expected to be between $5,150 and $5,700 per hectare based on conversion of 800 hectares per year over 30 years. An analysis of fixed sprinkler systems was also undertaken. however the calculations suggest that this option is the least favourable of the three. The values listed in Table 22 and Table 23 are for conversion of 1 hectare only. For implementation of the entire program, the present value of the costs and benefits is shown in Table 24.

- **Table 24: Present value of costs of proposed conversion from flood to spray program – assuming equal conversion to lateral spray and centre pivot systems**

Scenario and item	Present value over 30 years	
	4% discount rate	8% discount rate
SMP + Current (800 ha/yr)		
Program costs	$ 62.0 M	$ 43.1 M
Program benefits	$ 83.1 M	$ 44.8 M
Net present value	$ 21.1 M	$ 0.7 M
SMP Only (150 ha/yr)		
Program costs	$ 11.6 M	$ 8.1 M
Program benefits	$ 15.6 M	$ 8.2 M
Net present value	$ 4.0 M	$ 0.1 M

Similar calculations for low permeability soils show that none of the spray irrigation types are likely to be economically viable for either a 4% or 8% discount rate (SKM, 2004d). DNRE (2002a) suggests that a 4% discount rate is equivalent to the return Government expects from its investment in natural resource management. Therefore, from a Government perspective, the economic analysis shown in Table 22 and Table 23 shows that conversion from flood irrigation to lateral or centre pivot spray irrigation on high permeability soils is a worthy investment.

High flow flood irrigation

SKM (2004d) documents a cost-benefit analysis of conversion to high flow flood irrigation. The assumptions and inputs for the analysis are documented in SKM (2004d). The various costs and benefits quantified are shown in Table 25 along with the cost benefit ratio and net present values for the target rate of 50 ha/year conversion over 30 years.

- **Table 25: Cost benefit analysis for high flow flood irrigation**

Item	Present Value (or Benefit Cost Ratio), applied over 30 years	
	4% discount rate	8% discount rate
Benefits		
Salinity	$ 60,000	$ 30,000
Labour saving	$ 80,000	$ 50,000
Water saving	$ 3,250,000	$ 1,880,000
Total benefits	$ 3,400,000	$ 1,960,000
Costs		
Capital	$ 460,000	$ 370,000
Admin./Agency	$ 130,000	$ 110,000
Total Costs	$ 590,000	$ 470,000
Net Present Value for target rate of 50ha/yr over 30 years	$ 2,800,000	$ 1,500,000
Benefit Cost Ratio	5.7	4.1

The average annual cost to landowners for conversion to high flow flood irrigation is expected to be between $200 and $300 per hectare based on conversion of 50 hectares per year over 30 years.

Prevention of salt build-up from irrigating with saline water

SKM (2004d) documents a cost-benefit analysis of the prevention of salt build-up from irrigating with saline water including input values and the key assumptions. The various costs and benefits quantified are shown in Table 26 along with the cost benefit ratio and net present values for the target rate of 50 ha/year conversion over 30 years.

Table 26: Cost benefit analysis for prevention of salt build-up from irrigating with saline water

Item	Present Value and Benefit Cost Ratio, applied over 30 years	
	4% discount rate	**8% discount rate**
Benefits		
On-farm production benefit (reduced salinisation)	$ 1,100,000	$ 870,000
Total benefits	$ 1,100,000	$ 870,000
Costs		
Model calibration	$ 45,000	$ 45,000
Admin./Agency	$ 97,000	$ 83,000
Total Costs	$ 142,000	$ 128,000
Net Present Value for target of 50ha/yr over 30 years	$ 950,000	$ 740,000
Benefit Cost Ratio	7.7	6.8

Barriers to adoption

Some of the barriers to the adoption of more efficient irrigation practices include:

- Landowner uncertainty regarding the economic viability of flood to spray irrigation conversion even with the current incentives program;
- Landowner reluctance to convert costly laser-graded irrigation layouts to spray irrigation;
- Lack of incentive for irrigators to irrigate more efficiently; and
- Limited access to three-phase power in some regions of the Macalister Irrigation District (SKM, 2003f).

Another conflict with the use of spray irrigation systems is that they can require the removal of trees, which can have adverse impacts on biodiversity and the release of greenhouse gases. However, the Draft West Gippsland Native Vegetation Plan clearly states the requirements of 'Net Gain' and outlines the process involved in determining whether or not to grant permission to remove native vegetation. They also use significantly higher amounts of electricity than flood irrigation systems, which leads to an increase in greenhouse gases, although this is likely to be more than balanced by the saving in emissions of nitrous oxides (a more harmful greenhouse gas) due to the reduction in waterlogging.

Knowledge Gaps

The key knowledge gaps include:

- The current geographic spread of flood and spray irrigation in the Macalister Irrigation District;
- The increase in production resulting from the conversion from flood to spray irrigation which may have a significant impact on the economic benefits of conversion;

- There have been several studies into appropriate maximum irrigation volumes in the Macalister Irrigation District, all with slightly different outputs (eg Wood *et al*, 2002, DSE, 2004b). There is a strong need to review these studies to determine the most appropriate maximum irrigation volume to be used for "water use licences" in the Macalister Irrigation District as detailed in the State Government's paper on water reform, *Our Water Our Future* (DSE, 2004a); and
- There is very little information on the appropriate irrigation volumes to be applied to areas outside the Macalister Irrigation District for use in determining appropriate allocations for "water use licences" as detailed in DSE (2004a).

Recommended actions, prioritisation and management action targets.

Recommended actions and projects based on the above discussion are outlined in Table 27.

Table 27: Recharge control – Irrigation Management options

Management options	Potential future actions	Type of project	Benefit-risk score	Overall priority	2004/05^	5 year management actions					5 year Management Action Target	Impact on salinity over 30 years	WGCMA partners
						2005/06	2006/07	2007/08	2008/09	2009/10			
IA Recharge control – Irrigation Management													
IA1. Irrigation Farm Plans	**IA1.1** Provide financial and extension assistance to irrigators to compile Irrigation Farm Plans	Extension	**NA**	**Priority 1**							**MAT IA1:** 10,500ha additional irrigated area covered by WFPs (approx 20 to 30 WFPs per year)	Efficient irrigation and reduced recharge when WFPs are implemented	On-ground implementation: Department of Primary Industries
	IA1.2 Undertake stakeholder review of Irrigation Farm Plans	Stakeholder consultation	**NA**	**Priority 1**									WGCMA only
IA2. Conversion from flood to spray irrigation	**IA2.1** Review cost sharing arrangements	Research and Investigation	**49**	**Priority 1**							**MAT IA2:** To convert 800ha/year of flood irrigation to spray irrigation	Reduction in 2580ha of <2m depth to watertable	On-ground implementation: Department of Primary Industries
	IA2.2 Provide financial incentives for the conversion of flood to spray irrigation and advise farmers of the implications to salt levels in the soil (especially groundwater based irrigators).	On-ground works											
	IA2.3 Determine the current extent of spray and flood irrigation across the MID and the key target areas for future extension programs	Monitoring and evaluation											
	IA2.4 Promote the benefits of conversion of flood to spray irrigation including the benefits of the current incentives scheme	Extension											
IA3. More efficient flood irrigation	**IA3.1** Investigation into flood irrigation techniques including documentation of IBIS trial results	Research and Investigation	**45**	**Priority 1**							**MAT IA3:** 50ha/year converted to high flow rate flood irrigation = 250Ha over 5 years	Reduction in 42ha of <2m depth to watertable	Department of Primary Industries
	IA3.2 Extension of best practice flood irrigation techniques	Extension											
IA4. Efficient irrigation development on 'Greenfield sites'	**IA4.1** Develop guidelines for approving new irrigation developments	Research and Investigation	**45**	**Priority 1**							**MAT IA4:** All new irrigation developments using efficient irrigation techniques	Prevention of future salinity	On-ground implementation: Department of Primary Industries
	IA4.2 Implementation of new irrigation development guidelines	Licensing											
	IA4.3 Extension of best practice irrigation planning for new irrigation developments	Extension											
IA5. Irrigation Management to reduce effects of saline irrigation water	**IA5.1** Calibrate current "safe salinity" model to local conditions using field based examples (SKM, 2003a)	Research and investigation	**43**	**Priority 2**							**MAT IA5:** Investigation work completed and extension program begun	Prevention of land salinity on 1500ha	Department of Primary Industries
	IA5.2 Publicise results of "safe salinity" model and extension to individual farmers	Extension											

^ 2004/2005 management actions are currently being undertaken and were recommended by the draft West Gippsland Salinity Management Plan.

6.4.4 Vegetation program

On-ground works

The most suitable use for trees as a salinity control mechanism in the Macalister Irrigation District and surrounds is for interception purposes. As discussed in Section D2.2 (Appendix D), trees can be used to intercept groundwater prior to discharge further down-slope. Trees are especially suitable for this purpose at the break of slope above saline discharge areas. There are many examples in the Macalister Irrigation District where trees can be planted above the break of slope to reduce the effect of salinity on the lower slopes including:

- Along both edges of the Thomson/Macalister River floodplain between Gibson Knox Bridge and Sale – there are significant patches of salinity along this stretch; and
- Along the southern edge of the Avon River floodplain at Airly.

Agronomic and native vegetation options such as trees and perennial pasture establishment to control recharge are considered of low priority for salinity control in irrigated areas for the following reasons:

- Perennial pastures are already prevalent in most of the irrigated areas;
- Trees take up valuable agricultural land that could otherwise be irrigated or can restrict the use of some spray irrigation systems. The opportunity cost of production forgone from tree planting is much greater in irrigated areas relative to dryland; and
- Trees cannot be economically planted over a large area to have an effect on watertable levels if planted for recharge purposes alone. However, this conclusion may not hold if trees are used in farm forestry applications.

However, there may be an opportunity for the use of trees and perennial pastures to help reduce recharge in dryland areas adjacent to irrigated areas affected by salinity. Trees grown as irrigated crops are unlikely to be economically viable. To achieve multi-benefits, tree planting should aim to establish native plants of local provenance wherever possible, as set out in the West Gippsland Draft Native Vegetation Plan (WGCMA, 2003).

Despite the lack of evidence for the planting of trees to rehabilitate irrigation induced salinity, there is a strong argument for the protection of existing native vegetation in these areas to avoid any additional salinisation. Clearing of any native vegetation in and around the Macalister Irrigation District may exacerbate the salinity problem.

Implementation mechanisms

Victoria's Native Vegetation Management: A Framework for Action (DNRE, 2002b) requires that there is a 'net gain' in the extent (area) and quality (condition) of native vegetation. This applies to all activities including any that directly or indirectly result in the loss or clearing native vegetation including trees, shrubs, herbs and grasses. Therefore, even without the salinity plan, native vegetation is likely to be protected at least to some extent. However, in the implementation of the Native Vegetation Management Framework the impact of native vegetation clearing on future land salinisation should be taken into account when issuing clearing permits. Therefore, the salinity program has a role to play in informing relevant agencies of the key strategic areas to avoid clearing from a salinity perspective. Also, market based incentives are currently used to protect native vegetation stands in the area (e.g. the BushTender program), and new incentives are being offered for carbon sequestration purposes.

The salinity program recommends that the successful trial of the Bush Tender program be extended to include all significant areas of native vegetation in the West Gippsland CMA region. Also, the BushTender program should consider the benefits of land salinity mitigation (in addition to biodiversity) when determining successful applicants.

The implementation of trees in dryland areas affected by irrigation salinity will be conducted through existing vegetation programs. The salinity program's role in the delivery of these programs is to ensure that the salinity benefits of tree planting are maximised. This may be achieved by liaison with Government officers responsible for implementing revegetation and biodiversity programs or by providing input and assistance to Landcare groups on appropriate locations for vegetation establishment to maximise salinity benefits (especially in break of slope areas above saline discharge zones). There may be the potential to increase existing revegetation incentives based on additional salinity benefits. This would need to be determined through an economic assessment.

Perennial pasture establishment in dryland areas affected by irrigation salinity will be implemented through extension programs.

Barriers to adoption and knowledge gaps

The key barriers to adoption and knowledge gaps are:

- The impact of perennial pastures and trees on the recharge rates in the dryland areas being affected by irrigation salinity;
- Trees are unlikely to be economic as a 'cash crop' and take up land that may otherwise be used for more valuable agricultural production; and
- Lack of information on priority dryland areas for the location of trees in the landscape to maximise recharge reduction benefits.

Recommended actions, prioritisation and management action targets.

Recommended actions and projects based on the above discussion are outlined in Table 28.

- **Table 28: Recharge control – Agronomic and native vegetation options**

Management options	Potential future actions	Type of project	Benefit-risk score	Overall priority	2004/05^	5 year management actions 2005/06	2006/07	2007/08	2008/09	2009/10	5 year Management Action Target	Impact on salinity over 30 years	WGCMA partners
IB. Recharge control and groundwater interception – pasture and native vegetation options													
IB1. Perennial pasture and tree establishment in dryland areas affected by irrigation salinity and in irrigated areas	**IB1:** Provide input to existing programs to ensure that recharge control and groundwater interception is taken into consideration in any tree planting activities (eg Landcare and/or other native vegetation programs). Extension and native revegetation activities should specifically focus on break of slope tree planting above saline discharge areas especially on the edge of the Macalister, Thomson and Avon River floodplains.	Extension and on-ground works	**39**	**Priority 3**							**MAT IB1:** All Research & Investigation work completed and extension program commenced	Production increased from 40% to 80% on salt-affected land	Department of Primary Industries
IB2. Protecting, enhancing and restoring native vegetation	**IB2:** 1) Work closely with biodiversity programs to ensure that existing native vegetation is protected or there is a "net gain" of native vegetation of local provenance in any instances of clearing 2) Review the "Bush Tender" trial program to determine if applicable to wider area	Extension	**45**	**Priority 1**							**MAT IB2:** Existing extension programs provided with target areas for tree planting for salinity control	Prevention of future salinity	WGCMA only

^ 2004/2005 management actions are currently being undertaken and were recommended by the draft West Gippsland Salinity Management Plan.

6.4.5 Sub-surface drainage program

On-ground works

The sub-surface drainage program primarily involves the promotion of private groundwater pumping and the installation of public groundwater control pumps. However, there are also a number of 'free flowing' bores in the Clydebank and Nambrok Salinity Management Areas and a tile drainage scheme at the Clydebank School. Although the economics and operation of the free flowing bores and tile drainage schemes require review, widespread application of these techniques is not recommended in this plan mainly due to the limited effectiveness for reducing the watertable.

Where groundwater pumping can be justified to protect high value assets, the hierarchy of the type of groundwater pumping shown in Table 29 should be used.

- **Table 29: Hierarchy of priorities for type of groundwater pumping used for salinity control**

Priority	Type of groundwater pumping	Fate of pumped water	Situation where used	Appropriate Program
1	Private pumping	Irrigation	Groundwater salinity is low enough to use without any detrimental effect on pastures (approx 1,500µS/cm)	Targeted Exploration Drilling Scheme and Capital Grants Scheme
2	Private irrigation bore shandied with channel water	Irrigation	Groundwater is too high to use on pastures without shandying with fresher water	Targeted Exploration Drilling Scheme and Capital Grants Scheme
3	Landowner contracted to pump private irrigation bore	Irrigation and disposed of to drains, channels or rivers	Landowner pumping for irrigation is not sufficient to protect high value asset or groundwater is too saline to use	Contract private pumping program
4	Groundwater control pumps	Disposed to channels for re-use as irrigation water	Groundwater salinity is too high to use on farm and it is impractical or impossible to shandy to a salinity suitable for pastures and disposal to a channel is possible	Groundwater Control Pumping program
5	Groundwater control pumps	Disposed to drains or rivers and eventually to the Gippsland Lakes	Groundwater salinity is too high to use on farm and it is impractical or impossible to shandy to a salinity suitable for pastures and disposal to a channel is not possible	Groundwater Control Pumping program

The groundwater pumping program will continue to promote private pumping in high watertable areas within the Macalister Irrigation District and surrounds through implementation of the Targeted Exploration Drilling Scheme and the Capital Grants Scheme (see Appendix F1.3).

Although the program of installing public groundwater control pumps is nearing an end, there are potentially areas of high watertable where short-term engineering solutions are economically justified but the groundwater salinity of pumped water is too high for on-farm uses. If possible, options to shandy the saline groundwater with fresh channel water for use on farm should be explored in preference to pumping for disposal. However, if this is not possible, then public groundwater control pumps are appropriate that dispose to drains, channels or rivers.

The short term priority for the public groundwater control pumping program is to complete the installation of the two groundwater pumps currently in various stages of implementation (Pumps 29 and 30) followed by completion of the investigations into possible installation of Groundwater Control Pumps at an additional five sites (Newry in Maffra Salinity Management Area and Marshalls Rd, Cairnbrook Rd (2) and Kilmany in Nambrok Salinity Management Area).

Groundwater modelling has shown that additional groundwater pumping is likely to be warranted in some key areas of high value agricultural and environmental assets that are unlikely to be significantly affected by recharge control measures (SKM, 2004c). Figure 13 shows the remnant areas of high watertable after 18 years of full conversion from flood to spray irrigation and with the current level of groundwater pumping. High value assets that are judged to require investigation for potential new groundwater pumping are shown in Figure 13 based on:

- The expected future depth to watertable with current levels of groundwater pumping and an accelerated rate of flood to spray irrigation conversion;
- The salinity mapping and assessment of future needs for groundwater pumping detailed in SKM (2001a), SKM (2001b), SKM (2002a) and SKM (2003b);
- Previous analysis of the groundwater pumping needs in various Salinity Management Areas (eg SKM, 2004a in prep; 2004c in prep); and
- A qualitative judgement on the social, environmental and economic benefits of groundwater pumping based on the value of the asset being protected.

The new groundwater investigation sites shown in Figure 13 are divided into potential new private pumping and public groundwater control pump sites. This division is based solely on the expected groundwater salinity. If there is any chance that the groundwater salinity is sufficiently low for use on farm as irrigation water, the site has been labelled as being potentially suited for private pumping. All other sites have been designated as being suited to Groundwater Control Pumps.

The analysis shows that there are approximately 10 different areas that could be targeted for private pumping and approximately 5 sites that could potentially be investigated for new Groundwater Control Pumps. The 5 new public groundwater control pump site investigations are in addition to the 7 sites currently in various stages of investigation or implementation. This does **not** indicate that there should be 5 more Groundwater Control Pumps installed, but instead that 5 more investigations are required, with the final decision on pump installation based on site-specific analysis of the social, environmental and economic costs and benefits of pump operation and disposal.

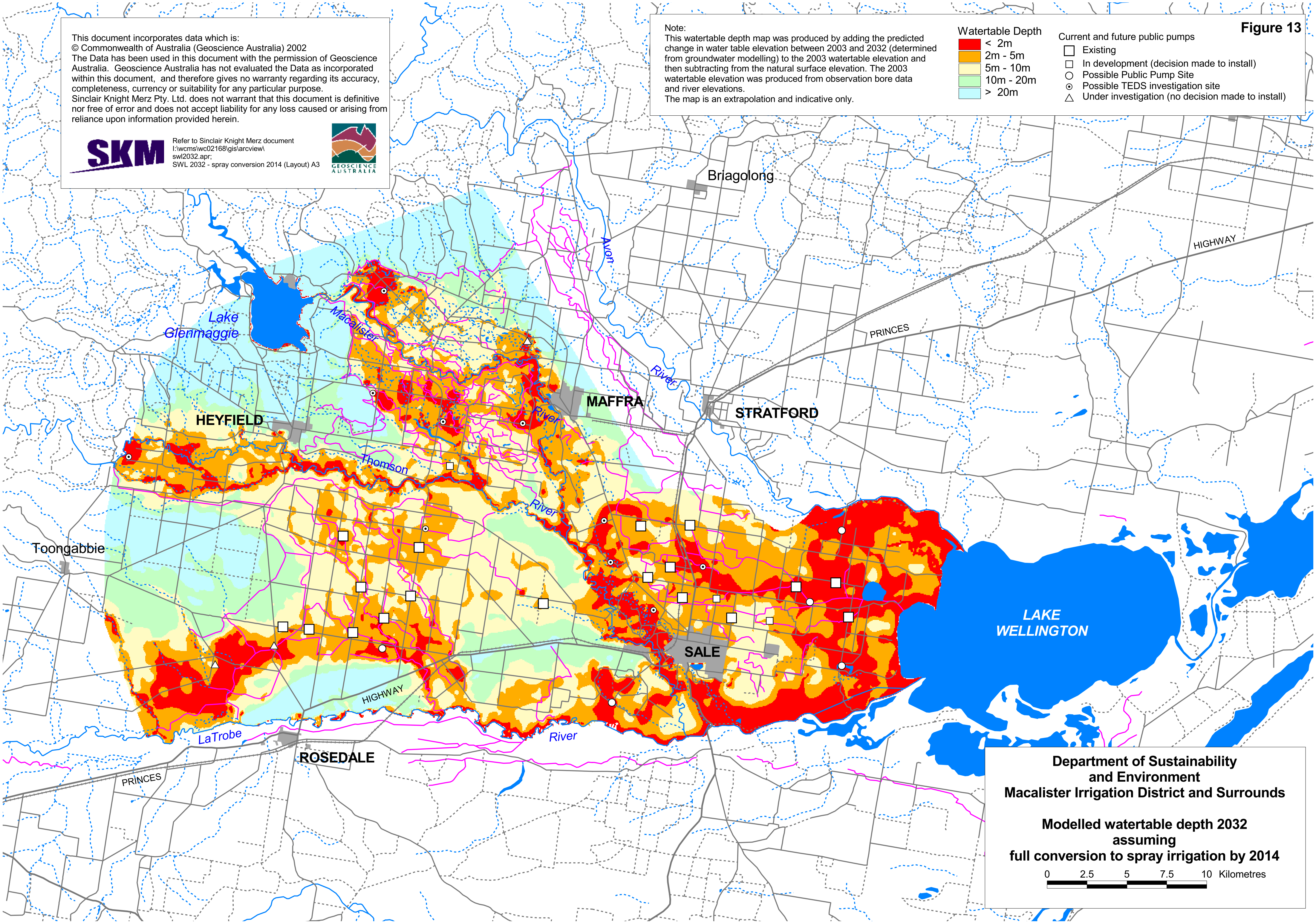
Implementation mechanisms

The current arrangements for the implementation of the groundwater pumping program have been developed and refined over a number of years and provide an excellent platform for future implementation. The currently employed methodology is described in detail in the “Salinity Mitigation Flow Chart” (SKM, 2003). The methodology uses the groundwater pumping type hierarchy shown in Table 29. The Targeted Exploration Drilling Scheme and Capital Grants

Scheme should be used as the main vehicle for promoting private pumping based on the economic cost sharing analysis detailed below.

There is potential to use market based mechanisms to encourage the greater use of shallow groundwater in preference to channel water. For instance, the water right and on-going unit costs for groundwater use could be made to be relatively cheaper than channel water use at a level that is sufficient to encourage widespread adoption. These market-based mechanisms require further investigation in conjunction with statewide policies on these issues.

Irrigation Farm Planning is another mechanism that should be used to promote private groundwater use in high watertable areas. This provides another justification for the current financial incentives offered for Irrigation Farm Planning in the Macalister Irrigation District.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SKM
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swl2032.apr;
SWL 2032 - spray conversion 2014 (Layout) A3
GEOSCIENCE AUSTRALIA
Note:
This watertable depth map was produced by adding the predicted change in water table elevation between 2003 and 2032 (determined from groundwater modelling) to the 2003 watertable elevation and then subtracting from the natural surface elevation. The 2003 watertable elevation was produced from observation bore data and river elevations.
The map is an extrapolation and indicative only.
Watertable Depth
< 2m
2m - 5m
5m - 10m
10m - 20m
> 20m
Current and future public pumps
Existing
In development (decision made to install)
Possible Public Pump Site
Possible TEDS investigation site
Under investigation (no decision made to install)
Figure 13
Briagolong
Avon
HIGHWAY
PRINCES
River
Lake
Glenmaggie
Macalister
MAFFRA
STRATFORD
HEYFIELD
River
Thomson
River
Toongabbie
LAKE
WELLINGTON
SALE
HIGHWAY
LaTrobe
River
ROSEDALE
PRINCES
Department of Sustainability
and Environment
Macalister Irrigation District and Surrounds
Modelled watertable depth 2032
assuming
full conversion to spray irrigation by 2014
0 2.5 5 7.5 10 Kilometres

Barriers to adoption

The key barrier to the promotion of additional private pumping in high watertable areas is the difficulty in obtaining irrigation bore licenses in areas covered by fully allocated Groundwater Salinity Management Areas (GMAs). The Wa De Lock GMA and the Denison GMA cover the useable shallow aquifer over much of the high watertable area of the Macalister Irrigation District and surrounds. Irrigators are only able to obtain temporary transfer of groundwater entitlement, which provides little on-going security. The current lack of water security and flexibility in allowing additional irrigation bore licences in high watertable areas is hindering the promotion of private groundwater pumping in high watertable areas. The future of the TEDS and Capital Grants Scheme in the Macalister Irrigation District is dependent on resolution of this issue. Possible solutions could include the designation of high watertable zones where additional irrigation licenses could be issued or the issuing of a licence to pump groundwater conditional on watertable level criteria being satisfied. The best avenue for exploring these issues is through the Groundwater Management Plans for both Denison and Wa De Lock GMAs. Currently, the Denison Groundwater Management Plan is in draft form and the Wa De Lock Plan has yet to commence. The State Government's paper on water reform, *Our Water Our Future* (DSE 2004a) states that special rules may be established to address salinity issues in high watertable areas. The salinity program needs to have a strong input into the development of any local rules.

Finding new sites for the installation of Groundwater Control Pumps that are economically viable is becoming increasingly difficult for a number of reasons including:

- Difficulty in finding high value land affected by salinity in order to justify the large public and private expenditure required to install new groundwater pumps; and
- Difficulty in finding suitable disposal sites for saline groundwater from public groundwater control pumps that will not adversely affect downstream users and the in-stream environment (as determined by the EPA's SEPP guidelines). The disposal of pumps into channels instead of drains and rivers is one possible solution to this problem.

Another barrier to the addition of new public groundwater control pumps in the region is the fossil fuels they consume and the associated emission of greenhouse gases. There is an argument that the problem of salinity is being transferred to a greenhouse gas problem. Addressing this issue will require the investigation of renewable energy sources for public groundwater control pumps.

Knowledge gaps

The key knowledge gaps in the groundwater pumping program are:

- The extent to which current Groundwater Control Pumps are complying with the EPA's State Environment Protection Policy for the Waters of Victoria especially the requirement that point source discharges not increase salinity of the receiving waters by greater than 10%;
- Whether the discharge from some of the current pumps can be transferred from drains and rivers to channels for re-use by irrigators;
- How to encourage greater private groundwater use from the shallow aquifer in fully allocated high watertable areas within the Denison and Wa De Lock Groundwater Salinity Management Areas;

- The effectiveness of the tile drainage system at the Clydebank School and the 'free flowing bores' located along some drains in the Nambrok and Clydebank Salinity Management Areas;
- The impact of groundwater pumps on greenhouse gas emissions. Quantification is needed of the greenhouse gas emissions of groundwater pumps, particularly in relation to the likely decrease in the release of nitrous oxides due to a reduction in waterlogging; and
- The relationship between the watertable aquifer and the deeper aquifers and the effect on salinity of declining groundwater pressures in the deeper aquifers. In particular, the effect of the Boisdale Formation on the watertable aquifer in the Clydebank area is important to understand for the future of salinity in this area. Also, the effect of the declining pressures of the Latrobe Group and Balook Formation Aquifers in the high watertable areas around Yarram and the South Gippsland coast requires investigation.

Economic analysis

An economic analysis of the costs and benefits of public groundwater control and private groundwater pumps was conducted as part of the development of this plan and is detailed in Sinclair Knight Merz (2004). The calculations for Groundwater Control Pumps are shown in Table 30 and assume:

- The continued operation of the existing 19 Groundwater Control Pumps;
- The operation of the 2 new pumps currently being installed (Pumps 29 and 30);
- The installation and operation of 5 new public groundwater control pump sites currently being investigated; and
- The installation and operation of 5 new public groundwater control pumps yet to be investigated.

The calculations are conducted with and without the currently operating and approved pumps to determine the marginal cost of the investigation component. The net present value of installing 3 private pumps per year for 5 years is given in Table 31.

Table 30: Benefit cost analysis of public groundwater control pumping over 30 years

Item	All approved and potential future pumps 21 approved pumps +10 additional		Potential future pumps only 10 additional pumps only	
	4% disc. rate	8% disc. rate	4% disc. rate	8% disc. rate
Costs				
Investigation and Capital	$ 2,870,000	$ 2,420,000	$ 1,940,000	$ 1,800,000
Operation and Maintenance	$ 2,460,000	$ 1,620,000	$ 850,000	$ 560,000
Total Cost	$ 5,330,000	$ 4,030,000	$ 2,790,000	$ 2,360,000
Benefits				
Production Benefits if…				
100% irrigated dairy	$ 38,170,000	$ 25,080,000	$ 13,160,000	$ 8,650,000
100% dryland dairy	$ 4,670,000	$ 3,070,000	$ 1,610,000	$ 1,060,000
100% dryland beef production	$ 2,270,000	$ 1,490,000	$ 780,000	$ 510,000
Net present value if…				
100% irrigated dairy	$ 32,840,000	$ 21,040,000	$ 10,380,000	$ 6,290,000
100% dryland dairy	-$ 670,000	-$ 970,000	-$ 1,180,000	-$ 1,300,000
100% dryland beef production	-$ 3,060,000	-$ 2,540,000	-$ 2,000,000	-$ 1,850,000
Benefit Cost ratio if…				
100% irrigated dairy	7.2	6.2	4.7	3.7
100% dryland dairy	0.9	0.8	0.6	0.5
100% dryland beef production	0.4	0.4	0.3	0.2

disc. rate – discount rate, 30 year analysis period. Assumed $100 per ML per year, based on temporary water trade value in the Macalister Irrigation area (see SKM (2004d) for further details). Volume utilised depends on whether the farm has access to storage facilities, however would be in the order of 60 ML per year.

Table 31: Benefit cost analysis of private groundwater pumping

Item	3 private pumps installed per year for 5 years = 15 additional pumps	
	4% discount rate	8% discount rate
Costs		
Investigation and Capital	$ 890,000	$ 740,000
Operation and Maintenance	$ 570,000	$ 350,000
Total Cost	$ 1,450,000	$ 1,090,000
Benefits		
Production Benefits if…		
100 % irrigated dairy	$ 7,040,000	$ 4,390,000
100 % dryland dairy	$ 860,000	$ 540,000
100% dryland beef production	$ 420,000	$ 260,000
Net present value if…		
100 % irrigated dairy	$ 5,580,000	$ 3,300,000
100 % dryland dairy	-$ 590,000	-$ 560,000
100% dryland beef production	-$ 1,040,000	-$ 830,000
Benefit Cost ratio if…		
100 % irrigated dairy	4.8	4.0
100 % dryland dairy	0.6	0.5
100% dryland beef production	0.3	0.2

The figures presented in Table 30 indicate that Groundwater Control Pumps only appear to be economically viable where high value land (or potentially other high value assets) are protected. However, installation of Groundwater Control Pumps in the lower value dryland areas can be justified when protecting environmental assets such as wetlands or when addressing the social in-equity between those being affected by salinity and those causing the problem. Similar results are indicated for private pumps in Table 31.

Recommended actions, prioritisation and management action targets.

Recommended actions and projects based on the above discussion are outlined in Table 32.

Table 32: Engineering options – sub-surface drainage options

Management options	Potential future actions	Type of project	Benefit-risk score	Priority	2004/05^	5 year management actions 2005/06	2006/07	2007/08	2008/09	2009/10	5 year Management Action Target	Impact on salinity over 30 years	WGCMA partners
IC. Engineering options – Sub-surface drainage													
IC1 Public Groundwater Control Pumps	**IC1.1** Continue operating existing Groundwater Control Pumps on an as needs basis	On-ground works	**49**	**1**							**MAT IC1.1:** Continue operation and maintenance of 19 existing pumps	Continued reduction in <2m DTWT	Southern Rural Water, Wellington Shire
	IC1.2 Continue installation of 2 new Groundwater Control Pumps (29 and 30) and continue investigating 5 unfinished public groundwater control pump investigations	R&I/On-ground Works	**43**	**2**							**MAT IC1.2:** Install 2 new Groundwater Control Pumps and investigate pump viability at 5 sites	Reduction of 750ha of <2m DTWT	Invest: WGCMA only Implement: SRW
	IC1.3 Apply steps in "Salinity Implementation Flow Chart" to areas either not affected by recharge control or where short term relief is required	Res. And Invest/ On-ground Works	**41**	**2**							**MAT IC1.3:** Investigate 5 sites for additional public groundwater control pumps, review alternative disposal options for existing pumps and investigate the potential for use of alternative power sources	Reduction of 750ha of <2m DTWT	Invest: WGCMA only Implement: SRW
	IC1.4 Review option for installing wind/solar power on new public groundwater control pump sites	Res & Inv	**39**	**3**									Southern Rural Water
	IC1.5 Review SEPP compliance for existing pumps. Review possible alternative disposal options (eg channel instead of drain disposal)	Res & Inv	**41**	**2**								Reduction in in-stream salinity	Southern Rural Water
	IC1.6 Soil salinity surveys around new pumps to benchmark and existing pumps for comparison with previous benchmarks	Monit and evaluation	**45**	**1**								Salinity mitigation impact	WGCMA only
IC2 Private Groundwater Pumps in high watertable areas	**IC2.1** Review existing irrigation bores to determine possibility of additional private pumping in high watertable areas	Research and Investigation	**43**	**2**							**MAT IC2:** 3 TEDS investigations and 3 Capital Grants Scheme per year starting 2005/06	Increased opportunities for pumping for salinity control	WGCMA only
	IC2.2 Input into Groundwater Management Plans to address conflict between salinity management and groundwater resource management	Research and investigation	**43**	**2**									Southern Rural Water
	IC2.3 Investigate methods for encouraging shallow groundwater use in preference to channel or river water and implement where appropriate	Research and Investigation	**41**	**2**									Southern Rural Water
	IC2.4 Implement TEDS/CGS in areas of suspected reasonable water quality	On-ground works	**43**	**2**								Reduction of 900ha of <2m DTWT	Southern Rural Water
	IC2.5 Review effectiveness of previous FEDS/TEDS schemes and change procedure accordingly	Monit & eval.											WGCMA only
IC3 Free flowing bores	**IC3** Review current state and effectiveness of free flowing bores and recommend appropriate action. Review the need for additional free flowing bores	Research and Investigation	**33**	**4**							**MAT IC3:** Free flowing bores reviewed and recommended actions implemented	Reduction in area of <2m DTWT	Southern Rural Water
IC4 Tile and mole drains	**IC4** Review cost effectiveness of tile drains in Clydebank School and determine whether appropriate to apply to other areas	Research and investigation	**33**	**4**							**MAT IC4:** Tile and mole drains reviewed and recommended actions implemented		Southern Rural Water

^ 2004/2005 management actions are currently being undertaken and were recommended by the draft West Gippsland Salinity Management Plan.

6.4.6 Surface drainage program

On-ground works

The surface drainage program will be directed to:

- Improving the surface drainage in the Macalister Irrigation District and surrounds; and
- Improving environmental flows to reduce river salinity.

There are some areas of the Macalister Irrigation District that suffer from waterlogging and/or episodic groundwater recharge events resulting from the ponding of surface water. Some of these areas would benefit from increased surface drainage to remove the ponded surface water. Examples of these areas include the region around Flooding Creek at the northern edge of the Sale township and the Marshalls Road area at the north-eastern end of the Nambrok Salinity Management Area. Although there are no plans by Southern Rural Water to increase the network of Government owned drains in the region, there is potential to aid landowners in developing 'community drains' in the region.

Implementation mechanisms

Extension programs will be the main mechanism for the implementation of community drains, which will involve provision of advice and the facilitation of landowner groups. As detailed below under cost sharing, there may also be justification for public investment in on-ground works to construct new drainage schemes especially if it avoids the need for costly groundwater control pumps. To date there has been no government incentives offered to landowners to construct community drains in the Macalister Irrigation District. There is a need to investigate the public benefits achieved from community drains and the potential to offer government incentives to construct such drains. Such a scheme operates in the Shepparton Irrigation Area.

Barriers to adoption

The key barriers to the adoption of community drains in key water logged areas of the Macalister Irrigation District are the community's capacity and willingness to pay for these schemes and the potential impact of these schemes on the nutrient and salt loads on the receiving waters. Both these issues need to be investigated before any on-ground works can occur. It is expected that salinity funding may be required to overcome the barrier of community capacity to pay. Impacts on native vegetation, biodiversity and threatened species also need to be evaluated prior to any on-ground works and works plans should include necessary actions to avoid, minimise and offset impacts.

Knowledge gaps

The key knowledge gap is the identification of key areas requiring additional surface drainage in the Macalister Irrigation District to reduce waterlogging and episodic recharge events. Also, the potential impacts of additional surface drainage on nutrient and salinity loads in receiving streams and rivers needs to be evaluated prior to any on-ground works.

Further investigation is required into the public benefits of community drainage schemes and the appropriate cost sharing arrangements for potential government incentives to construct community drains.

Recommended actions, prioritisation and management action targets

Recommended actions and projects based on the above discussion are outlined in Table 33.

- **Table 33: Engineering options – Surface drainage options**

Management options	Potential future actions	Type of project	Benefit-risk score	Overall priority	2004/05^	5 year management actions					5 year Management Action Target	Impact on salinity over 30 years	WGCMA partners
						2005/06	2006/07	2007/08	2008/09	2009/10			
ID. Engineering options – Surface drainage													
ID1. Improved surface drainage	**ID1:** Complete MID drain management plan with specific emphasis on highlighting areas with minimal surface drainage (eg Flooding Creek area in Bundalaguah/Sale area)	Research and Invest.	**31**	**Priority 4**							**MAT ID1:** Drainage plan complete and implemented	Reduction in area of <2m DTWT	Southern Rural Water
ID2. Assess viability of community drains	**ID2**: Undertake research and investigations into the viability of community drains in the MID	Research and Invest.	**NA**	**Priority 4**							**MATID2:** Research into viability of community drains complete	Reduction in area of <2m DTWT	Southern Rural Water

^ 2004/2005 management actions are currently being undertaken and were recommended by the draft West Gippsland Salinity Management Plan.

6.4.7 Living with Salt Program

On-ground works

The Living with Salt program will focus on improving the productivity of saline land and water. Saline land will be addressed through fencing and livestock management to reduce grazing impacts and the sowing of salt tolerant crops and pastures. The planting and management of salt tolerant crops and pastures should be part of the farm planning process and farmers should be encouraged to include this in their Irrigation Farm Plans. There may also be the potential for land retirement or Government buy back of saline land that has a low agricultural value but a high environmental value. The grazing land adjacent to current wetland reserves in the lower Clydebank Salinity Management Area is a possible example where this strategy may be appropriate although further economic analysis is required to justify. This program will also review possible uses of saline water in drains and the outputs of Groundwater Control Pumps including aquaculture and desalination.

This plan recommends that 25% of areas affected by Class 2 and 3 salinity induced by irrigation be sown to salt tolerant pastures or crops over the next 30 years. The key proviso for this recommendation is that types of crops and pastures can be found that are economic for the landowner to sow (see economic discussion below). The productivity for areas of Class 1 salinity is likely to be maximised through the use of normal pastures (ie not salt tolerant pastures) explaining why areas of Class 1 salinity are not targeted in this program. The target for the sowing of salt tolerant pastures equates to an area of approximately 1,375ha over 30 years or 45 ha per year. The main target area is the dryland areas affected by irrigation induced salinity. Due to the flushing effects of irrigation water, there is little Class 2 and 3 salinity in irrigated areas.

It is important to ensure that the sowing of any introduced species does not become a weed. Special care needs to be taken when sowing salt tolerant crops and pastures in areas adjacent to environmentally sensitive areas such as wetlands. Species such as Tall Wheat Grass have been known to spread outside their sown areas and can become weeds.

Implementation mechanisms

The main mechanism to implement the Living with Salt program will be extension. Research and investigation is also important to address some of the key knowledge gaps and barriers to adoption.

Barriers to adoption and knowledge gaps

The key barriers to adoption and knowledge gaps for the Living with Salt program include:

- Current lack of information on types and economics of salt tolerant crops and pastures suited to local conditions;
- Current lack of local agency resources to provide extension advice on salt tolerant crops and pastures;
- The business case for the Government buy back of saline land has not been established;
- The feasibility and economics of aquaculture or desalinisation has not been investigated; and
- The type of salt tolerant crops and pastures used needs to be compatible with adjacent landuses such as wetlands to prevent infestation of inappropriate weeds.

Economic analysis

An economic analysis was conducted for planting Tall Wheat Grass in the target areas described above. The areas to be planted were assumed to be dryland areas on the margins of the irrigated areas for the reasons stated above. The calculations were conducted separately for beef/sheep and dairy landuses. The economic analysis including all assumptions is discussed in SKM (2004d). The results are shown in Table 34.

- **Table 34: Economic analysis of planting Tall Wheat Grass on 45ha/yr for 30 years**

Item	Present value and benefit cost of planting 45 ha/yr over 30 years			
	Dryland beef or sheep enterprise		Dryland dairy enterprise	
	4% discount rate	8% discount rate	4% discount rate	8% discount rate
Benefits				
Agricultural productivity improvement	$ 240,000	$ 130,000	$ 1,900,000	$ 1,000,000
Total benefits	$ 240,000	$ 130,000	$ 1,900,000	$ 1,000,000
Costs				
Establishment	$ 240,000	$ 160,000	$ 240,000	$ 160,000
Fencing	$ 900,000	$ 600,000	$ 900,000	$ 600,000
Agency extension	$ 1,000,000	$ 700,000	$ 1,000,000	$ 700,000
Total costs	$ 2,200,000	$ 1,500,000	$ 2,200,000	$ 1,500,000
Net present value	-$ 1,900,000	-$ 1,300,000	-$ 300,000	-$ 500,000
Benefit cost ratio	0.1	0.1	0.9	0.7

The results of the economic analysis indicate that neither dryland beef/sheep or dryland dairy are likely to be economic to plant Tall Wheat Grass. The results in Table 34 do not include the cost of gypsum. Gypsum is only expected to be required on some paddocks. The results are even more uneconomic if gypsum is required for some areas.

There are other intangible public benefits that can be used to help justify the use of Tall Wheat Grass such as improved aesthetics and reduced saline runoff from saline land. However, the activity needs to be economic from the landowners' perspective to be legitimately recommended in this plan to ensure reasonable uptake rates and that landowners are not economically disadvantaged. The dominance of private benefits over public benefits means that large amounts of Government investment are not justified (eg investment in a financial incentives scheme). However, the small proportion of public benefits does justify investment in research and investigation to find salt tolerant pastures and crops which may be more economic than the Tall Wheat Grass example used in the above tables. This is an area that is receiving significant attention on a State and National scale and there is justification for conducting investigations into possible local applications of new developments in this area.

The economics of alternative uses of saline land and water such as aquaculture have yet to be investigated. However, there may be opportunities to further share the costs of public groundwater control pump operation with private enterprise such as aquaculture that utilise the pumped saline water.

The economics of Government buy back of saline land has not been investigated. Justification would need to demonstrate that:

- the environmental value of the land was worth more than the economic return from agriculture (either rehabilitated or in its current state); and
- the costs of rehabilitating the land in private ownership was greater than the combined purchase, rehabilitation and management costs in public ownership.

In most cases, the above criteria are unlikely to be satisfied. However, in very unusual cases of extremely high environmental value (eg margins of Clydebank Morass), these conditions have the potential to be satisfied.

Recommended actions, prioritisation and management action targets

Recommended actions and projects based on the above discussion are outlined in Table 35.

■ **Table 35: Management actions for 'Living with Salt Program'**

Management options	Potential future actions	Type of project	Benefit-risk score	Overall priority	2004/05^	5 year management actions					5 year Management Action Target	Impact on salinity over 30 years	WGCMA partners
						2005/06	2006/07	2007/08	2008/09	2009/10			
IE. Living with salt													
IE1. Returning land with a reduced watertable into production	**IE1.** Advice to landowners within the area of influence of private and public groundwater control pumps on how to rehabilitate once saline land	Extension	**41**	**Priority 2**							**MAT IE1**: All landowners around operating Groundwater Control Pumps have been provided with advice on rehabilitation of salinity affected land	Production increased from less than 40% to 80% production on salt-affected land	Department of Primary Industries
IE2. Salt tolerant crops and pastures	**IE2.1** Determine appropriate salt tolerant crops and pastures for local area by reviewing previous local trials plus general literature review	Research and Investigation	**37**	**Priority 3**							**MAT IE2:** Review of suitable salt tolerant crops and pastures complete and extension program in place	Production increased from less than 40% to 80% production on salt-affected land	Department of Primary Industries
	IE2.2 Extension of appropriate salt tolerant crops and pastures to farmers in salt affected areas with preference to areas not expected to be affected by other management options	Extension											Department of Primary Industries
IE3. Alternative uses of saline land and water including aquaculture and Govt buy back.	**IE3.** Review alternative uses of saline land and water and implement recommendations	Research and Investigation	**33**	**Priority 4**							**MAT IE3:** Review of alternative uses of saline land and water complete and recommendations implemented	Increased production on saline land	West Gippsland CMA only

^ 2004/2005 management actions are currently being undertaken and were recommended by the draft West Gippsland Salinity Management Plan.

6.4.8 Monitoring, evaluation and reporting

The monitoring, evaluation and reporting program for this plan was guided by the Gippsland Monitoring Evaluation and Reporting Framework (SKM, 2004g). The monitoring, evaluation and reporting component of the salinity plan has a number of key objectives:

- To determine the progress towards the resource condition targets and the aspirational targets;
- To inform investors on the success or otherwise of salinity control works; and
- To allow new programs to develop taking into account previous successes and failures.

The key monitoring, evaluation and reporting activities for the irrigation, dryland and surface water salinity programs are shown in Table 36. Wherever possible, the monitoring of control sites should also be undertaken when determining the effectiveness of management actions or on-ground works.

Table 36: Key monitoring, evaluation and reporting activities for the Irrigation Salinity Management Program

Resource Condition Targets	Timeframe for RCT	Monitoring to determine level of achievement of resource condition targets	Salinity Man. Area	Overall priority	2004/05^	5 year management actions					Evaluation and reporting to determine if resource conditions have been met	WGCMA partners
						2005/06	2006/07	2007/08	2008/09	2009/10		
<2% increase in area of <2m depth to watertable from Jan 2003 levels	16 years	**MAT IF1.1:** Continuation of the current monitoring of over 300 observation bores across the MID and surrounds for water levels and salinity with progressive implementation of recommendations of monitoring review. Continued monitoring of 3 sets of bores in and around Sale	Clydebank	**Priority 1**							**MAT IF1.2:** Yearly depth to watertable maps created for all irrigated Salinity Management Areas using a consistent methodology to allow comparison with previous maps. Maps should be communicated to all stakeholders including the community and government. The annual reporting should also include analysis of climate variability including distinction between depth to watertable changes induced by rainfall changes relative to control options. 5 yearly reports on major spatial and temporal trends in watertable levels and salinity is recommended.	SRW
>11% decrease in area of <2m depth to watertable from Jan 2003 levels	16 years		Nambrok	**Priority 1**								SRW
>7% decrease in area of <2m depth to watertable from Jan 2003 levels	16 years		Heyfield	**Priority 1**								SRW
>23% decrease in area of <2m depth to watertable from Jan 2003 levels	16 years		Maffra	**Priority 1**								SRW
>23% decrease in area of <2m depth to watertable from Jan 2003 levels	16 years		Boisdale	**Priority 1**								SRW
No area of 2m depth to watertable within the Sale urban boundary	15 years		Clydebank	**Priority 1**							**MAT IF1.3:** Creation of an annual depth to watertable map for Sale township and reported to Wellington Shire and the community	SRW, Wellington Shire
>50% reduction in soil salinity around existing and new Groundwater Control Pumps	15 years from pump start date	**MAT IF2.1:** Continuation of program of soil salinity monitoring before pump commencement and at five yearly intervals after pump commencement	Clydebank, Nambrok, Heyfield	**Priority 1**							**MAT IF2.2:** 5 yearly reports on soil salinity around Groundwater Control Pumps is recommended including a clear statement of methodology and comparison with baseline information collected prior to pumping commencement.	SRW, DPI
No net loss of native vegetation	5 years	**MAT IF3:** No monitoring required in addition to that undertaken as part of the West Gippsland Native Vegetation Plan. New vegetation establishment needs to be compared to the areas identified for salinity action (and thereby contributing to the plans goals and a Net Gain in extent and quality), and to the efficacy of the management actions in avoiding, and/or minimising salinity impacts on native vegetation (and how this relates to Net Gain)	All irrigated Salinity Management Areas	**Priority 1**							No additional reporting required for salinity program in addition to reporting conducted for the West Gippsland Native Vegetation Plan	