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CORANGAMITE CATCHMENT MANAGEMENT AUTHORITY

Victoria The Place To Be

Corangamite Salinity Action Plan

Setting resource condition targets.

Background report 9
December 2005

ms&a
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Cover Photo: Lake Cundare, a Ramsar-listed semi-permanent hypersaline wetland, near Cundare (P. Dahlhaus, November 2005)

Executive Summary

This report is the ninth in a series of Background Reports on the development of the Corangamite Salinity Action Plan (SAP) for the Corangamite Catchment Management Authority (CCMA). The SAP is the second-generation salinity plan for the Corangamite region developed with the guidance from the National Action Plan (NAP) for Salinity and Water Quality; Victoria's Salinity Management Framework - Restoring our Catchments; and the Corangamite Regional Catchment Strategy 2003-2008. Each of these documents set broad and challenging targets for management of salinity in the national, state and regional context. A Regional Draft of the Corangamite SAP and six of the Background Reports were published in July 2003 for comment.

The National Framework for Natural Resource Management Standards and Targets provides the principles and requirements for targets which are used to guide the investment in regional salinity management. The framework outlines a minimum set of matters for which regional targets are required, with guidelines and protocols for target-setting, monitoring and reporting. These targets set by the CCMA are considered by the Commonwealth and State as part of the accreditation process prior to investment by governments in the SAP. The targets relate to an absolute improvement in resource condition, or a decrease in the rate of degradation, and are usually expressed as numbers or percentage changes. The targets are categorised into three levels: aspirational targets, achievable resource condition targets, and management action targets.

This report details the revision of the interim Resource Condition Targets (RCTs) set in the Regional Draft SAP (2003). The revision takes into account the most current knowledge in the research, investigations and studies within the Corangamite region. They are considered pragmatic and achievable as required by the National Framework.

The total number of RCTs for SAP target areas reduced from 42 in the Regional Draft SAP, to 37. The revised RCTs can be grouped into four broad categories:

Land salinity – RCTs have been set as no net gain in secondary salinity over 2005 levels in the eight target areas where land salinity has been identified as a threat to assets.

Surface water salinity – these RCTs are set in two categories: ***a)*** a quantitative end-of-valley target for those target areas where there is sufficient data to determine a trend; and ***b)*** a stated action to establish a target for those target areas where more data is required before a trend can be determined.

Aquatic and estuarine ecosystem integrity – two distinct types of RCTs have been set to maintain the integrity of aquatic ecosystems: ***a)*** actions to establish a range for the salinity of specific lakes identified as threatened by increasing or decreasing salinity, and ***b)*** no net loss of primary salinity in target areas where primary saline ephemeral wetlands have been identified as under threat from changed hydrology and salinity.

Infrastructure integrity – RCTs have been set to protect ***a)*** roads in target areas where they have been identified as threatened by salinity, and ***b)*** a reduction in the urban infrastructure at risk in the City of Colac.

The SAP monitoring requirements and research requirements have also been revised, taking into account the completed research, the research underway, the revised RCTs, and the new knowledge and information listed in this report. The recommended monitoring and research programs highlight the need for improved knowledge in high priority salinity target areas before management actions can be formulated.

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1 Introduction

This report is the ninth in a series of background reports on the development of the Corangamite Salinity Action Plan (SAP) for the Corangamite Catchment Management Authority (CCMA). The SAP is the second-generation salinity plan for the Corangamite region, and has been developed with the guidance from:

- The National Action Plan (NAP) for Salinity and Water Quality (CoAG 2001)
- Victoria's Salinity Management Framework - Restoring our Catchments (NRE 2000)
- The Corangamite Regional Catchment Strategy 2003-2008 (CCMA 2003a)

These documents set broad and challenging targets for management of salinity in the national, state and regional context.

The CCMA released a Regional Draft of the SAP in July 2003 (CCMA 2003b) together with six Background Reports and several other technical reports. These documents have detailed the process for the selection of target areas for salinity management, interim resource condition targets, community consultation, management options and targets, benefit-cost analyses, monitoring, and research and development.

Following the implementation of the Regional Draft SAP in 2003, several research and investigation projects have been completed. The knowledge gained through the completion of these projects has provided greater capability to set resource condition targets for the SAP target areas. This report documents the process used in setting those targets.

1.1 Targets

The National Framework for Natural Resource Management Standards and Targets (NRM Ministerial Council, 2003a) provides the principles and requirements for targets which are used to guide the investment in regional salinity management. The framework outlines a minimum set of matters for which regional targets are required, with guidelines and protocols for target-setting, monitoring and reporting. The document states the desired national natural resource outcomes and specifies the minimum set of matters for which the CCMA must set regional targets (Table 1.1).

The targets set by the CCMA (in line with the National Framework) are considered by the Commonwealth and State as part of the accreditation process prior to investment by governments in the SAP. The targets relate to an absolute improvement in resource condition, or a decrease in the rate of degradation, and are usually expressed as numbers or percentage changes. The targets are categorised into three levels: aspirational targets, achievable resource condition targets, and management action targets.

1.1.1 Aspirational target

An aspirational target is a long-term vision or goal about the desired condition of the natural resource in the 50^+ year time frame. These targets should align with the national outcomes listed in Table 1.1 and set the context for the resource condition targets and management action targets.

The aspirational target for the Corangamite SAP was set by the CCMA Sustainable Agriculture and Land Management Implementation Committee (SALMIC), members of the CCMA Board and other invited stakeholders at a workshop held in Colac on May 29th 2003. The workshop participants agreed on the following aspirational target:

Corangamite will - by ongoing measurement, monitoring and experimentation - attempt to sustainably manage the region's salinity impacts.

National Outcomes The national outcomes are aspirational statements about desired national natural resource outcomes	**Matters for which Regional Targets must be set** **Resource Condition Matters for Targets**
1. The impact of salinity on land and water resources is minimised, avoided or reduced. **2.** Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated **3.** Populations of significant species and ecological communities are maintained or rehabilitated. **4.** Ecosystem services and functions are maintained or rehabilitated. **5.** Surface and groundwater quality is maintained or enhanced. **6.** The impact of threatening processes on locations and systems which are critical for conservation of biodiversity, agricultural production, towns, infrastructure and cultural and social values, is avoided or minimised. **7.** Surface water and groundwater is securely allocated for sustainable production purposes and to support human uses and the environment, within the sustainable capacity of the water resource. **8.** Sustainable production systems are developed and management practices are in place, which maintain or rehabilitate biodiversity and ecosystem services, maintain or enhance resource quality, maintain productive capacity and prevent and manage degradation.	**1.** Land salinity. **2.** Soil condition. **3.** Native vegetation communities' integrity. **4.** Inland aquatic ecosystems integrity (rivers and other wetlands). **5.** Estuarine, coastal and marine habitats integrity. **6.** Nutrients in aquatic environments. **7.** Turbidity / suspended particulate matter in aquatic environments. **8.** Surface water salinity in freshwater aquatic environments. **9.** Significant native species and ecological communities. **10.** Ecologically significant invasive species. **Management Action Matters for Targets** **1.** Critical assets identified and protected. **2.** Water allocation plans developed and implemented. **3.** Improved land and water management practices adopted.

Table 1.1 National Outcomes and Minimum Set of Regional Targets

Source: NRM Ministerial Council, 2003a

1.1.2 Achievable resource condition targets

The National Framework defines achievable resource condition targets as "…*specific, timebound and measurable targets, relating largely to resource condition, against the minimum set of matters for regional targets (set out in Table 1). The timeframe for achievement of these targets is likely to be 10-20 years. These targets must be pragmatic and achievable. They would be developed iteratively, including through a benefit/cost analysis. Examples could include: average salinity of X ECs at specific end-of-valley site by year Y; X hectares of specific native vegetation type within region at year Y maintained or regenerated; X stream sites within region in specific river condition category by year Y. Within their regional plans, regional bodies may also wish to set targets for matters that are additional to the minimum set."* (NRM Ministerial Council, 2003a, page 4).

Forty two resource condition targets (RCTs) were set for the CCMA Regional Draft SAP using the best knowledge available at the time (SAP Background Reports 3, 4 & 6). These RCTs were aligned to the National Framework, which was also in development at the time. The RCTs are specific for each SAP target area (Table A1, Appendix A).

1.1.3 Management action targets

Management action targets (MATs) are the short-term (1 – 5 years) targets which relate to salinity management actions or capacity building. These targets contribute to progress towards the longer-term RCTs. The MATs for the CCMA Regional Draft SAP were derived in consultation with the managers of assets which were considered at risk due to salinity (Background Report 4, Nicholson *et al.* 2003). The MATs have since been revised based on the experience of the SAP implementation over the past two years (refer to Background Report 8, Nicholson 2005).

1.2 Indicators and monitoring

The National Natural Resource Management Monitoring and Evaluation Framework (NRM Ministerial Council, 2003b) documents the principles for the monitoring, evaluation and reporting on natural resource condition. The framework also provides a set of indicators for assessing change in resource condition and the performance of the salinity plan.

Although many of the indicators are still under review at the time of writing, the indicators for land salinity and surface water salinity in freshwater aquatic environments have agreed status. That is, these indicators have been fully agreed by the Monitoring and Evaluation Working Group that contains representatives from all jurisdictions. They are awaiting final endorsement by the Natural Resource Management Ministerial Council (NRM website 2005). Others have yet to be finalised.

The relevant salinity indicators and their relationship to the targets are provided in Table 1.2.

Matter for Target	Indicator Heading	Recommended Indicators
Land Salinity	Area of land threatened by shallow or rising water tables	Depth to groundwater *(status: agreed)*
		Groundwater salinity *(status: agreed)*
		Location and size of salt affected areas *(status: agreed)*
Surface Water Salinity in freshwater aquatic environments	In-stream salinity	Total dissolved solids (TDS) + Flow *(status: agreed)* OR Electrical conductivity (EC) + Flow *(status: agreed)*
Inland Aquatic Ecosystems Integrity (Rivers and other Wetlands)	River Condition	Water quality (EC is one parameter)
	Wetland ecosystem extent and distribution	Extent of regionally significant wetlands
	Wetland ecosystem condition	Extent of inundation
Estuarine, coastal and marine habitat integrity	Estuarine, coastal and marine habitat extent and distribution	Salinity

Table 1.2 Recommended indicators to monitor resource condition targets

Source: NRM website 2005

Those indicators with agreed status have documented protocols for monitoring, summarised below:

Depth to groundwater. Monitoring groundwater levels may indicate areas where rising saline groundwater threatens to impact on catchment assets. The type of groundwater flow system provides the context to choosing where (in 3-dimensional space) the groundwater levels should be monitored and the frequency of the monitoring.

Groundwater salinity. Monitoring the salinity of shallow groundwater may indicate if rising water tables will impact on catchment assets. Changes to the salinity of shallow groundwater may also occur in irrigated areas and may impact on baseflow to streams.

Location and size of salt affected areas. The area and severity of salt-affected land should be monitored every 5 to 10 years using geophysics (electromagnetic techniques), aerial photographs or remote sensing, and/or soil surveys. The monitoring may indicate the success or failure of the implementation of salinity management actions.

Total dissolved solids (TDS) + Flow OR Electrical conductivity + Flow. Monitoring stream water salinity and stream flow can indicate if the salinity within a catchment is expanding. Trends in stream water salinity can also indicate if the implementation of salinity management actions has the desired effect.

Some other indicators listed in the National Framework are regarded as relevant to the CCMA SAP but are yet to be agreed by the Monitoring and Evaluation Working Group and approved by the NRM Ministerial Council (NRM website 2005). These relate to wetlands, estuarine and river condition (Table 1.2).

1.3 The relevance of the Precautionary Principle

The Intergovernmental Agreement on the Environment (IGAE) concluded in 1992 between the Commonwealth, States, Territories and representatives of Local Government, sets out a number of principles which the parties agree will inform their decision-making in the environmental context (Spry, 1997). These principles include polluter pays, intergenerational equity and the precautionary principle. The precautionary principle is expressed in the IGAE as follows:

Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, public and private decisions should be guided by:

> *(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
>
> *(ii) an assessment of the risk-weighted options of the various options.*

In short, the precautionary principle states that where the scientific evidence is uncertain, decision-makers should take action to limit continued environmental damage and should err on the side of caution when evaluating proposals that may seriously or irreversibly impact on the environment.

The precautionary principle is relevant in some SAP target areas, where the threat of salinity to high value assets has been identified, but there is little or no scientific evidence to indicate the urgency or magnitude of the impact on the assets. This is particularly the case where increasing or decreasing salinity trends threaten the integrity of aquatic and estuarine ecosystems, and rare animal and plant species, such as those in primary saline areas. In these cases the precautionary principle has been used to justify the need for establishing an RCT, even though the salinity trend and the nature of the threat are currently unknown.

2 Land salinity

Eight of the 12 target areas for salinity management in the Regional Draft SAP have interim RCTs for land salinity (Table 2.1). These interim RCTs were developed to monitor the resource condition related to the assets at risk in those areas, as determined by the target area selection process (documented in Background Reports 2 & 3).

Target area	**Matter for target: Land salinity**	
	Area of land threatened by shallow or rising water tables	
	Primary salinity	**Secondary salinity**
Lismore – Derrinallum		No net gain
Lake Corangamite	Establish risk to ecology	No net gain
Colac - Eurack	Establish risk to ecology	No net gain
Warncoort		No net gain
Murdeduke	Establish risk to ecology	No net gain
Modewarre		No net gain
Geelong – Lake Connewarre	No net loss	No net gain
Lara	No net loss	

Table 2.1 Interim RCTs based on location and size of salt affected areas threatening catchment assets which were set in Regional Draft SAP 2003.

Source: SAP Background Report 6

2.1 New data, research and investigations

The area of land salinised in the Corangamite CMA has been assessed at various times over the past 30 years. The known salinity assessment dates are tabulated below.

Date	Study	Region
1952 - 1958	Cope 1956, 1958	Victorian salinity study. Salinity sites at Barrabool Hills, Berringa, Birregurra, Cressy, Mount Moriac, Murroon, Pitfield, Pittong, Ross Creek, and Winchelsea districts.
1976 - 1980	Duff 1983	Corangamite region except Otways.
1988	Sturmfells 1988	Ballarat region.
1988	Calcutt 1988	Heytesbury region.
1991 - 1992	Scott 1992	Geelong and Bacchus Marsh regions.
1994	Whattam 1995	Heytesbury region.
1999 - 2000	Clark & Hekmeijer, 2004	Survey of state discharge sites at Beeac, Gerangamete, Moriac, Pittong & Wingeel.
2001	Gardiner 2001	15% of mapped salinity in the Corangamite region.
2002	Nicholson *et al.* 2003	Community additions to mapped salinity in Corangamite SAP target areas.
2003	Wagenfeller 2004	Woady Yaloak River catchment: Pittong and Illabarook areas.
2005	Miller *et al.* 2005	Salinity Management Overlay project: Designated growth corridors in Colac Otway, Corangamite, Golden Plains and Surfcoast Shires.

Table 2.2 Known salinity mapping projects in the Corangamite region.

At the time of the development of the Regional Draft SAP (2001- July 2003) the only salinity mapping data available was that provided by Primary Industries Research Victoria (PIRVic). The PIRVic layer had amalgamated the 1976 to 1991 data, and probably includes the 1952 to 1958 data as part of the 1976 to 1980 collection. As a component of the community consultation at the time, additional areas of salinised land were identified by the landholders and these were also captured into the GIS data base (documented in Background Reports 3 & 4).

Since the completion of the Regional Draft SAP, a number of projects have been completed, which add new data, research findings and investigation outcomes to our understanding of land salinity. These are summarised in the following sections.

2.1.1 Salinity mapping (Gardiner 2001)

As part of the review of the success of implementation of the initial Corangamite salinity management plan - *"Restoring the Balance"* (Nicholson *et al.* 1992), a project to reassess 15% of the mapped salinity discharge was undertaken by the Department of Natural Resources and Environment (DNRE), Colac (Gardiner 2001). The project mapped 156 sites, of which 133 were previously mapped and 23 were new additions to the database. The 156 sites represented 17% of the discharge sites mapped at the time. The report was made available in 2005.

The review found that the 2006.6 hectares of land salinity previously mapped had increased 11% to cover 2242.9 hectares. The new additions to the mapped land salinity covered 137.4 hectares in the regions mapped. The severity of the land salinity at the reassessed sites had changed considerably, with a 36% increase in severity 1 (low salinity), 24% decrease in severity 2 and a 0.9% decrease in severity 3 (high salinity).

Gardiner's survey was the first attempt to achieve a statistically significant reassessment of land salinity in the Corangamite region. Although the results are valuable, the timing of the survey – January to March 2001 – was not ideal for the accurate identification of saline vegetation indicators and came at a time when rainfall had been below average for the antecedent 5 years. This highlights the fact that visual monitoring of land salinity is only useful as an indicative measure.

2.1.2 Review of salinity mapping (Pillai et al. 2003)

A review of the salinity mapping in the Corangamite region was commissioned by the SALMIC as part of the 2002-2003 hydrogeology support program. The report (Pillai *et al.* 2003) outlines the history of salinity discharge mapping in the CCMA region, the salinity discharge monitoring program, and makes recommendations in relation to salinity discharge monitoring and data improvement.

The review highlighted that the previously *ad hoc* salinity mapping needs to be more rigorous to comply with the requirements of the RCS and SAP. In particular, the monitoring of land salinity requires an on-going commitment from the CCMA to routinely map and monitor land salinity, improve the data quality, and add emergent sites.

2.1.3 Review of research and investigation (Pillai 2003)

As part of the 2002-2003 hydrogeology support program the SALMIC also requested a summary of the key outcomes and recommendations from salinity research and investigations relevant to the CCMA, that had been completed since the first Corangamite salinity management plan - *"Restoring the Balance"* (Nicholson *et al.* 1992). The resulting report (Pillai 2003) concluded that there had been broad advances in the understanding of the salinity processes which stemmed from the recognition of the complexity of the Corangamite landscapes, the conceptual understanding of the hydrogeology, and limited site-specific numerical models. The report made recommendations on the need for a technical group, peer review of outcomes, knowledge management and communication of results. Three unfinished PIRVic research and investigation programs were highlighted and recommendations made to bring them to completion.

2.1.4 Discharge monitoring (Clark & Hekmeijer 2004)

In August 2004, PIRVic reported on the re-assessment of six discharge sites in the Corangamite region which are part of the Victorian Dryland Salinity Monitoring Network (VDSMN) (Clark & Hekmeijer 2004). A summary of their findings are tabulated below (Table 2.2).

Location	**Beeac**	**Gerangamete agroforestry**	**Gerangamete control**	**Moriac**	**Pittong**	**Wingeel**
Year established	1996	1994	1994	1995	1996	1995
Year reassessed	2000	1999	1999	2000	2000	1999
Change in total salt-affected area	13% decrease	7% increase	25% decrease	7% decrease	8% increase	18% decrease
Change in groundwater levels	~ 1metre lower	0-5 m to 1.5 m lower	stable	~ 0.6 metre lower	Slightly lower	~ 0.4 metre lower

Table 2.2 Summary of discharge monitoring at the six State discharge monitoring reference sites

Source: summarised from Clark & Hekmeijer 2004

The results of the monitoring indicate the difficulty in linking cause and effect at an individual site. As an example, at the Gerangamete agroforestry site, recharge control treatment (planting of tree belts) commenced in 1993. Since that time, the area of land affected by salinity has increased by at least 7% and the groundwater tables have dropped ½ to 1½ metres. During the same period at the control site at Gerangamete, where no treatment has been undertaken, the area of land affected by salinity has decreased 25% and the groundwater levels have remained relatively stable.

Similarly, at the Pittong monitoring site, the area of land affected by salinity has increased 8% over the period from 1996 to 2000, while the groundwater levels had dropped slightly over the same period. This phenomenon has been verified by the landholders in the SAP target area who have witnessed new salinity discharge sites emerge in the past five years (Figure 2.1).

Figure 2.1 A salinity discharge site that has emerged in the Pittong landscape since 2000.

2.1.5 SGSL site characterisation (Church 2004)

Research completed by the University of Ballarat (Church 2004) characterised three sites in the Woady Yaloak River catchment chosen for the Sustainable Grazing of Saline Lands (SGSL) project. The sites are located at Mt Mercer, Illabarook and Pittong, in the Illabarook and Pittong SAP target areas respectively. Characterisation of the sites included soil salinity analysis, geophysical surveys and water salinity measurement. The research confirmed that wash-off from the areas of salt-affected land is a major contributor of salt to the Woady Yaloak River at these sites.

The study sites were intended to be regularly monitored as catchment health sites in the Corangamite SAP, however since their initial characterisation, monitoring has lapsed.

2.1.6 Bore database (Dahlhaus et al. 2004)

Following the creation of a CCMA groundwater bore monitoring database for the SAP (Nolan-ITU 2003), the CCMA commissioned the University of Ballarat to undertake a review of groundwater monitoring. The review reconstructed the groundwater database, physically checked the majority of groundwater bores constructed under the CCMA salinity program, cleaned the bore data records and identified the bores available for groundwater monitoring (Dahlhaus *et al.* 2004). The research found that of the 9260 bores in the CCMA database, 956 have a groundwater level monitoring record.

The research identified that 519 of the 580 salinity monitoring bores that were believed to have been constructed in the first decade of salinity management in the Corangamite CMA region were registered on the government databases. Of these, a field checking program located 409 bores, with the remaining 110 consisting of 42 bores that could not be located with the information available, 62 that apparently did not exist at all in the area of their stated location (based on landholder information), and 6 that were located but their identity could not be determined. Of the 409 bores field checked, 75 (19%) had broken standpipes, with 52 (13%) broken at or below ground level and 23 (6%) broken above ground level. The field checking measured 266 bores shallower than recorded (most probably due to silting) and 81 bores deeper than recorded.

A number of recommendations were made to improve the groundwater bore monitoring database, continue monitoring the network, evaluate the monitoring network, and enhance the network.

2.1.7 Target setting – Glenelg Hopkins SAP (Smitt et al. 2004)

In 2003-2004 CSIRO commenced a project for the Glenelg Hopkins Catchment Management Authority (GHCMA) to develop resource condition targets for the GHCMA Salinity Plan (Smitt *et al.* 2004; 2005; Cox *et al.* 2005) To determine land salinity targets, the project used two main tools:

- Development of conceptual hydrogeological models for cross sections across the base level sub-catchments where assets are at risk of salinity and estimation of hydrogeological parameters needed for the groundwater modelling, and
- Groundwater modelling using FLOWTUBE to determine whether land management changes will protect the assets at risk of salinisation.

The outcomes of the models showed that reduction in the area of land salinised using recharge control was highly dependent on the hydrogeological processes operating within the sub-catchment. In some sub-catchments reduction in land salinity can only partly be achieved with recharge control, whereas in others, it would be highly successful. However, the outcomes of the modelling have not yet been used to set RCTs for the GHCMA Salinity Plan (Anderson 2005).

2.1.8 Recharge mapping (Dahlhaus 2005a)

Recharge mapping at an appropriate strategic planning scale was completed for the three SAP target areas where recharge management is considered a priority (Dahlhaus 2005a). The recharge maps indicate higher priority recharge control areas where replanting vegetation and rehabilitation of degraded areas can provide multiple benefits such as reducing land salinity, improving water quality, reducing soil erosion, and controlling infestations of pest plants and animals. In the immediate term the management of saline groundwater discharge sites can provide the greatest gain in reducing salt wash-off and improve water quality.

2.1.9 Pittong salinity management (Dahlhaus 2005b)

In 2004-2005 extensive investigations for a property-scale salinity management program was commenced in the Pittong SAP target area (Dahlhaus 2005b). The investigations further developed the existing conceptual model for land salinisation in the area and confirmed that the area of salt-affected land continues to increase. The source of the salinity is the spring discharge of regional groundwater, the source of which is outside of the CCMA region. This increase in discharge area and salt wash-off is a contributor to the rising salinity in the Woady Yaloak River.

Geophysical surveys, soil salinity analysis and interpretation of the results within the context of the conceptual model have formed the basis of property-scale salinity management plans. The plans have been developed in consultation with the landholders and a schedule of works derived for each property. The salinity management will continue within the area over the next few years.

2.1.10 Depth to watertable models (SKM 2005)

In late 2005 a state-wide re-evaluation of the depth to groundwater maps and predictions were completed by Sinclair Knight Merz (SKM) for the National Land and Water Resources Audit (the Audit). The predictions in the initial Audit (NLWRA 2001) were dire and had been based on coarse resolution data available at the time. Since then, finer resolution digital elevation models had become available and the predicted depth to watertable models were regenerated using a different interpolation algorithm (Peterson *et al.* 2003; Peterson & Barnett 2004). The resulting numerical surfaces show considerably less area predicted to experience shallow watertables in 2050 than previously predicted (Figure 2.2).

2.1.11 Salinity mapping protocols (Clark & Allan 2005)

In June 2005 PIRVic released a report detailing the standards and procedures for collecting data at the salinity monitoring site network in Victoria (Clark & Allan 2005). The report outlines the methods for assessing land salinity using electromagnetic induction, vegetation assessment and soil sampling, based on the PIRVic method developed over the past decade. The documented method will probably be adopted as the *de facto* standard for monitoring land salinity in all CMAs, with the advantage of the results being directly comparable across the State.

2.1.12 Salinity mapping (Miller et al., pending)

Salinity mapping commenced in 2005 in a program aimed at protecting urban developments from the threat of secondary salinity. The mapping, carried out by DPI, relates to MAT number 70 in the CCMA RCS, viz: *"By 2005, develop baseline mapping on all urban salinity. Provide this information to local government and other asset managers."* The MAT relates to two RCTs in the RCS that were set in relation to the threat of land salinity in the urban environment.

Mapping commenced in October 2005 and approximately 1300 saline sites were examined. Of these, approximately 500 sites were accurately mapped by 16 individual assessors, each using handheld GPS. The mapping was based solely on vegetation indicators, using one of the standard salinity mapping methods developed by PIRVic (Clark & Allan 2005). Parameters recorded were the severity rating (i.e. the percentage of the site affected by low, medium, high or severe salinity) and the type of salinity (natural, induced or a combination of both). Additional mapping was completed using classic stereo photogrammetric techniques to assess recent aerial photos.

In the areas assessed within the Corangamite CMA, the 2005 project mapped 548 polygons of salinised land totalling 5160.4 hectares. This represents an increase of 49% in the area of land salinity from the previous number of 282 polygons totalling 3456.0 hectares. The 2005 mapping categorised 844.3 hectares of secondary salinity (139 polygons), 957.5 hectares (91 polygons) of primary salinity, 3316 hectares (133 polygons) of primary and secondary salinity, with the remaining 42.6 hectares (5 polygons) not categorised.

2.1.13 Bore monitoring review (Dahlhaus et al., pending)

As an extension to the groundwater monitoring bore database project (Dahlhaus *et al.* 2004), the University of Ballarat is currently completing a review of the monitoring bores across the CCMA region. The review will determine which bores are priority bores for monitoring watertable fluctuations and salinity, and which are no longer useful.

Preliminary results of the bore monitoring review indicate that the quality of the salinity bore monitoring network is generally very poor, with little useful data recorded for most bores and piezometers that were installed over the past 15 years.

2.2 Revised RCTs for land salinity

The RCTs relating to land salinity which are currently stated in the Regional Draft SAP (Table 2.1) require revision to conform to the agreed status of indicators for matters for target (Table 1.3), and take into account the additional knowledge learned over the past three years.

2.2.1 Depth to groundwater

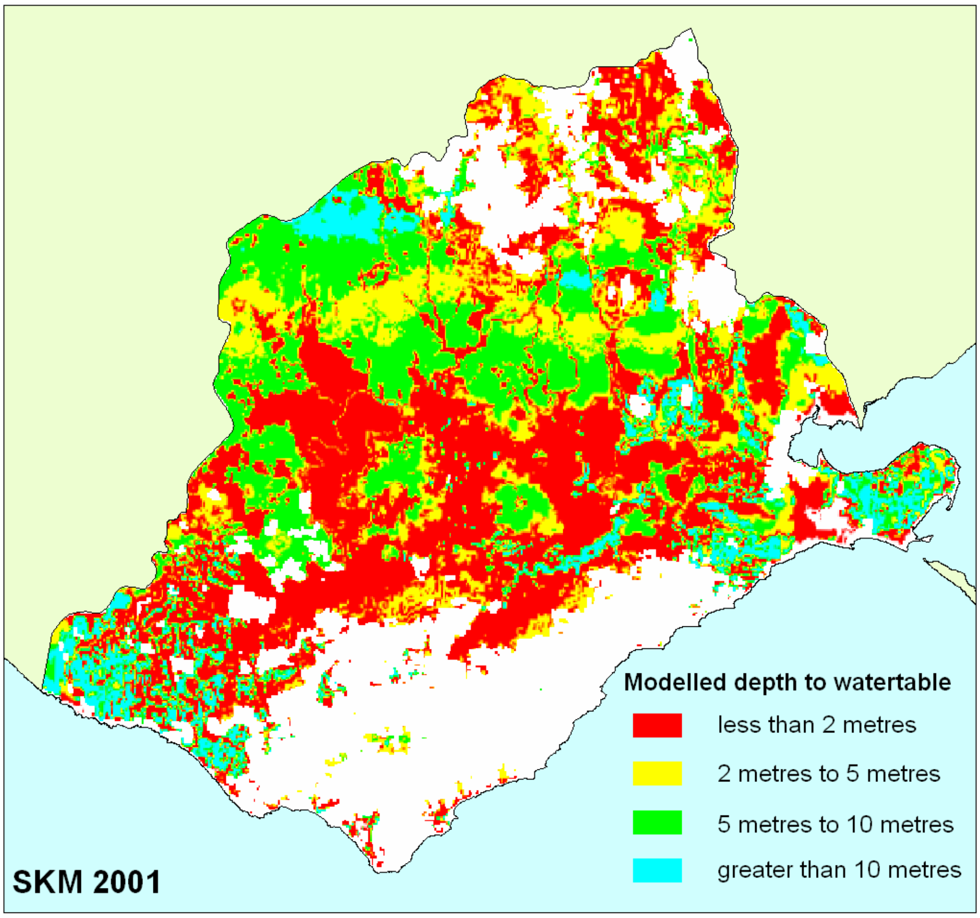
The recent evaluation of the Audit predictions by SKM included maps of rising or falling trends in the watertable (Figure 2.3). The rising trends are shown in the Upper West Moorabool, Illabarook, and Murdeduke SAP target areas, and in the Heytesbury, Ross Plain and Gerangamete regions. Both the reliability diagram (Figure 2.3 - top left) and an inspection of the data used to create the numerical surfaces indicate that the trend shown for the Heytesbury is probably an artefact of the modelling process.

In the Corangamite region, the relationship between widespread land-use change, groundwater fluctuations, and salinity processes is not as straightforward as in other regions of Australia. It is apparent that salinity has been a feature of the region for millennia and that groundwater tables have not changed significantly in some areas (Dahlhaus & Cox 2005). For example, despite the strongly rising trends shown in the SKM model, the current groundwater levels in the Upper West Moorabool are, on average, several metres below the water levels measured in 1870. In this region the water table fluctuates significantly in response to irrigation using groundwater and the SKM model may be misinterpreting aquifer recovery as rising water tables.

In addition it is clear that the relationship between the monitored water tables and the area of land salinised is poorly understood in some regions. Of the six monitored discharge sites, three show relationships which are contrary to that which is normally assumed (Table 2.2). This may be because the groundwater table being monitored has little or no relationship to the salinity process (e.g. Pittong), or that surface water movement and climate trends have a greater impact on land salinity than groundwater levels (e.g. Gerangamete).

Setting RCTs for groundwater levels is considered inappropriate given the current knowledge regarding the complexity of the salinity processes, the complexity of interactions between groundwater flow systems, the conflicting knowledge on water table trends, and the poor quality of data on monitoring bore construction. Nevertheless, it is essential to continue monitoring groundwater levels and improving the quality of the bore monitoring data to the point where it will be possible to establish RCTs in areas where the relationship is proven.

Monitoring of the groundwater is particularly important in the Lake Corangamite SAP target area, if the CCMA Board adopt the recommendations of the Drainage Scheme Review (GHD 2004). This review recommends that the level of water in Lake Corangamite be allowed to rise to 118 metres AHD by 2009. The increase in lake levels will also cause a rise in groundwater levels around the lake and new areas of secondary salinity may emerge.



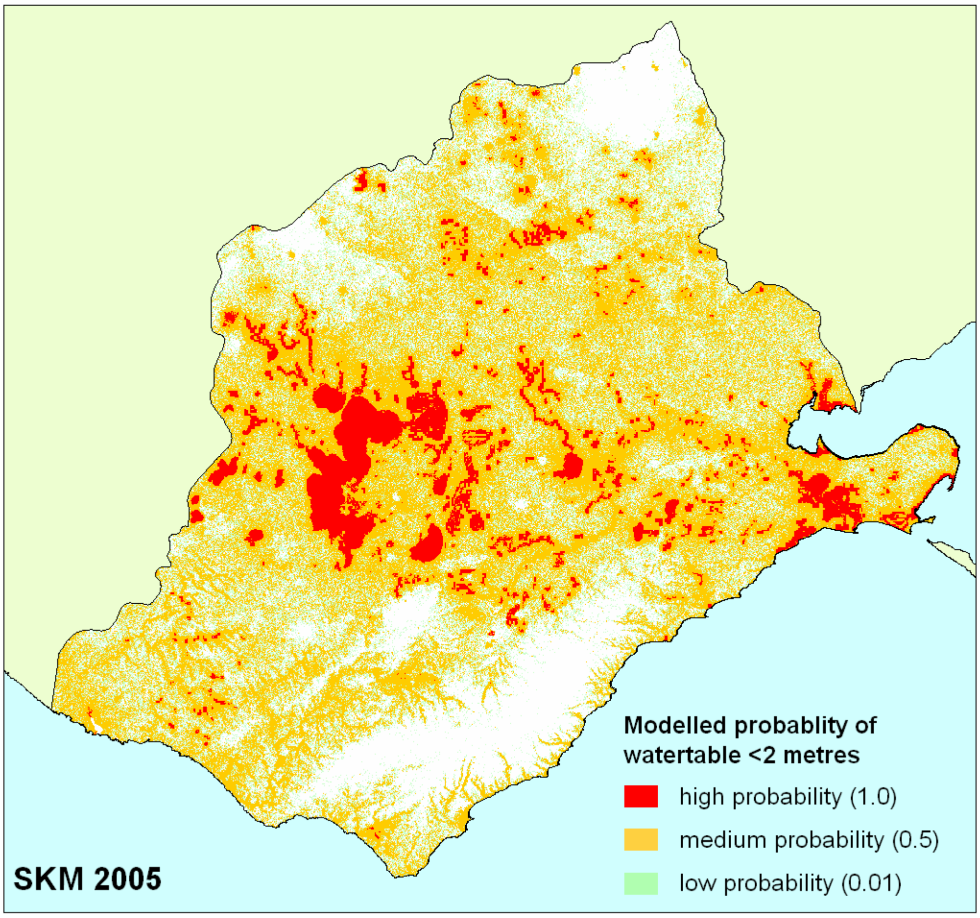


Figure 2.2 The 2001 prediction for 2050 (worst case) compared to 2005 prediction for 2050.

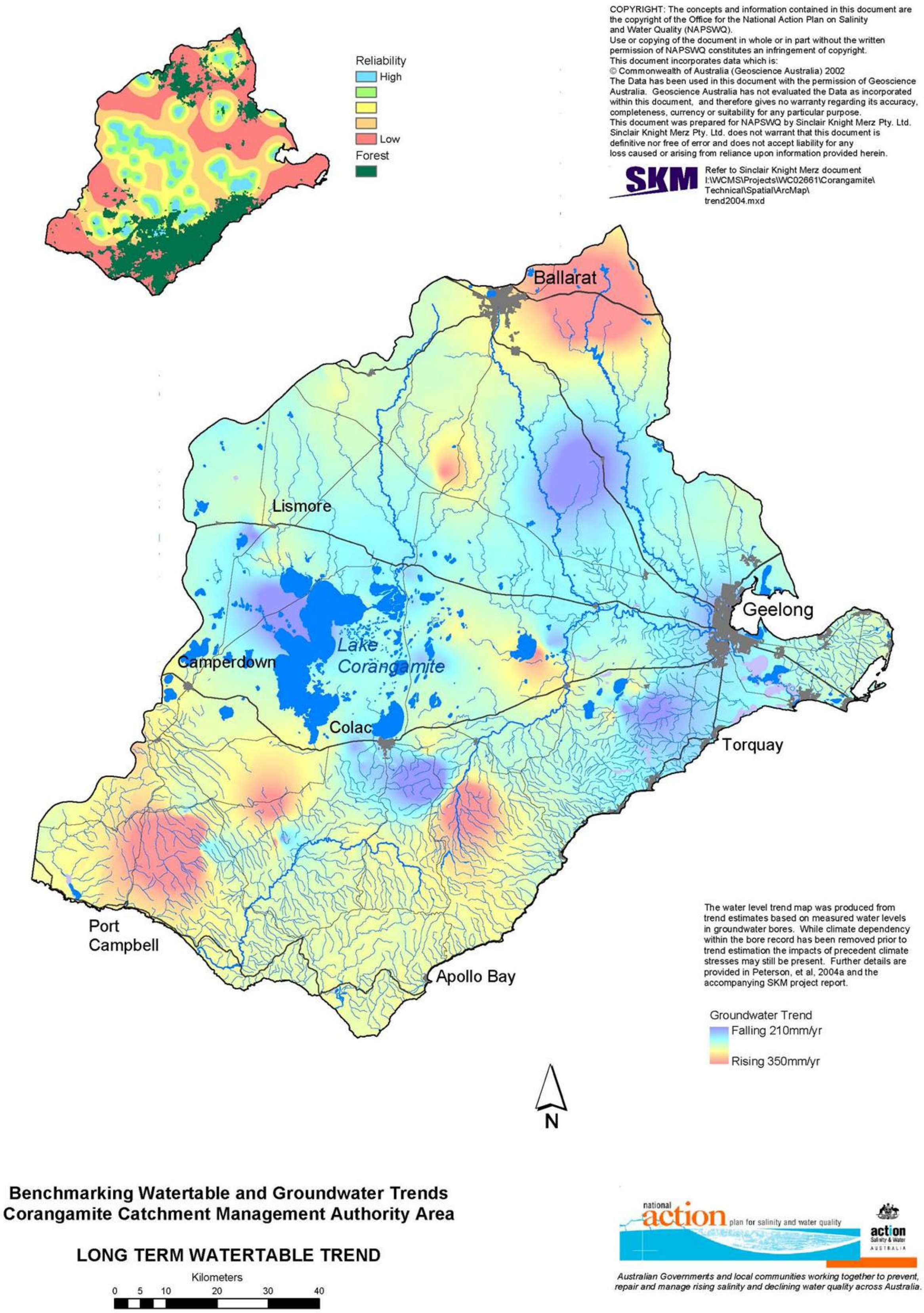


Figure 2.3 Long-term watertable trend (SKM 2005)

2.2.2 Groundwater salinity

There is insufficient data to establish any trends on changes to the salinity of groundwater over time. Very few bores have more than one salinity measurement recorded, and less than ten have more than two measurements. However, because groundwater salinity is now an agreed indicator, monitoring groundwater salinity on a regular basis should be commenced.

Given the paucity of data, RCTs cannot yet be set for this indicator.

2.2.3 Location and size of salt affected areas

The research and investigations over the past three years clearly indicate that the area of land salinised is increasing in some areas of the Corangamite region. This expansion has been variously quantified as 11% based on the remapping of 15% of known land salinity (Gardiner 2001); and 8% at Pittong, and 7% at Gerangamete (treated site) based on the discharge monitoring program (Clark & Hekmeijer 2004). At the same time, the discharge monitoring program measured a decrease in area of land salinised of 25% at Gerangamete (control site), 18% at Wingeel, 13% at Beeac and 7% at Moriac. The latest 2005 mapping for the municipal salinity management overlays (Miller *et al., in prep*) records an increase of 49% from the previous mapping.

Given the database and quality of land salinity mapping, there is some opportunity to set RCTs for the target areas where appropriate. The "no net gain" RCT for secondary salinity remains appropriate for the Colac-Eurack, Geelong-Lake Connewarre, Lake Corangamite, Lismore-Derrinallum, Modewarre, Murdeduke, and Warncoort as currently stated. The 2005 mapping now provides a suitable benchmark to measure from.

For the Pittong SAP target area, an RCT is appropriate because the area of land salinity is obviously expanding (Clark & Hekmeijer 2004; Dahlhaus 2005). This expansion in secondary salinity increases the area for salt wash-off and increases the salt export to the Woady Yaloak River and Lake Corangamite. An appropriate RCT would be:

- By 2015, there is no net increase in the area of land salinity in the Pittong target area (compared to the area in 2005).

Because salinity in the Pittong target area is increasing, this RCT is quite challenging. However, since salinity management targeted at reducing the area of land salinised is currently being implemented, the RCT is considered both pragmatic and achievable.

For the Lara SAP target area, the strategic and high value asset of Avalon airport is among those threatened by secondary salinity. However, since there is no recorded data or evidence to indicate an increasing trend in the area of secondary salinity, and the only monitored bore in the area shows falling watertable trends, setting an RCT cannot be justified at this stage.

In many cases, land salinity has been recognised as being primary in origin and therefore may constitute an asset in its own right, especially where the indigenous flora and fauna remain intact. Establishing RCTs land salinity which is recognised as primary salinity is discussed under the maintaining the integrity of inland aquatic ecosystems (Section 4.2).

An RCT for the area of land salinity within the City of Colac urban has also been set to ensure the integrity of urban infrastructure (refer to Section 5.3).

3 Surface water salinity

In the Regional Draft SAP, interim RCTs for surface water salinity are recommended for all SAP target areas except Murdeduke and Lara. However, some of these salinity RCTs are directly related to maintaining the integrity of saline ecosystems and will be discussed in the next section.

In the Regional Draft SAP, the interim RCTs related to maintaining surface water quality related to urban use, irrigation or environmental quality, are those listed as 2, 3, 5, 6, 8, 10, 11, 12, 15, 17, 22, 27, 35, 36 & 40 in Table A1 (Appendix A).

3.1 New data, research and investigations

Since the completion of the Regional Draft SAP, a number of research and investigation projects have been completed that contribute to the knowledge regarding surface water salinity. These projects are summarised in the following sections.

3.1.1 Review of diversion and drainage schemes (GHD 2004)

A review of the Woady Yaloak Diversion Scheme and the Lough Calvert Drainage Schemes was undertaken as one of the major investigation projects in the NAP foundation year. The review was completed in December 2003 (GHD 2003) and a draft summary document for public comment was released a year later (GHD 2004). The draft summary recommends no change in the operation of the Lough Calvert scheme for the next three years (Option L1). This recommendation is based on the lack of data due to the scheme not operating for the past 7 years because of the dry period.

However, the draft summary (GHD 2004) recommends implementing changes for the Woady Yaloak Diversion Scheme as follows:

- Continue operating the scheme under the current rules until June 2006;
- Implement Option 4b from July 2006 to June 2009. Option 4b is to close 25% of the Woady Yaloak Diversion Scheme from July 2006 to June 2009 and target a rise in the level of Lake Corangamite to 115.28 m. AHD. The diversion channel operates only when the Lake exceeds 115.28 m AHD;
- Implement Option 6 in July 2009. Option 6 is to close the Woady Yaloak Diversion Scheme in July 2009 and purchase all private land up to 118.1m AHD. Maintain the current diversion channel and infrastructure to a bare minimum to be used whenever Lake Corangamite reaches higher levels.

Under this scenario the salinity outcomes they predict are:

- For Option 4b (July 2006 to June 2009): A salinity of 50,000 EC_{25} in Lake Corangamite will be exceeded 55% of the time (50,000 EC_{25} salinity is near the tolerance limit of most life living in the lake), and the average monthly salinity of the Barwon River at Pollocksford = 1,650 EC_{25} (range 1,450 to 2,010 EC_{25}).

- For Option 6 (post July 2009): A salinity of 50,000 EC_{25} in Lake Corangamite will be exceeded 30% of the time (50,000 EC_{25} salinity is near the tolerance limit of most life living in the lake), and the average monthly salinity of the Barwon River at Pollocksford = 1,590 EC_{25} (range 1,380 to 1,970 EC_{25}).

The GHD study did not consider the impact of the higher water levels in Lake Corangamite and Cundare Pool on the regional groundwater tables and potential impact of salinity of the surrounding assets (i.e. agricultural land, groundwater resources in the Warrion Groundwater Management Area; roads and utilities; and cultural and heritage assets). If the CCMA Board adopts the recommendations, these impacts would need to be modelled, and the asset managers consulted. The consequences are that additional RCTs and MATs for the SAP may be required.

For the Lough Calvert Drainage Scheme the GHD study ranked their recommended Option L1 as zero risk to the environment. However the Regional Draft SAP has identified a current salinity risk to the Lough Calvert environmental and agricultural assets (Background Reports 2 & 3). In particular, the threat to the Upper, Middle, and Lower Lough Calvert and Lake Thurrumbong and the groundwater dependant ecosystems (GDEs) is nationally recognised (Clifton & Evans 2001) and may result in increasing salinisation of these wetlands as fresh water is diverted by the drainage scheme (when it operates). The current declining trend in groundwater levels is also recognised as a threat to the GDEs, whereas the rising regional groundwater levels associated with changes to the Woady Yaloak Scheme may also significantly impact on GDEs in the future. These scenarios would need to be modelled and would result in setting appropriate RCTs and then MATs in consultation with the asset managers.

3.1.2 Moorabool River study (SKM 2004)

The second major investigation funded in the NAP foundation year was a study of the water resources in the Moorabool River (SKM 2004). The SKM investigation has short-listed 10 options for improving flows in the Moorabool River. The options were ranked according to the following criteria:

- Impact on security of supply;
- Environmental costs and benefits;
- Socio-economic costs and benefits;
- Financial costs and benefits.

It should be noted that salinity was not a major criterion in the weightings.

The options are ranked as follows:

Option		Average Ranking
23	Farm dams to pass summer flows	1
27	Reallocation from savings due to demand management across all consumptive users other than the environment	3
3a	Find an augmentation option for Ballarat and get back part of Moorabool or Lal Lal Reservoir: from bores west of Ballarat	3
25	Encourage conjunctive use	4.5
2	Connect Barwon Water to the Upper Werribee system and buy/trade back some of their share of Lal Lal	4.5
28	Environmental water allocation	6.5
	Base Case	7.5
8	Buy back licences / sleepers	8
26	Potable water substitution for Ballarat	8
1	Enhance flows passed downstream from major storages (environmental flows)	9.5
20	Transfer Ballarat South recycled water into the Moorabool Basin	10.5

Table 3.1 Evaluated options to enhance environmental flows in the Moorabool River

The key conclusions were:

- None of the options assessed can maintain security of supply at the current level
- All options have high financial cost
- There is no clearly favourable option to supply environmental flows

The report made a number of recommendations for further investigations and studies.

Naturally, all of the options being considered have implications for the salinity threat to the major assets (i.e. urban water quality) considered in the Regional Draft SAP. However, given that there is no single recommended option, it is assumed that any decisions on the future of the Moorabool River will be delayed until after the SAP is finalised.

As indicated in the Regional Draft SAP, until such time as the cause of the rising trend in salinity of the Moorabool River is known, salinity management actions for the Upper West Moorabool target area cannot be formulated. Likewise, the current tree planting in the Morrisons-Sheoaks target area will not prevent, stabilise or reverse the rising trend (although it will assist).

3.1.3 Benchmarking catchments (SKM 2005)

A study to benchmark saline flows in key rivers and streams for resource condition target development analysed all available stream salinity data for the major basins in the CCMA area (SKM 2005). Key findings were that the existing salinity monitoring provides an invaluable resource for resource condition target setting (RCT) and location of end of valley (EoV) locations, although gaps exist in some areas that prevent the development of resource condition targets.

The report makes a series of recommendations based on an analysis of the existing gauging station data for the Corangamite CMA region. These are listed below (Table 3.2):

Recommendations for SAP target areas
Establish hydrographic monitoring station in Naringhil Creek below the Pittong target area (high priority)
Review and investigate the need for a monitoring station upstream of Lake Tooliorook (moderate priority)
Review and investigate the need for a monitoring station upstream of Lake Beeac and Lough Calvert (moderate priority)
Review and investigate the need for a monitoring station upstream of Lake Modewarre, Gherang Swamp and Browns Swamp (moderate priority)
Upgrade Lal Lal Creek gauge upstream of Bungal Dam (232213) to incorporate salinity monitoring (low priority)
Investigate the reasons for the poor quality salinity record at West Moorabool River gauge at Lal Lal (low priority)
Upgrade Tea-Tree Creek gauge at Morrisons (232240) to collect hydrographic data (low priority)
Re-establish salinity monitoring at downstream end of West and East branches of the Moorabool River (low priority)
Review and investigate the need for salinity monitoring at Sheoaks Weir (low priority)
Investigate the reasons for the poor quality salinity data of the Thompson Creek gauge at Ghazeepore (235255) (low priority)
Review and investigate the need for salinity monitoring of the Barwon River downstream of Geelong (low priority)
Recommendations for "end-of-valley" type points
Establish a salinity and hydrographic monitoring station on the Curdies River at the downstream end (high priority)
Adopt Mia Mia Creek gauge upstream of Lake Murdeduke (233251) as an EoV monitoring point, and review and investigate the need for a salinity monitoring station at the downstream end of the Warrambine Creek (moderate priority)
Review and investigate the need for salinity monitoring of the Barwon River downstream of Geelong (low priority)
Further recommendations
Review the salinity monitoring network at a later date to re-evaluate monitoring needs

Table 3.2 Summary of recommendations taken from the Benchmarking Catchments study

Source: SKM 2005

The recommendations were based on an examination of the data available for the setting the RCTs listed in the Regional Draft SAP (Appendix A) and the Corangamite Draft River Health Strategy (CCMA 2004).

3.1.4 Index of Stream Condition – 2nd benchmark (DSE 2005)

The second state-wide survey of the Index of Stream Condition was conducted in 2004, following from the initial assessment in 1999. The report on the findings was released in August 2005 (DSE 2005) and confirmed that the rivers in the Moorabool, Barwon and Corangamite Drainage Basins are among the most stressed rivers in Victoria. Based on the percentage of the river reaches assessed as being in poor and very poor condition, the Moorabool River Basin ranks third worst in Victoria, behind the Hopkins and Loddon River Basins.

The comparative rankings of the four river basins in the Corangamite CMA region are tabulated overpage (Table 3.3).

River basin	Stream condition (% length)				
	Excellent	Good	Moderate	Poor	Very poor
Moorabool		3	42	32	23
Barwon	2	1	54	27	15
Corangamite		5	48	43	4
Otway	24	16	53	5	1

Table 3.3 Results of the 2nd ISC for the Corangamite region river basins, 2004

Source: DSE 2005

3.1.5 Stream salinity trend analysis (CSIRO 2003, 2005)

Limited analysis of stream salinity was included in the development of the Regional Draft SAP in 2003, as part of the assessment of threat to water quality (Background Report 3). Initially the salinity trends in the major rivers were used to determine the SAP target areas. Trend analysis on all rivers and streams with a record of salinity measurement was completed at a later date[1] (CSIRO, unpublished data, 2003). The results are tabulated in Appendix B.

The trend analyses obtain stream salinity trends that are independent of fluctuations in flow and season, and hence are indicative of the impacts of saline groundwater inflows caused by catchment salinisation. A semi-parametric statistical method based on the Generalised Additive Model (GAM) approach was used (Morton, 1997). Although the method corrects for flow and seasonal effects, the analyses do not account for longer term climate variations, such as a run of wet years or a run of dry years.

The length of record varies for the gauging stations within the Corangamite region. The EC measurements for most gauges commence from the late 1970s, but several have since ceased monitoring that parameter. Nevertheless, all available EC data were used to determine the trends. Obvious outliers, caused be erroneous flow or EC values, were identified by high residual values and were removed from the data set and the trends recalculated.

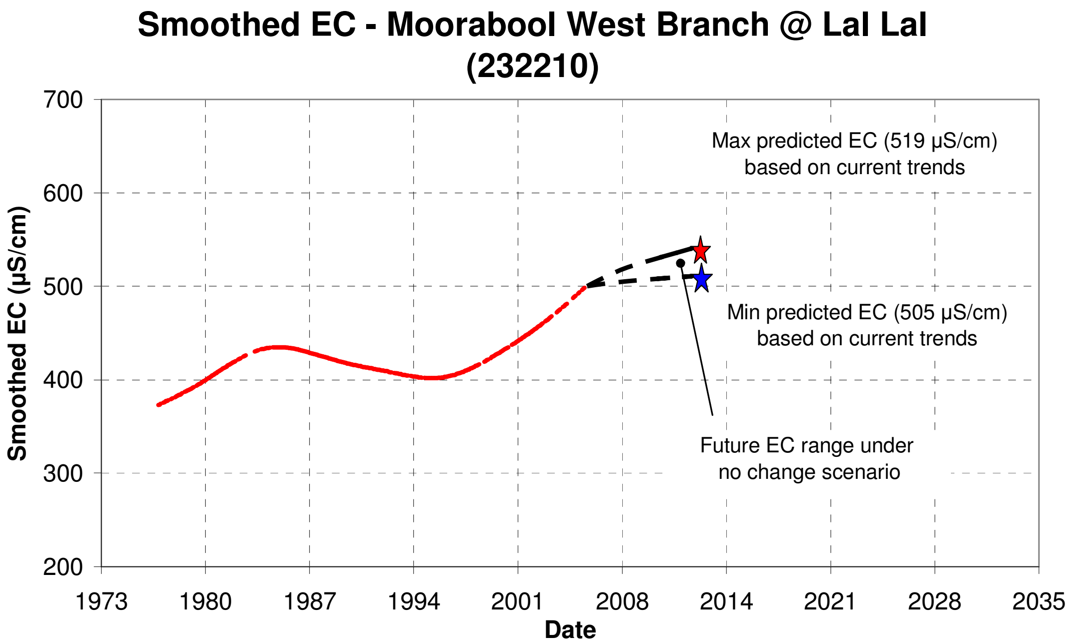
The trend analysis for the rivers which have been identified in the Regional Draft SAP as requiring RCTs has recently been updated to include the last four years of data (CSIRO, unpublished data, 2005). The statistical analysis (Figures 3.1 to 3.6) provides:

- A linear trend for EC, averaged over the period of gauging station record
- A non-linear trend showing the variation in EC with time, which includes a forecast of future trends based on the statistical analysis
- An exceedence curve showing the percentage of time that the stream water exceeds any given EC value

[1] Following the completion of the Regional Draft SAP, in July 2003.

Gauge 232210 - Moorabool River West Branch at Lal Lal

Start date:	December 1976		
End data:	February 2005		
No of samples:	319		
Mean flow:	22 Megalitres/day		
EC:	Mean 421 µS/cm	Highest 2600 µS/cm	Lowest 160 µS/cm
Mean salt load:	5 tonnes/day		
Linear EC trend:	1.0 ± 1.9 µS/cm/yr		



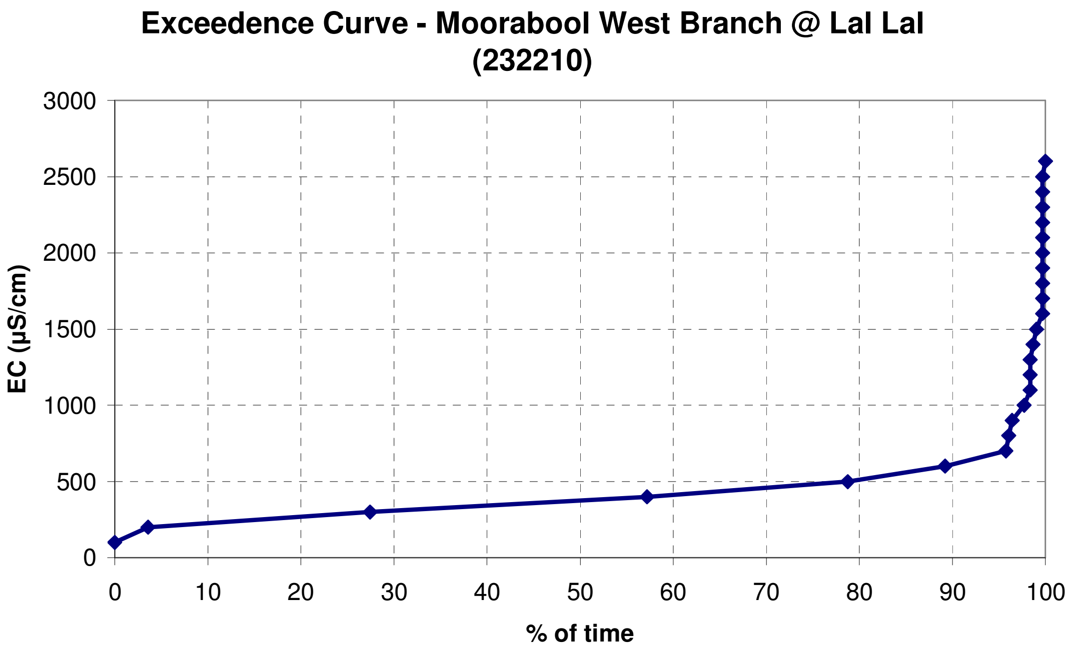
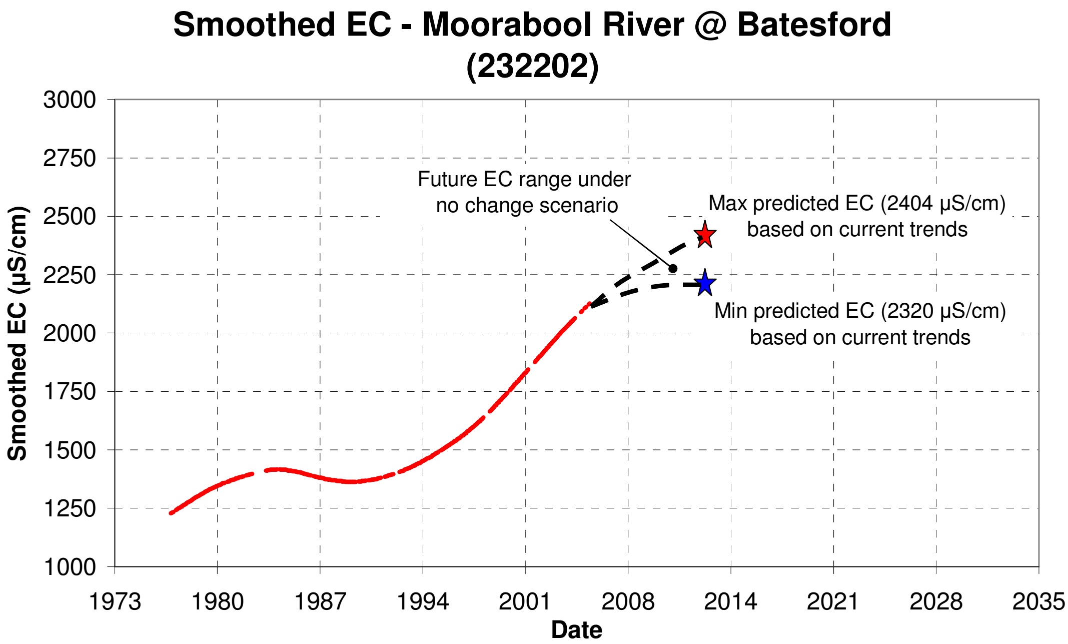


Figure 3.1 Statistical analysis of stream salinity for West Moorabool at Lal Lal (1976-2005)

Gauge 232202 - Moorabool River at Batesford

Start date:	November 1976		
End data:	February 2005		
No of samples:	312		
Mean flow:	89 Megalitres/day		
EC:	Mean 1521 µS/cm	Highest 4000 µS/cm	Lowest 340 µS/cm
Mean salt load:	81 tonnes/day		
Linear EC trend:	23.7 ± 6.0 µS/cm/yr		



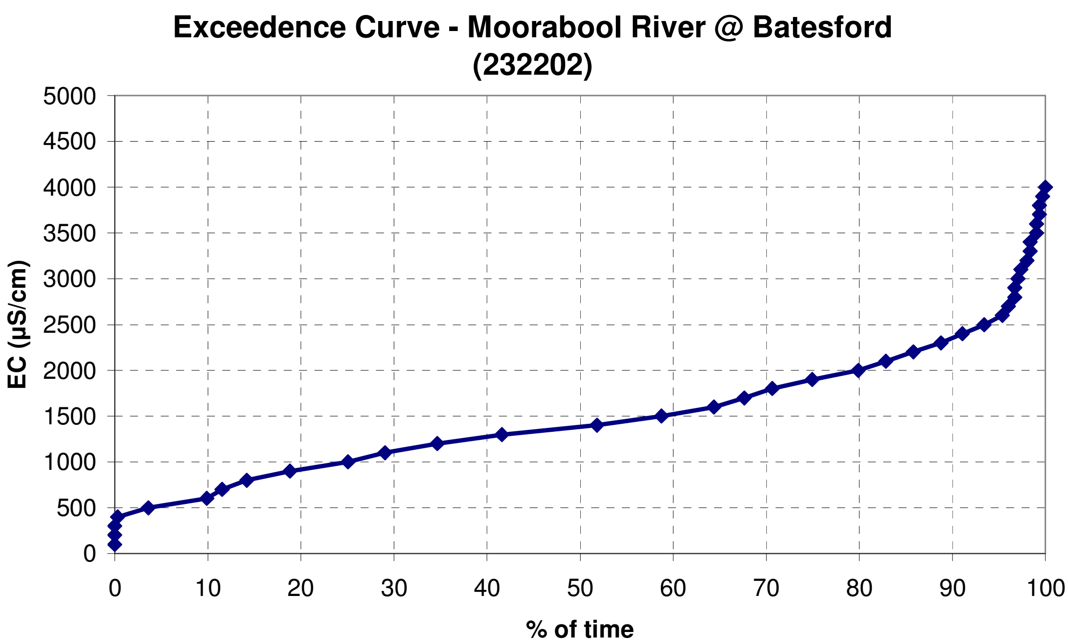
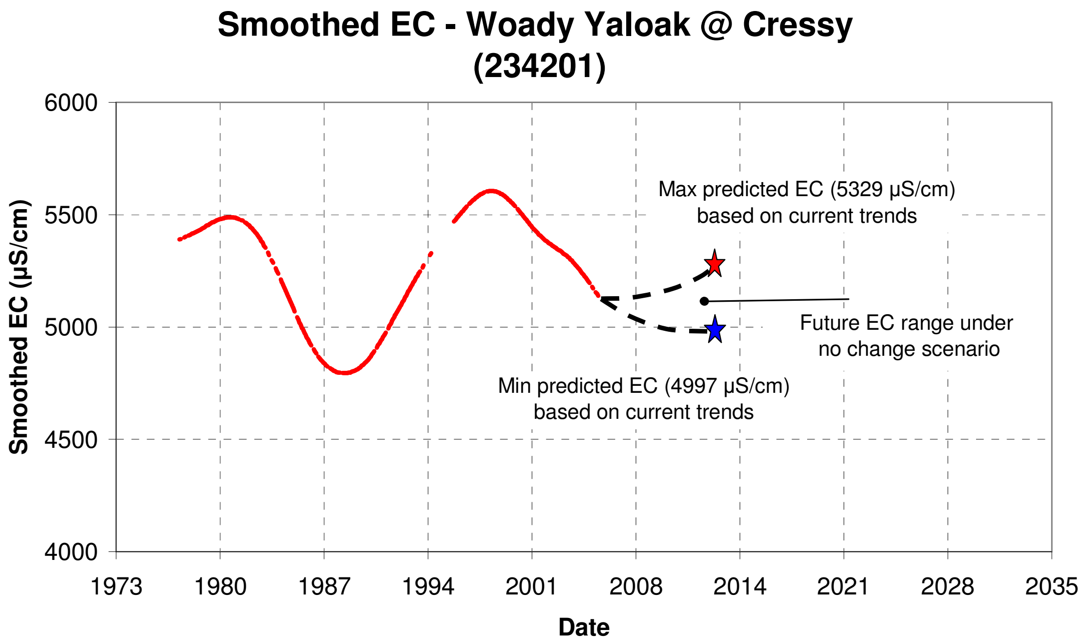


Figure 3.2 Statistical analysis of stream salinity for the Moorabool at Batesford (1976-2005)

Gauge 234201 – Woady Yaloak River at Cressy

Start date:	November 1976		
End data:	February 2005		
No of samples:	308		
Mean flow:	77 Megalitres/day		
EC:	Mean 5265 µS/cm	Highest 10500 µS/cm	Lowest 620 µS/cm
Mean salt load:	242 tonnes/day		
Linear EC trend:	3.4 ± 23.7 µS/cm/yr (i.e. not statistically significant)		



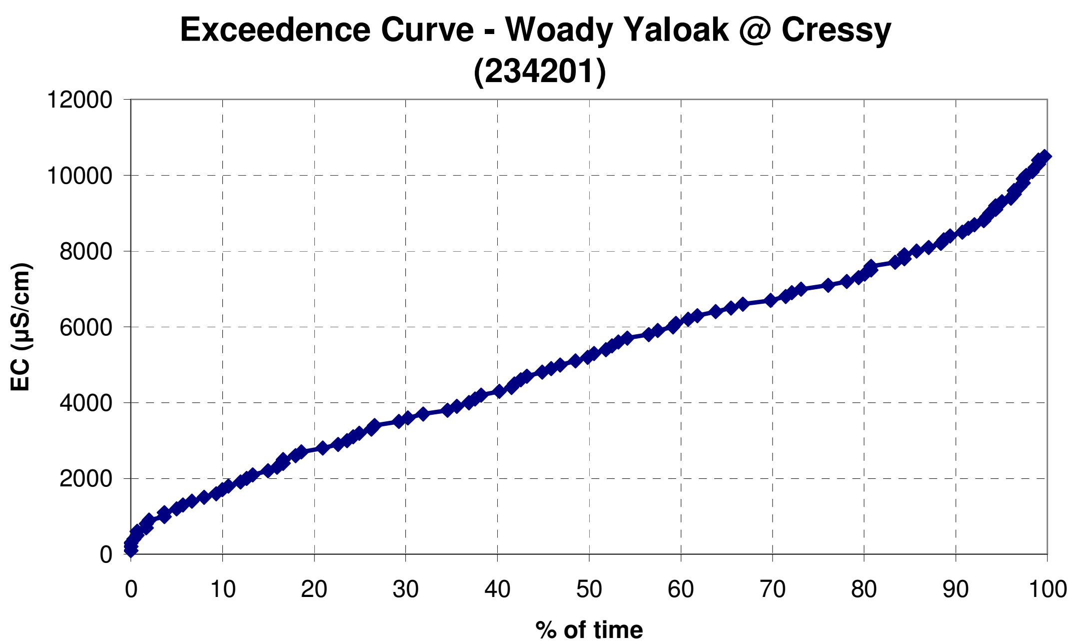
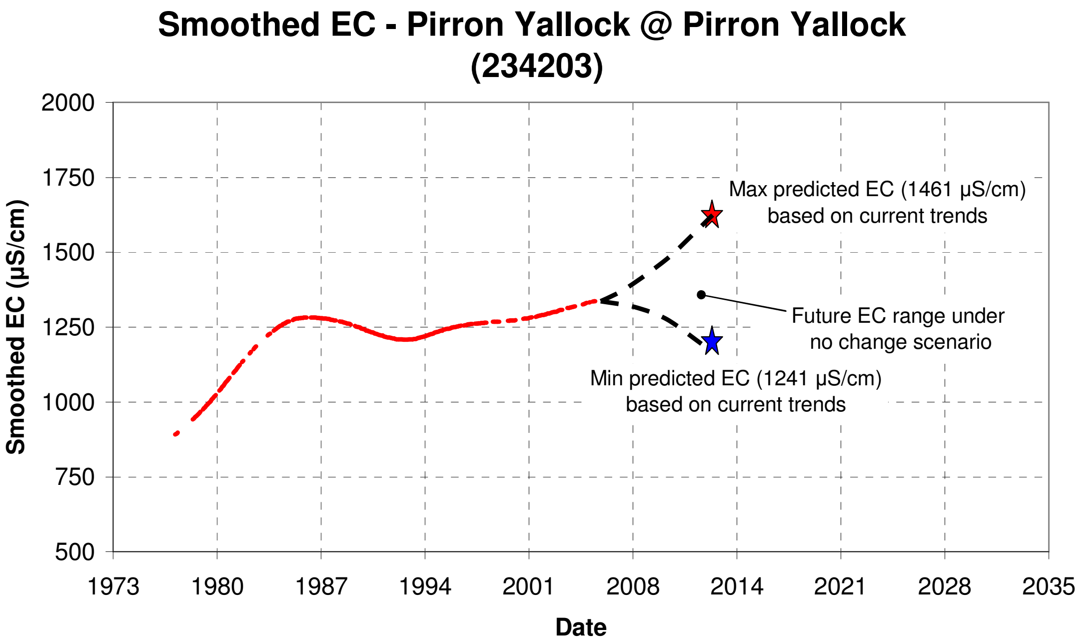


Figure 3.3 Statistical analysis of stream salinity for Woady Yaloak at Cressy (1976-2005)

Gauge 234203 – Pirron Yallock Creek at Pirron Yallock

Start date:	January 1977		
End data:	February 2005		
No of samples:	281		
Mean flow:	48 Megalitres/day		
EC:	Mean 1221 µS/cm	Highest 10800 µS/cm	Lowest 160 µS/cm
Mean salt load:	35 tonnes/day		
Linear EC trend:	10.3 ± 7.4 µS/cm/yr		



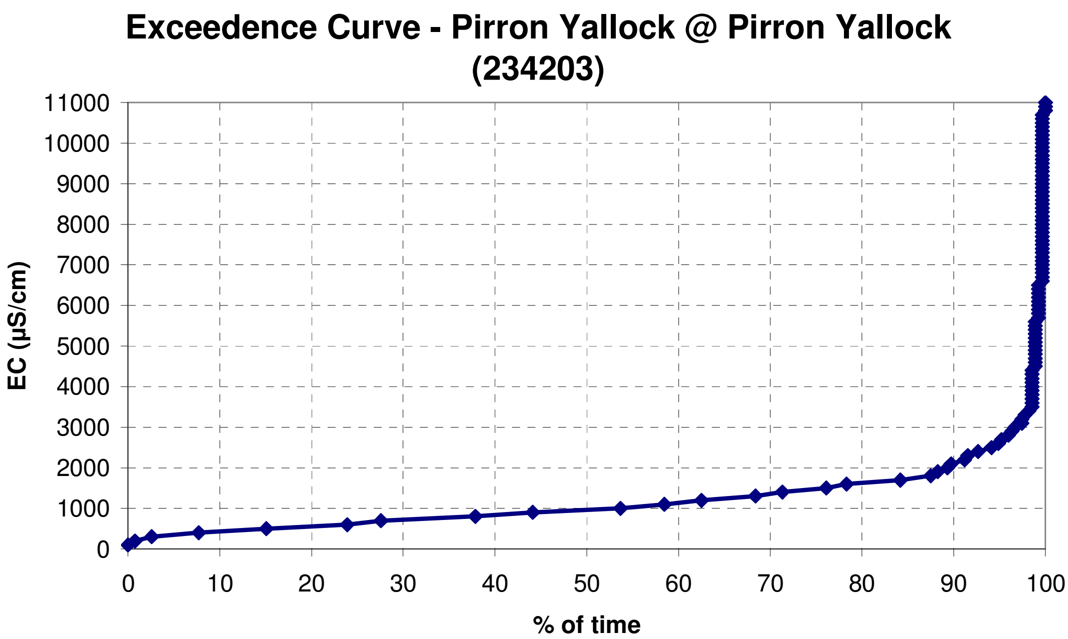
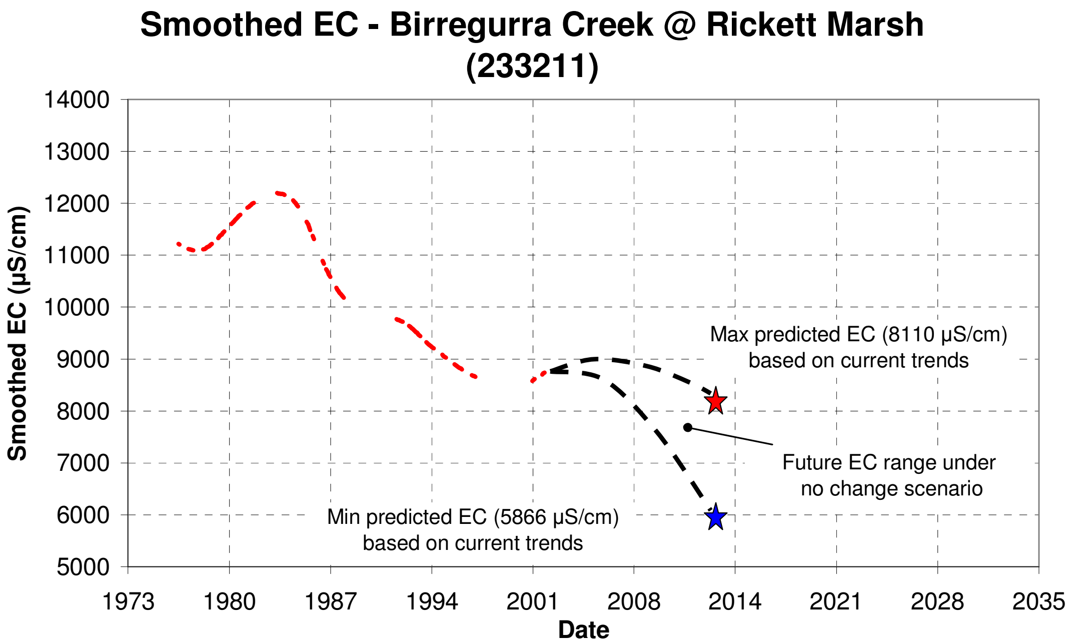


Figure 3.4 Statistical analysis of stream salinity for Pirron Yallock Creek at Pirron Yallock (1977 - 2005)

Gauge 233211 – Birregurra Creek at Ricketts Marsh

Start date:	October 1976		
End data:	December 2004		
No of samples:	275		
Mean flow:	47 Megalitres/day		
EC:	Mean 10429 µS/cm	Highest - 44900 µS/cm	Lowest 1000 µS/cm
Mean salt load:	294 tonnes/day		
Linear EC trend:	-175.1 ± 112.2 µS/cm/yr		



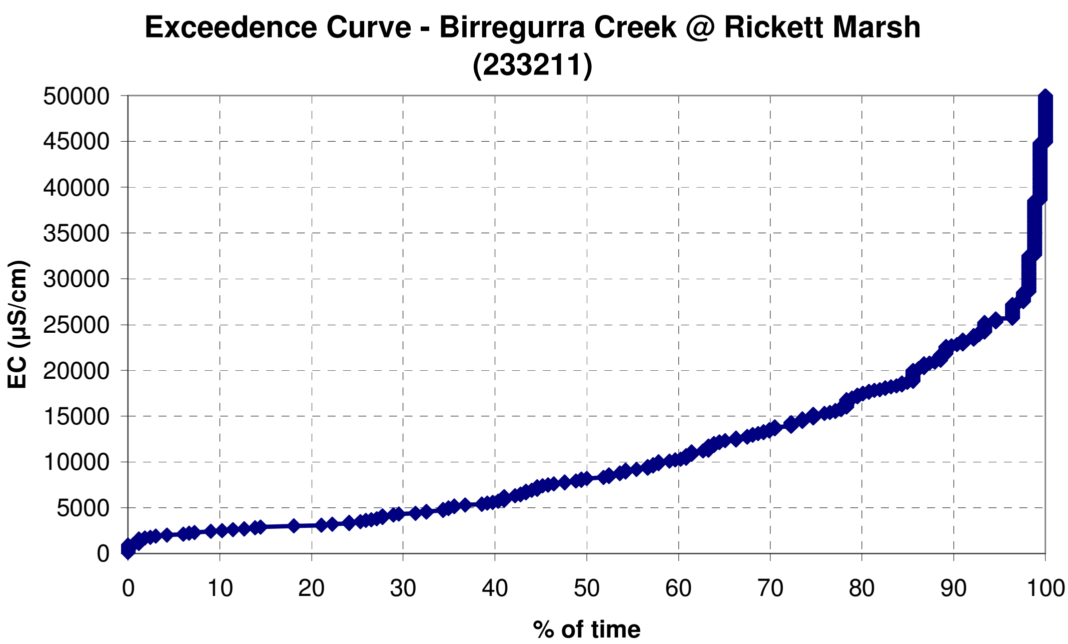
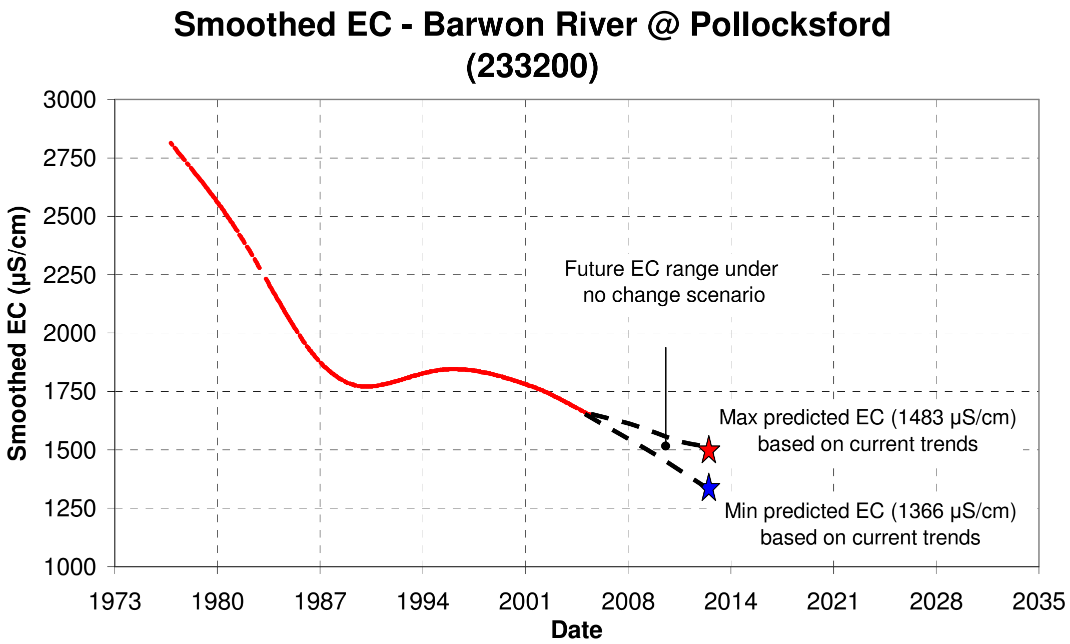


Figure 3.5 Statistical analysis of stream salinity for Birregurra Creek at Ricketts Marsh (1976-2004)

Gauge 233200 - Barwon River at Pollocksford

Start date:	November 1976		
End data:	February 2005		
No of samples:	329		
Mean flow:	414 Megalitres/day		
EC:	Mean 1991 µS/cm	Highest 4800 µS/cm	Lowest 350 µS/cm
Mean salt load:	495 tonnes/day		
Linear EC trend:	-31.8 ± 8.3 µS/cm/yr		



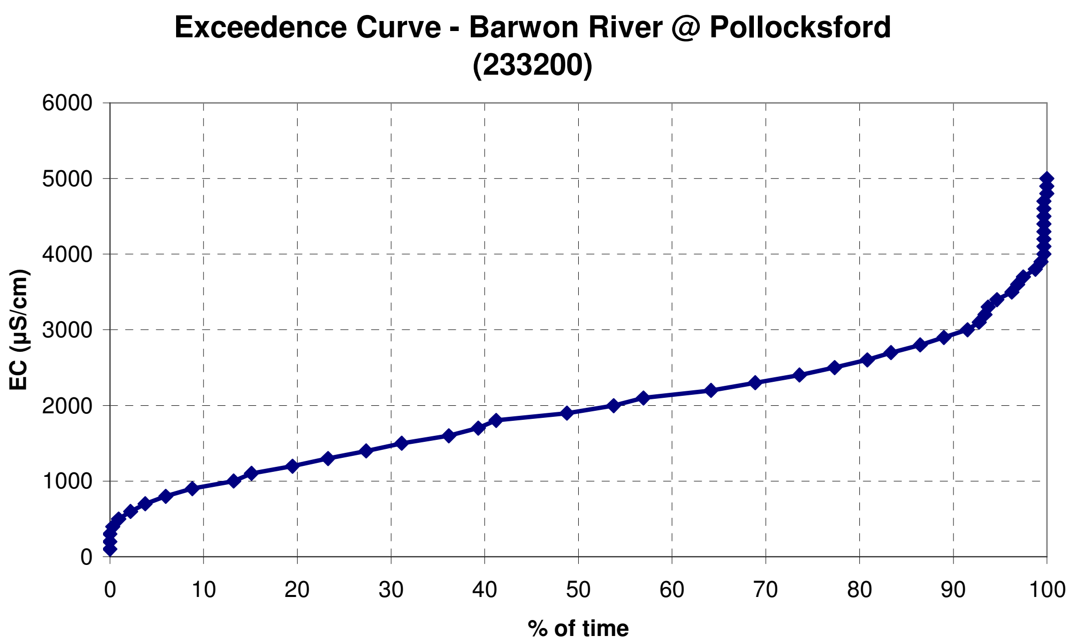


Figure 3.6 Statistical analysis of stream salinity for Barwon at Pollocksford (1976-2005)

3.2 Revised RCTs for surface water salinity

3.2.1 Moorabool River West Branch at Lal Lal (232210)

Current situation and no change scenario

The most recent modelling of the EC data recorded at the Lal Lal gauging station over the period from December 1976 to February 2005 shows an increasing salinity trend of 1.0 ± 1.9 µS/cm/yr (Figure 3.1). This value is slightly down on the previous value of 1.3 ± 1.0 µS/cm/yr for the 1976 – 2001 period (Table B1, Appendix B), and is not statistically significant. The projected values for 2012 range from a minimum mean EC of approximately 500 µS/cm, which is near that of the current average value, to a maximum mean value of approximately 520 µS/cm.

The exceedence curve shows that the EC values are mostly within the range of 100 to 700 µS/cm, with the EC exceeding these values on relatively few occasions (4% of the time). However, values greater than the 90% exceedence value of 600 µS/cm have been recorded 28% of the time in the past five years (February 1999 to February 2005). This includes 5 occasions when the values exceeded 1000 µS/cm, and the three highest values ever recorded, *viz:* 1600 µS/cm (April & May 2003) & 1500µS/cm (May 2004).

Change scenario

The causes of the rising salinity trends in the West Moorabool River remain unknown, however a research project commenced in late 2005 with the aim of finding the causes and possible solutions. Until that project is completed, the appropriate management actions cannot be formulated.

RCT

Based on the precautionary principle, an interim RCT can be set as a trigger to indicate significant changes in the salinity trends. An appropriate RCT would be a mean monthly EC of less than 1000 µS/cm for 90% of the time. This value has been exceeded 8% of the time in the past five years. The RCT will require revision once the salinity management actions have been decided.

3.2.2 Moorabool River at Batesford (232202)

Current situation and no change scenario

Recent modelling of the mean monthly EC measured at Batesford gauge on the Moorabool River over the period from November 1976 to February 2005 indicates that the salinity is continuing to rise. The current trend of 23.7 ± 6.0 µS/cm/yr is higher than the previous value of 18.7 ± 7.0 µS/cm/yr calculated for the 1976 to 2001 period (Table B1, Appendix B). Based on the statistical modelling, the rising trend in EC is predicted to continue to 2012, with a projected mean EC of between 2320 µS/cm and 2404 µS/cm.

Based on the 1976 – 2005 data, an EC of 2350 µS/cm is exceeded 10% of time (Figure 3.2), however, the records indicate that this value has been exceeded 36% of the time in the past five years (February 1999 to February 2005). The highest recorded value of 4000 µS/cm was measured in June 2002, and the lowest recorded value (340 µS/cm) was measured in July 1978.

Change scenario

Until the current research has been completed, the causes of the rising salinity trends measured at the Batesford gauge remain unknown. However salinity management in the Morrisons – Sheoaks salinity target area has been implemented based on the conceptual model for the saline groundwater discharge which contributes a proportion of the salinity (refer to Background Report 3 for details). A reduction in salinity of one µS/cm/yr in the EC of the river is predicted for every 500 hectares of recharge control, based on Flowtube models. The reduction for discharge control is estimated as ½ µS/cm/yr based on the reduction in salt wash-off from the discharge areas. The revised MATs for the Morrisons-Sheoaks salinity management target area (Background Report 8) estimate that 302 hectares per year will be treated with the implementation of the plan. Therefore, the expected reduction in EC would be < 1µS/cm/yr.

RCT

Setting an end of valley RCT for the Moorabool River is challenging, as the increasing trend is predicted to continue and the current salinity actions have a minimal effect. An optimistic view is that the minimum projected mean EC of 2320 µS/cm is achievable by 2015. However, this value has been exceeded 36% of the time in the past five years. A challenging, but possible interim end of valley RCT for the Moorabool River is proposed as a mean monthly EC of less than 2500 µS/cm for 90% of the time by 2015. This target should be reviewed once the causes for the rising salinity are understood.

3.2.3 Woady Yaloak River at Cressy (234201)

Current situation and no change scenario

The recent modelling of the salinity trends in the Woady Yaloak River confirms the variability of the data and the difficulty in achieving a statistically significant result. The current trend in EC values of 3.4 ± 23.7 µS/cm/yr for the period from November 1976 to February 2005 compares with the initial (1976 - 2001) calculated trend of 5.0 ± 5.3 µS/cm/yr (Table B1, Appendix B). Both are not statistically significant, despite the identification and removal of outlying data points from the dataset as part of the modelling process. The mean EC value of 5265 µS/cm is spanned by a significant range of values from a high of 10500 µS/cm to a low of 620 µS/cm. The 2012 projected maximum mean EC is around 5300 µS/cm, and the projected minimum mean EC is about 5000 µS/cm.

The variation in the data is also highlighted by the shape of the exceedence curve (Figure 3.3) which shows a relatively linear rise in comparison to the other gauges. Values above the 90% exceedence value of 8450 µS/cm were last recorded in autumn and early winter flows in 1997, 1998, 2000 & 2001. This indicates that a substantial proportion of the salt is contributed from wash-off from saline discharge sites.

Change scenario

The causes of the salt in the Woady Yaloak River are believed to be both saline groundwater discharge and seasonal salt wash-off from saline land. Two target areas – Illabarook & Pittong - were chosen in the Regional Draft SAP on the basis of them being the most likely contributors in the catchment. Quite different salinity management actions have been developed for each target area based on the conceptual models of salinity processes (refer to Background Report 3 for details).

The Flowtube models for the Illabarook target area (Background Report 3) indicated a reduction in EC of between 6 µS/cm/yr and 11 µS/cm/yr for ever 100 hectares treated. The lower figure assumes that the Illabarook target area contributes 30% of the salt measured at the end of valley, whereas the higher figure assumes a contribution of 50% of the salt. The revised MATs for Illabarook (Background Report 8) estimate that 27 hectares per year of discharge treatment and 42 hectares per year of recharge treatment with the implementation of the SAP. Therefore, the expected reduction in EC would be between 4 µS/cm/yr and 7.5 µS/cm/yr, depending on the proportion of salt that the Illabarook target area contributes to the end of valley measurement. An alternative model of annual payments for recharge planting has also been proposed (Background Report 8) which would raise the MAT for recharge treatment to 198 hectares per year. Under this scenario, the reduction in salinity could be between 13.5 µS/cm/yr and 25 µS/cm/yr.

In the Pittong target area, the previously calculated reduction in salt export to the Woady Yaloak River of 3 tonnes/yr/ha (Background Report 3) is under revision, but not yet quantified. The revised

MATs for the Pittong target area (Background Report 8) are 36 hectares per year of discharge treatment and 405 hectares per year of recharge treatment.

RCT

Taking into consideration the predicted reduction in salt due to the management actions in the Illabarook and Pittong salinity management target areas, the projected minimum mean EC value of approximately 5000 µS/cm would be an achievable target by 2015. Over the period of gauging records, this has been exceeded 53% of the time. However given the huge seasonal variation in the data, it is reasonable to expect that much higher EC values will be recorded, particularly in autumn, despite the salinity management that specifically targets a reduction both saline groundwater discharge and the salt wash-off from the discharge sites. Currently, an EC of 8450 µS/cm is exceeded 10% of the time. With consideration of the scheduled salinity management actions, an achievable and pragmatic end of valley RCT can be set at less than 8000 µS/cm for 90% of the time.

3.2.4 Pirron Yallock Creek at Pirron Yallock (234203)

Current situation and no change scenario

Based on the results of the modelling of the gauging station data for the Pirron Yallock Creek, the EC has been increasing on average 10.3 ± 7.4 µS/cm per year over the 28 year period from January 1977 to February 2005 (Figure 3.4). The non-linear trend shows a sharp rise in EC from 1976 to mid 1986, followed by a slight decrease until 1993, and then a moderate rise until the present. The mean EC is approximately 1330 µS/cm and by 2012 the projected maximum mean EC is 1460 µS/cm, and the projected minimum mean EC is 1240 µS/cm.

Over the period of recorded data, the EC remained below 2100 µS/cm for 90% of time, although an average value greater than 2100 µS/cm has been recorded during four months over the past two years. As seen by the exceedence curve (Figure 3.4), quite high EC values have been recorded on rare occasions in the Pirron Yallock Creek. The majority of higher values were recorded during the 1980s (maximum of 10,800 µS/cm in June 1985).

Change scenario

The causes of the increasing trend of the salinity in the Pirron Yallock Creek are yet to be determined. The lower four kilometres of the creek and the gauging station lie within the Lake Corangamite SAP target area. The creek is incised along the boundary of the Newer Volcanics and the Dilwyn Formation sands. Relatively little salinity has been mapped within the catchment, and it is speculated that that the salinity may be contributed by groundwater baseflow from the fractured basalts, or via the Pirron Yallock drain, which enters the creek just upstream of the gauge.

RCT

Given that the causes of salinity are yet to be determined, it is unknown if the management actions within the Lake Corangamite SAP target area will change the rising trend. Based on the precautionary principle, an end of valley target of a mean monthly EC of less than 2500 µS/cm for 90% of the time is achievable. The target provides a trigger to indicate when the salinity trend of the Pirron Yallock Creek has increased. A more pragmatic target can be set once the causes of the salinity are understood and management actions can be developed.

3.2.5 Birregurra Creek at Ricketts Marsh (233211)

Current situation and no change scenario

The EC data for the Birregurra Creek at the Ricketts Marsh gauging station from October 1976 to December 2004 is only 81% complete (275 readings out of a possible 338). The non-linear data shows a dramatic 30% decline in mean EC from approximately 12200 µS/cm in early 1984 to approximately 8500 µS/cm in late 2000. Based on the statistical trend, the projected mean maximum EC is 8110 µS/cm and the projected mean minimum EC is 5866 µS/cm (Figure 3.5).

Over the same period, the recorded EC was below 25000 µS/cm for more than 90% of the time, with the last occasions being in April and May 1994. Since July 1994, the recorded EC has not reached above 20000 µS/cm.

Change scenario

The GHD study recommended no change to the Lough Calvert Drainage Scheme, over the next three years, so the situation for Birregurra Creek remains much the same as the present. Because of the proposed salinity management actions in the Colac-Eurack and Warncoort target areas, there will be some changes to the salt input to the creek, but this has not been quantified.

RCT

Based on the declining trend in EC since 1984, and the projected mean EC values for 2012, a mean monthly EC of less than 25000 µS/cm for 95% of the time is regarded as achievable. The target should be reviewed if the operation of the Lough Calvert Drainage Scheme is changed.

3.2.6 Barwon River at Pollocksford (233200)

Current situation and no change scenario

The CSIRO modelling of the available gauging station data shows a dramatic fall in the salinity of the Barwon River during the period from November 1976 to February 2005 (Figure 3.6). The mean EC over that period was 1991 µS/cm, and by 2012 the projected maximum mean EC is 1483 µS/cm and the projected minimum mean EC is 1366 µS/cm.

The exceedence curve for the EC during the gauging period indicates that 90% of the time the river salinity does not exceed 3000 µS/cm. A check of the data shows that because of the sharply declining trend in EC from 1976 to 1988, the last occasion a value above 3000 µS/cm was recorded was in July 1988, although it did reach 3000 µS/cm in July 1992 and June 1998. In the past five years (February 2000 to February 2005), the recorded EC has been below 2500 µS/cm for 93% of the time.

Change scenario

According to the GHD study, if the recommended changes to the Woady Yaloak Diversion Scheme are adopted, the average EC of the Barwon River (measured at the Pollocksford gauge) is predicted to be 1590 µS/cm, with a range of 1380 µS/cm to 1970 µS/cm after the recommended changes to management in July 2009 (GHD, 2004). These predicted changes are about 100 µS/cm higher that the maximum projected on the basis of the current "no change" scenario. The predicted average has been exceeded 65% of the time over the past 28 years of gauging history, and 69% of the records (40 out of 58) between February 2000 and February 2005 have exceeded this value.

RCT

The post-1988 trend suggests that an average monthly EC below 3000 µS/cm for 90% of the time is an achievable target. However the closure of the Woady Yaloak Diversion Scheme will probably increase the EC slightly and if the recommendations of the GHS study are adopted, the target may have to be revised after July 2009.

4 Inland aquatic ecosystems integrity

The integrity of inland aquatic ecosystems is largely addressed through the Corangamite Wetlands Strategy and the Corangamite River Health Strategy. However, the components that relate to salinity, and particularly the threat of changing salinity, are addressed in the Corangamite SAP.

The Regional Draft SAP recognises the salinity threats to wetlands, particularly those listed under the Ramsar Convention. At the time of development (i.e. 2002-2003) the CCMA wetlands strategy had not been developed and the National NRM framework was still in development. Fourteen interim RCTs were set which wholly or partly relate to inland aquatic ecosystems, *viz:* numbers 7, 9, 11, 15, 16, 18, 22, 23, 24, 33, 35, 38, 40 & 42 listed in Table A1 (Appendix A).

4.1 New data, research and investigations

Since the completion of the Regional Draft SAP, several projects relating to the integrity of inland aquatic ecosystems have been undertaken which are relevant to the SAP.

4.1.1 Drying of Red Rock lakes complex (Adler & Lawrence 2004)

A research abstract presented at the 23rd International Association of Hydrogeologists Congress in Zacetacas, Mexico in October 2004, detailed strong evidence that the increasing extraction of groundwater from the Warrion Groundwater Management Area (GMA) was responsible for the drying of a number of saline lakes at Red Rock, near Alvie (Adler & Lawrence 2004). The research, based on hydrologic budget calculations, indicated that the salt water previously held in the lakes has now entered the groundwater system, and that salt water from Lake Corangamite was also continuing to contaminate the irrigation resource. The paper illustrated the conflict between the economic interests of groundwater irrigators and the environmental interests.

This important research highlights the sensitivity of groundwater dependent ecosystems and how the lowering of groundwater tables (in this case through extraction for irrigation) can devastate the integrity of saline wetlands. The implications for the SAP are that lowering of saline watertables is not always the most appropriate action to reduce salinity.

4.1.2 Describing the ecological character of Ramsar wetlands (DSE 2005a)

A framework for describing the ecological character of Ramsar wetlands was published in February 2005 by the DSE (DSE 2005a). The framework provides background information on ecological character, guidance on interpreting terms and addressing Ramsar Convention and Australian requirements and a step by step guide on developing a description of ecological character for a Ramsar site. Primarily designed to guide managers in preparing descriptions for new Ramsar sites or enhancing the plans for existing sites, the framework is relevant to the SAP in that salinity is recognised as a threat to Ramsar wetlands in several SAP target areas.

The framework recognises water salinity, water source (i.e. groundwater or surface water) and the area of the wetland as ecological components of a Ramsar wetland. The framework proposes a seven step process which links the ecological character of the Ramsar site to the ecosystem service provided by the site. Step 6 *“Specify the critical components and processes that support each of the selected ecosystem services”* is particularly relevant in that the Regional Draft SAP identifies salinity as a critical component in the provision of ecosystem health for some Corangamite wetlands (e.g. Lake Corangamite).

4.1.3 Wetlands inventory (CEM, 2005)

The Wetlands Inventory project commenced in 2001 (CEM 2002) and the final report completed in December 2005 (CEM 2005). The project completed a review of the extent and adequacy of wetland inventory information and associated research (40 research papers). The review concluded that the present inventories were limited in scope and classification accuracy, and knowledge of values and threats were generally absent. Mapping of wetlands was completed using classification of remotely sensed images. The mapping identified a greater number of wetlands, especially those smaller than one hectare in size. Field checking of 96 wetlands was completed to record their spatial, physical, chemical and biological attributes. Of the wetlands assessed using the rapid assessment technique, 39 were assessed as threatened by altered water regimes, and 4 threatened by increasing salinity.

4.1.4 Draft Corangamite wetlands strategy (2005)

A draft version of the Corangamite Wetlands Strategy (CWS) was released for internal review in September 2005 (Sheldon 2005). The draft version of the strategy will be finalised early in 2006 for public release. The strategy outlines the logistic framework and investment plan that is required to achieve the CWS vision, *viz*: *"Maintain the extent and enhance the quality of Corangamite wetlands through a community inspired to wisely use and conserve these assets."*

The strategic framework aims to facilitate the maintenance of, and enhancement of the condition of, regional wetlands through a broad range of mechanisms. The RCTs and MATs are yet to be developed, as are actions specific to on-ground works. The draft strategy sets out a logical framework, summarised as an objective hierarchy with components that relate to the logical sequence of establishing goals which lead to objectives that in turn lead to outputs that finally lead to activities. The strategy details funding mechanisms for its implementation, monitoring and evaluation of the implementation and outputs, and guidance for prioritisation and action plan development.

The CWS suggests that the framework for asset-based wetland prioritisation should be based on the Policy Framework for Wetlands in Victoria (DSE 2003), which uses the following hierarchy:

1. Internationally listed wetlands are the highest priority wetlands for protection
2. Nationally significant wetlands, and
3. Significant wetlands on a local scale.

4.1.5 Index of wetland condition (DSE, 2005b)

The Index of Wetland Condition (IWC) is the standard method for assessing wetland condition in Victoria and was developed to address NAP and NHT requirements (DSE 2005b). The selection of measures for the IWC have been guided by the National Framework for Natural Resource Management Standards and Targets (NRM Ministerial Council, 2003a) and the indicators have been fully agreed by the Monitoring and Evaluation Working Group. The IWC was published in November 2005.

The IWC is a hierarchical index with six "fundamental characteristics" of the wetland, *viz:* wetland catchment, hydrology, water properties, soils, biota and physical form. Each of these fundamental characteristics has "key components" and each of the key components have "measures". Of these those considered relevant to the SAP are listed in Table 4.1.

Wetland Characteristic	Key component	Possible measure
Physical form	Area of wetland	Percentage reduction in wetland area
Hydrology	Water regime	Severity of activities that change the water regime
Water properties	Electrical Conductivity (salinity)	Factors likely to lead to wetland salinisation • input of saline water to the wetland • wetland occurs in a salinity risk area
	Vegetation indicator species or communities	None suitable at present (not included in the IWC)
	Groundwater levels at wetlands	Groundwater levels over time (not included in the IWC)

Table 4.1 Characteristics, components and measures of the IWC that are relevant to the SAP.

4.2 Revised RCTs for inland aquatic ecosystems integrity

The interim RCTs listed in the Regional Draft SAP which relate to the integrity of inland aquatic ecosystems were drafted without the benefit of the information and knowledge provided in the very recent reports listed above. It is therefore appropriate that they are reviewed and revised.

In relation to the requirement for RCTs to be “pragmatic and achievable” (DSE 2005c) discussions were held with Rebecca Sheldon, Wetlands Officer, Corangamite CMA, and advice was provided via email from Dr Rhonda Butcher, Monash University. The consensus was that those RCTs which relate to establishing the threat to ecology in the Woady Yaloak River (RCT 7 & 9 in Table A1, Appendix A), and the primary saline sites (RCT 18, 24 & 33 in Table A1) are not achievable in the timeframe suggested and that they relate more to the Corangamite River Health Strategy and the Corangamite Wetlands Strategy, than the SAP. Furthermore, the two RCTs related to refugia (RCT 16 & 23 in Table A1) were also considered too ambitious, as there is insufficient information on the identification of refugia in the Corangamite region.

The remaining RCTs related to inland aquatic ecosystem integrity were those where salinity ranges should be established in wetlands identified as being threatened. Although there are specified natural ranges of salinity for upland rivers, lowland rivers, and permanent freshwater lakes, there are none specified for primary saline wetlands (Rhonda Butcher, *pers. comm.*). It was therefore suggested that EC ranges could be set in a similar fashion to the surface water salinity ranges, i.e. establish the natural range over a suitable time period and then set the RCT as the median below the 80% or 90% exceedence value (refer to Section 3.2). The information does not currently exist to quantify these RCTs, so the RCT has been set as an intention to establish one within a stated timeframe.

Two additional RCTs have been added on the basis of the research by Adler & Lawrence (2004) and the precautionary principle. Groundwater extraction and the lowering of saline watertables in the Lake Corangamite and the Colac – Eurack SAP target areas can destroy the integrity of the inland aquatic saline ecosystems simply by drying them permanently. Therefore it is appropriate that there should be a target of no net loss of primary salinity in these target areas.

5 Other matters for targets

The National Framework for Natural Resource Management Standards and Targets (NRM Ministerial Council, 2003a) specifies other matters for target that have some relevance to the Corangamite SAP (Table 1.1). Of these the integrity of estuarine, coastal and marine habitats list salinity as an indicator (Table 1.2). In addition, the integrity of native vegetation, and the integrity of the built environment (particularly roads and urban infrastructure) are recognised in the SAP as assets which may be threatened by salinity.

5.1 Estuarine, coastal and marine habitat integrity

Very little information can be found on the threat of changing salinity to the integrity of estuarine, coastal and marine habitats in the Corangamite region. The GSHARP process used to identify target areas in the Regional Draft SAP identified the estuarine and coastal Ramsar sites of Corio Bay as potentially at risk, but there was no known monitoring or research which could be used to quantify the risk (Heislers & Brewin, 2003; and Background Reports 2 & 3). Nevertheless, two RCTs were developed (based on the precautionary principle), i.e. RCTs 38 & 42 in Table A1 (Appendix A), which state that there should be no net loss in the area of primary salinity at these sites.

5.2 Native vegetation communities' integrity.

At the time of development of the Regional Draft SAP in 2003, data on the integrity of native vegetation communities was not readily available. Over the past two years, the mapping of Ecological Vegetation Class (EVC) and bioregions has been completed for the Corangamite CMA region. As a result, the Draft Corangamite Native Vegetation Plan (NVP) has been published (CCMA 2005), which recognises salinity as a minor threat to the integrity of native vegetation and biodiversity. The NVP outlines a range of tools, services and mechanisms aimed at protecting, enhancing and restoring the region's native vegetation.

In order to include the salinity threats to the integrity of native vegetation communities and develop appropriate SAP management actions, two GIS layers were provided by DSE to the Corangamite CMA. These are: Conservation Significance (Potential) (CSP), and EVC – Bioregional Conservation Status (BCS). The layers were used to determine the salinity threat to vegetation in conjunction with the most recent land salinity mapping completed in 2005 by DPI. According to the metadata supplied with the layers, the CSP is a combination of the BCS and the Estimated Habitat Score (which was in turn, derived from the Native Vegetation Extent and the Landscape Context score). In other words, the CSP rates each polygon on the spatial extent of native vegetation, its conservation status, patch size, thickness, neighbourhood and connectivity. The BCS is a combination of Victorian Bioregions and the Extant EVC data, or in other words, a rating of the conservation status of the patches of remaining (indigenous) EVC. In some cases the EVC is clearly related to salinity (eg. the Cane Grass – Lignum Halophytic Herbland in the Geelong – Lake Connewarre target area), whereas others are less certain (eg. Swamp Scrub in the Modewarre target area).

In discussions with Nick McCristal, Team Leader, Natural Resource Management (Biodiversity Conservation), CCMA, it was concluded that the CSP layer was the more appropriate layer to use in the analysis of salinity threat to the integrity of native vegetation communities. The analysis examined where the mapped salinity intersected the native vegetation communities which were rated as Very High or High CSP (Table 5.1, Figures 5.1). The correlation between salinity and very high or high value CSP can be partly explained by the vulnerable and endangered BCS of EVCs associated with primary salinity (e.g. Geelong – Lake Connewarre, Lara, Lake Corangamite & Colac-Eurack target areas), and partly by the association of salinity with drainage lines and wetlands (e.g. Illabarook and Pittong).

	Native Vegetation Conservation Significance (Potential)					
	Very High		High		Medium	
	Total area (hectares)	Proportion of CSP	Total area (hectares)	Proportion of CSP	Total area (hectares)	Proportion of CSP
Whole of CCMA region	99916	100%	149736	100%	179546	100%
In mapped saline areas only	5392	**5.4%**	4750	**3.2%**	92	**0.05%**

Table 5.1 Intersection of mapped salinity with the CSP of native vegetation

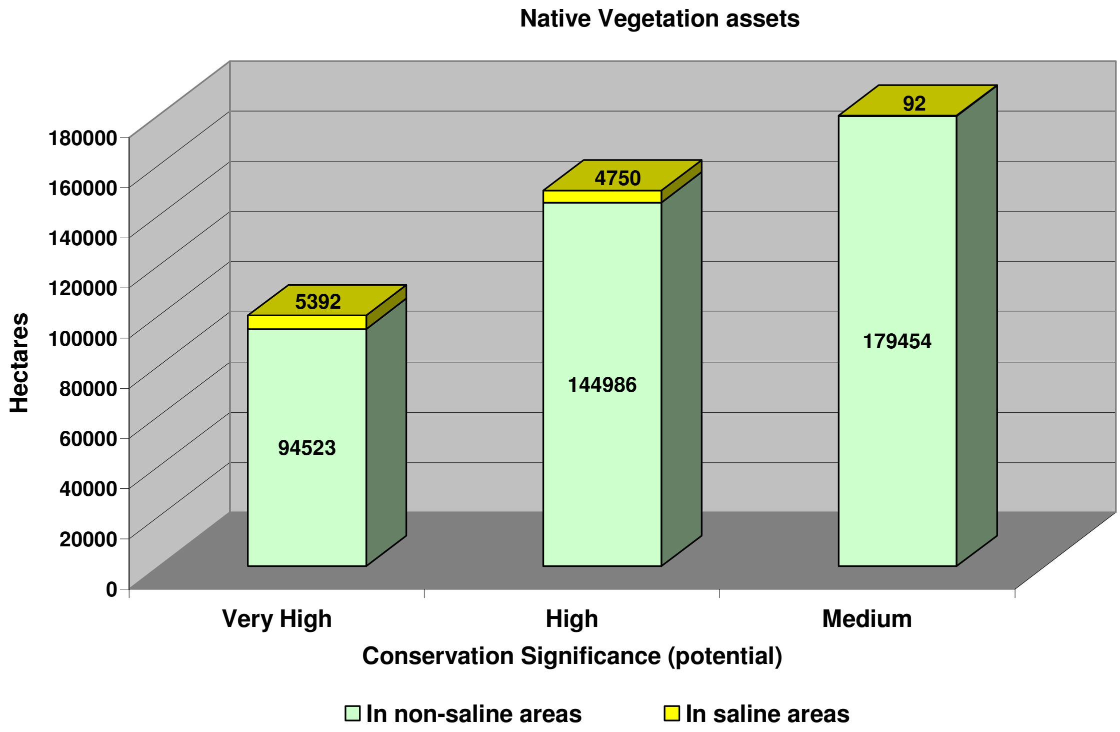


Figure 5.1 Proportion of native vegetation CSP in mapped saline areas

The provision of the relatively recent EVC, CSP and BCS data provides an opportunity to include the native vegetation communities and biodiversity assets into the future revisions of the SAP, particularly in the selection of target areas for salinity management. Nevertheless, of the 8.6% of native vegetation with very high and high conservation significance potential which is threatened or potentially threatened by salinity, the 72% is already within the boundaries of the SAP target areas (Figure 5.2).

Within the 28% that remains outside of the SAP target areas, there are six areas where there is a reasonably sized (>50 ha) area of native vegetation with very high or high conservation status threatened by salinity (Table 5.2). These areas were not identified in the original GSHARP analysis (Heislers & Brewin 2003) as areas where multiple assets were threatened by salinity. However, on the basis that high or very high value native vegetation is potentially at risk, these areas have been designated "areas of interest" for further investigation. As all of these areas are coastal or estuarine areas where primary salinity or saline wetlands have been mapped, it is possible that the very high and high conservation significance potential is related to saline environment EVCs. The threat to these high value assets requires further investigation and research.

Areas of interest	Area hectares	Native Vegetation CSP	
		Very High	High
		(hectares)	(hectares)
Point Henry	755.0		46
Point Richards	203.8		91
St Leonards	134.0	8	56
Swan Bay - Lake Victoria	2164.5	396	460
Princetown	2703.5	479	13
Peterborough	2619.0	337	115
Total		**1220**	**780**

Table 5.2 Six additional "areas of interest" identified for further investigation

With the addition of the "areas of interest", the SAP will capture 95% of the very high conservation significance potential and 89% of the high conservation significance potential native vegetation potentially threatened by salinity (Figure 5.2).

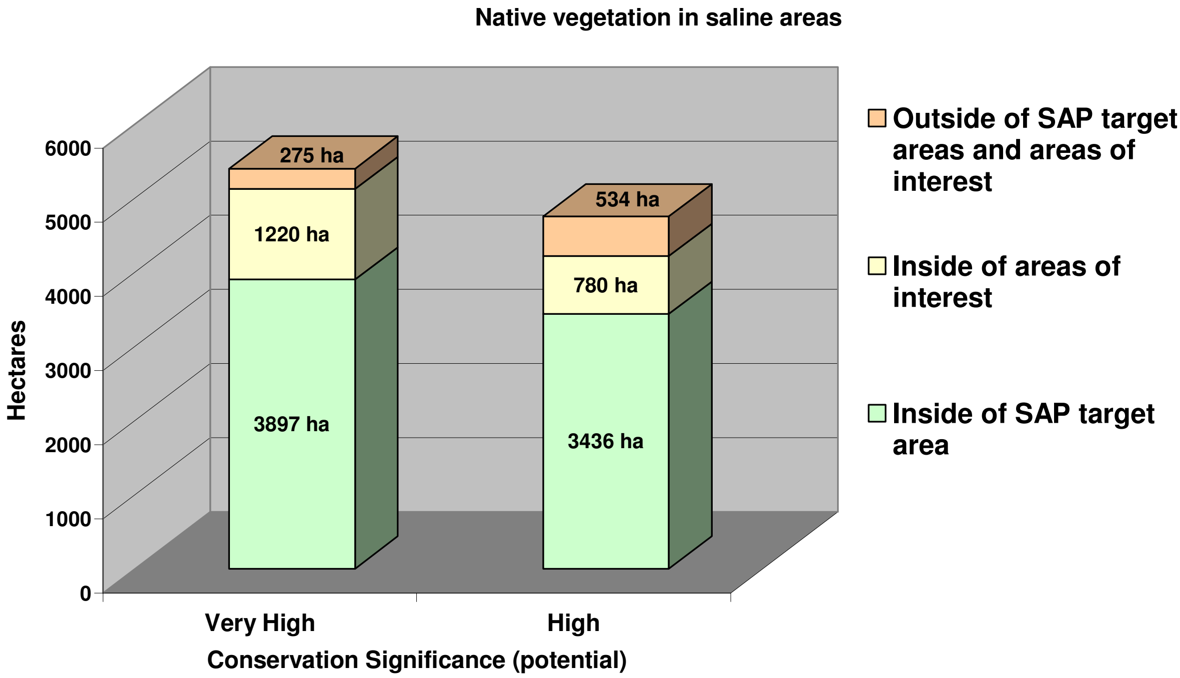


Figure 5.2 Native vegetation potentially threatened by salinity

The CSP and BCS layers provide the information of the potential threat at a specific site, and alert land managers to the need for appropriate salinity management options to ensure the integrity of the high value native vegetation communities are maintained. At this stage there is insufficient knowledge to set salinity-related RCTs for specific vegetation communities, particularly as the tolerance of specific EVCs to salinity (or a range of salinity values) is unknown (Chris Pitfield, *pers. comm.*).

The description of particular EVCs, the correlations of mapped salinity with BCS, and the relationship of the EVC – BCS to the targets in the Corangamite NVP are provided in Appendix C.

The provision of the relatively recent EVC, CSP and BCS data provides an opportunity to include the native vegetation communities and biodiversity assets into the future revisions of the SAP, particularly in the selection of target areas for salinity management.

5.3 The built environment - urban and road infrastructure

Although not listed as a matter for target in the National Framework (Table 1.1), the integrity of the built environment is recognised by both NAP and the Corangamite RCS as important. A number of interim RCTs were set in the Regional Draft SAP to address the salinity threat to road infrastructure (RCTs 13, 19, 25, 32, 37 & 41, Table A1, Appendix A) and urban infrastructure (RCT 21, Table A1). These current RCTs remain appropriate although the timeframes for some should be extended from 2010 to 2015 to allow for the response timeframes for municipalities.

The threat to urban infrastructure is being addressed through a current project to implement Salinity Management Overlays (SMO) in four municipalities: Corangamite Shire, Colac Otway Shire, Surfcoast Shire and Golden Plains Shire (EnPlan, *in prep.*). The salinity mapping project (Miller, *in prep.*), referred to in Section 2.1.12, was initiated through the SMO project and confirms the presence of land salinity within the designated urban growth corridors for each of the four shires. The nature, magnitude and immediacy of threat has not yet been determined, but will be addressed through the SMO project. RCTs should be revised when the information from this project is available.

6 Revised RCTs

The revision of the RCTs has taken into account the most current knowledge in the research, investigations and studies within the Corangamite region. They are considered pragmatic and achievable as required by the National Framework (NRM Ministerial Council, 2003a).

The revised RCTs can be grouped into four broad categories (termed types L, W, E & I):

Type **L - Land salinity** – RCTs have been set as no net gain in secondary salinity over 2003 levels in the eight target areas where land salinity has been identified as a threat to assets.

Type **W - Surface water salinity** – these RCTs are set in two categories: ***a)*** a quantitative end-of-valley target for those target areas where there is sufficient data to determine a trend; and ***b)*** a stated action to establish a target for those target areas where more data is required before a trend can be determined.

Type **E - Aquatic and estuarine ecosystem integrity** – two distinct types of RCTs have been set to maintain the integrity of aquatic ecosystems: ***a)*** actions to establish a range for the salinity of specific lakes identified as threatened by increasing or decreasing salinity, and ***b)*** no net loss of primary salinity in target areas where primary saline ephemeral wetlands have been identified as under threat from changed hydrology and salinity.

Type **I - Infrastructure integrity** – RCTs have been set to protect ***a)*** roads in target areas where they have been identified as threatened by salinity, and ***b)*** a reduction in the urban infrastructure at risk in the City of Colac.

Their relationship to the Corangamite SAP target areas is tabulated overpage (Table 6.1), and they are listed in full on the following pages (Table 6.2). The total number of RCTs for target areas reduced from 42 in the Regional Draft SAP to the current 37.

Matter for Target	Indicator or measure	SAP Target area											
		Lake Corangamite	Morrisons - Sheoaks	Upper West Moorabool	Colac - Eurack	Geelong – Lake Connewarre	Illabarook	Pittong	Lismore - Derrinallum	Murdeduke	Warncoort	Modewarre	Lara
National													
Land Salinity	Area of land threatened by secondary salinity	✓			✓	✓		✓	✓	✓	✓	✓	
Surface Water Salinity in freshwater aquatic environments	In-stream salinity	✓	✓	✓			✓	✓	✓		✓	✓	
Inland Aquatic Ecosystems Integrity (Rivers and other Wetlands)	River Condition (water EC only)	✓	✓	✓			✓	✓	✓		✓	✓	
	Wetland ecosystem extent and distribution	✓			✓	✓							✓
	Wetland ecosystem condition (salinity range)	✓			✓	✓			✓			✓	
Estuarine, coastal and marine habitat integrity	Estuarine, coastal and marine habitat extent and distribution					✓							✓
Local													
Rural and urban infrastructure integrity	Reduced threat to roads	✓			✓	✓			✓	✓	✓	✓	
	Reduced threat to urban assets				✓								

Table 6.1 Revised RCTs and their relationship to National Matters for Target and Indicators.

Type	No.	Upper West Moorabool
W	1	By 2015, maintain the EC measured in the Lal Lal Reservoir (Tower surface) below 700 µS/cm 95% of the time.
W	2	Maintain an EC of less than 1000 µS/cm for 90% of the time as measured at the Lal Lal gauging station (# 232210) on the West Branch of the Moorabool River.
		Morrisons-Sheoaks
W	3	By 2015, maintain the EC measured at the Sheoaks off-take below 800 µS/cm 90% of the time.
W	4	Maintain an EC of less than 2500 µS/cm for 90% of the time for the Moorabool River as measured at the Batesford Gauging Station (# 232202).
		Pittong
W	5	Maintain an EC of less than 8000 µS/cm for 90% of the time for Woady Yaloak River as measured at the Cressy gauging station (# 234201).
W	6	By 2012, establish a target for EC measured in the Naringhil Creek at the edge of the Pittong target area.
L	7	By 2015, there is no net increase in the area of land salinity in the Pittong target area (compared to the area in 2005).
		Illabarook
W	8	Maintain an EC of less than 8000 µS/cm for 90% of the time for Woady Yaloak River as measured at the Cressy gauging station (# 234201).
W	9	By 2012, establish targets for EC measured in the major tributaries to the Woady Yaloak River at the edge of the Illabarook target area.
		Lismore – Derrinallum
E	10	By 2010, establish the target range for salinity measured at appropriate sites in Lake Tooliorook to ensure the integrity of the aquatic ecosystem.
W	11	By 2008, establish a target for EC measured at the gauging station in Browns Waterholes (# 234212).
I	12	By 2015, ensure that 80% of the roads in saline areas (in the Lismore-Derrinallum target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
L	13	By 2015, there should be no net gain in the area affected by secondary saline discharge in the Lismore-Derrinallum target area (compared to 2005).
		Lake Corangamite
E	14	By 2010, establish targets for the ranges of salinity measured at appropriate monitoring sites in Lake Corangamite, Lake Gnarpurt, Lake Martin and Cundare Pool to ensure the integrity of the aquatic ecosystems.
W	15	Maintain and EC of less than 2500 µS/cm for 90% of the time for the Pirron Yallock Creek as measured at the Pirron Yallock gauging station (# 234203).
I	16	By 2015, ensure that 80% of the roads in saline areas (in the Lake Corangamite target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
L	17	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Lake Corangamite target area, compared to 2005.
E	18	By 2015 there should be no net loss in the area of primary saline land and saline wetlands in the Lake Corangamite target area, compared to 2005.

Table 6.2a Revised RCTs for the Corangamite SAP (continued overpage).

	RCT	Colac – Eurack
I	19	By 2015, reduce the area of land affected by salinity (saline discharge areas) within the zoned residential areas of the City of Colac by 90%.
E	20	By 2010, establish targets for the ranges of salinity measured at appropriate monitoring sites in Lake Colac, Lake Beeac and Lough Calvert to ensure the integrity of the aquatic ecosystems.
I	21	By 2015, ensure that 80% of the roads in saline areas (in the Colac - Eurack target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
L	22	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Colac - Eurack target area, compared to 2005.
E	23	By 2015 there should be no net loss in the area of primary saline land and saline wetlands in the Colac – Eurack target area, compared to 2005.
		Warncoort
W	24	Maintain an EC less than 25000 µS/cm for 95% of the time for the Birregurra Creek as measured at the Ricketts Marsh gauging station (# 233211).
L	25	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Warncoort target area, compared to 2005.
I	26	By 2015, ensure that 80% of the roads in saline areas (in the Warncoort target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
		Murdeduke
L	27	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Murdeduke target area, compared to 2005.
I	28	By 2015, ensure that 80% of the roads in saline areas (in the Murdeduke target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
		Modewarre
L	29	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Modewarre target area, compared to 2005.
E	30	By 2010, establish targets for the ranges of salinity measured at appropriate sites in Lake Modewarre, Gherang and Browns Swamps to ensure the integrity of the aquatic ecosystems.
W	31	By 2008, establish an appropriate end of valley target for salinity measured in Thompson Creek at the edge of the Modewarre target area.
I	32	By 2015, ensure that 80% of the roads in saline areas (in the Modewarre target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
		Geelong – Lake Connewarre
E	33	By 2015 there should be no net loss in the area of primary saline land and saline wetlands in the Geelong – Lake Connewarre target area, compared to 2005.
L	34	By 2015 there should be no net gain in the area of land affected by secondary salinity in the Geelong – Lake Connewarre target area, compared to 2005.
E	35	By 2010, establish targets for the ranges of salinity measured at appropriate sites in the Lower Barwon wetlands and the Thompson Creek estuary to ensure the integrity of the aquatic and estuarine ecosystems.
I	36	By 2015, ensure that 80% of the roads in saline areas (in the Geelong – Lake Connewarre target area) are managed to prevent deterioration at rates equivalent to non-saline areas.
		Lara
E	37	By 2015 there should be no net loss in the area of primary saline land and saline wetlands in the Lara target area, compared to 2005.

Table 6.2b Revised RCTs for the Corangamite SAP (continued from previous page).

7 Monitoring requirements

Monitoring requirements for the interim RCTs listed in the Regional Draft SAP (2003) were reported in Background Report 6 (Dahlhaus *et al.* 2003). However, with the revision of the RCTs (Table 6.2), the monitoring requirements also require revision.

7.1 Land salinity

Eight RCTs have been set in SAP target areas for land salinity (Table 7.1).

RCT	SAP target area	Target
L7	Pittong	By 2015, no net gain in the area of land affected by secondary salinity, compared to 2005.
L13	Lismore – Derrinallum	
L17	Lake Corangamite	
L22	Colac – Eurack	
L25	Warncoort	
L27	Murdeduke	
L29	Modewarre	
L34	Geelong – Lake Connewarre	

Table 7.1 RCTs for land salinity

Only three potential monitoring sites have been established to monitor these RCTs in the Corangamite region, *viz:* the VDSMN sites at Pittong and Beeac (Colac – Eurack SAP target area), and the SGSL site at Pittong. The VDSMN sites have been monitored once (refer to Section 2.1.4) and the SGSL site was established in 2004 (refer to Section 2.1.5), but is not currently monitored.

The monitoring of trends in land salinity requires a number of sites in each target area to ascertain the net gain or reduction secondary salinity. The protocols recently established by PIRVic (Clark & Allan 2005) stipulate a combination of mapping techniques such as geophysics, soil salinity testing and vegetation indicators. Rapid geophysical surveying using kinematic GPS and electromagnetic sensing are now routinely used in agriculture and could be used to establish several monitoring sites within a target area for a reasonable cost.

In addition, the monitoring of trends in land salinity outside of the current SAP target areas is equally important, so that emerging threats to assets can be identified. For this reason, the continued monitoring of all the VDSMN sites should be supported, along with support to research organisations undertaking salinity mapping or monitoring in the region for their own purposes. A region-wide audit of the land salinity each five years would provide an appropriate monitoring interval.

<u>Requirements:</u>

1. Support the continued monitoring of **all** of the VDSMN sites by PIRVic.
2. Commence monitoring of the SGSL sites established by Church (2004).
3. Establish two or more monitoring sites in each of the target areas in Table 7.1, using rapid geophysical surveying, soil sampling, vegetation indicators, groundwater monitoring and surface water sampling as appropriate.
4. Undertake a region-wide audit of the land salinity each five years, starting in 2010, to establish trends in target areas and non-target areas and identify emerging threats to assets.
5. Continue monitoring of the groundwater levels across the region, with preference given to the key bores identified in the groundwater monitoring review (Dahlhaus *et al., in prep*).

6. Implement a program to monitor the groundwater salinity in key bores across the region every five years, commencing immediately.

7.2 Surface water salinity

Twelve RCTs have been set to monitor surface water salinity (Table 7.2). Monitoring for the majority of the RCTs is already carried out by the DSE for the Victorian Water Quality Monitoring Network, and Barwon Water and Central Highlands Water. Four of the RCTs are yet to be set.

While the RCTs relate water salinity in those target areas where the water quality asset is threatened, monitoring should also continue to be supported on a region-wide basis so that emerging threats can be identified. Such support could be provided as in-kind or co-investment to research organisations, universities, schools, LandCare and community groups for programs ranging from research projects to Waterwatch.

Requirements:

1. Support the continued salinity monitoring of the stream gauging stations in the Corangamite region by DSE, and the monitoring by Barwon Water, Central Highlands Water and others. This should extend to areas outside of the SAP target areas as appropriate (eg. waterwatch).

2. Establish a gauging station in Naringhil Creek, downstream from the Pittong SAP target area. This action was recommended in SAP Background Report 6, and as a high priority recommendation in the SKM Benchmarking report (refer to Table 3.2).

3. Commence monitoring the EC in Illabarook Creek, Mount Misery Creek, Kuruc A Ruc Creek and Ferrars Creek downstream from the Illabarook SAP target area. At present there is little or no waterwatch data available for the Woady Yaloak River system, and the relative proportion of salt contributed by the tributaries is unknown. Regular monitoring of salinity in the tributaries draining the Illabarook target area will help target the salinity management actions. Two or three years of data will also be a useful guide to where a long term gauging station should be established so that an RCT can be established by 2012.

4. In 2008, establish an RCT for EC at the Browns Waterholes gauge (234212). Salinity monitoring at Browns Waterholes has only recently recommenced and the data record is too short for the setting of a target. By 2008 the record of monitoring should be sufficient to set an EC target.

5. Investigate the reasons for the intermittent record and poor quality EC data from the Thompson Creek gauge at Ghazeepore (235255), and remediate the problem so that an EC target can be set by 2008. This investigation was also a recommended (albeit a low priority recommendation) in the SKM Benchmarking report (refer to Table 3.2).

RCT	Target area	Target
W1	Upper West Moorabool	By 2015, <700 EC 90% of time @ Lal Lal reservoir
W2		<1000 EC 90% of time @ Lal Lal gauge (232210)
W3	Morrisons – Sheoaks	By 2015, <800 EC 90% of time @ Sheoaks off-take
W4		<2500 EC 90% of time @ Batesford gauge (232202)
W5	Pittong	<8000 EC 90% of time @ Cressy gauge (234201)
W6		By 2012, establish EC target for Naringhil Creek
W8	Illabarook	<8000 EC 90% of time @ Cressy gauge (234201)
W9		By 2012, establish EC targets for Woady River tributaries
W11	Lismore – Derrinallum	By 2008, establish EC target for Browns Waterholes gauge (234212).
W15	Lake Corangamite	<2500 EC 90% of time at Pirron Yallock gauge (234203)
W24	Warncoort	<25000 EC 95% of time at Ricketts Marsh gauge (233211)
W31	Modewarre	By 2008, establish EC target for Thompson Creek

Table 7.2 RCTs for surface water salinity

7.3 Aquatic and estuarine ecosystem integrity

Nine RCTs are set for aquatic and estuarine ecosystem integrity (Table 7.3).

RCT	Target area	Target
E10	Lismore – Derrinallum	By 2010, establish EC range for Lake Tooliorook
E14	Lake Corangamite	By 2010, establish EC ranges for lakes Corangamite, Gnarpurt, Martin & Cundare Pool
E18		By 2015, no net loss in area of primary salinity, compared to 2005
E20	Colac – Eurack	By 2010, establish EC ranges for lakes Colac & Beeac, & Lough Calvert
E23		By 2015, no net loss in area of primary salinity, compared to 2005
E30	Modewarre	By 2010, establish EC ranges for Lake Modewarre, Gherang & Browns swamps
E33	Geelong – Lake Connewarre	By 2015, no net loss in area of primary salinity, compared to 2005
E35		By 2015, establish EC ranges for Lower Barwon Wetlands and Thompson Creek estuary.
E37	Lara	By 2015, no net loss in area of primary salinity, compared to 2005

Table 7.3 RCTs for aquatic and estuarine ecosystem integrity

For all of these RCTs monitoring protocols and catchment health sites need to be established. For monitoring the loss or gain in the primary saline land and/or wetlands, the aerial extent can be measured using periodic measurements with GPS, or remote sensing (including geophysical techniques). Although the methods are yet to be established, the PIRVic salinity monitoring protocols (Clark & Allan 2005) and the Index of Wetland Condition (DSE 2005) provide the guiding framework.

As for the land salinity and water salinity monitoring, the monitoring of salinity in wetlands and estuaries outside of the SAP target areas should also be continued through supporting those organisations already involved in such activities.

Requirements:

1. Investigate the historical monitoring record for the target areas and sites listed in Table 7.3 and commence monitoring to benchmark the values. Provided the monitoring program commences immediately, there should be enough record to attempt setting an RCT by 2010.
2. Continue supporting organisations involved in the monitoring of wetland and estuarine salinity on a region-wide scale.

7.4 Infrastructure integrity

Eight RCTs have been set to maintain the integrity of urban infrastructure and roads (Table 7.4).

RCT	**Target area**	**Target**
I12	Lismore - Derrinallum	By 2015 80% of roads in saline areas managed to prevent deterioration equivalent to non-saline areas
I16	Lake Corangamite	
I19	Colac - Eurack	By 2015 reduce urban saline areas by 90%
I21		By 2015 80% of roads in saline areas managed to prevent deterioration equivalent to non-saline areas
I26	Warncoort	
I28	Murdeduke	
I32	Modewarre	
I36	Geelong – Lake Connewarre	

Table 7.4 RCTs for integrity of urban infrastructure and roads

Monitoring protocols and catchment health sites are yet to be determined for these RCTs. It is envisaged that monitoring would be jointly undertaken with the municipalities represented in each target area. For the monitoring of road management, it is probable that the maintenance records of municipal road works would be used. The RCT related to urban infrastructure in the City of Colac will require monitoring before and after the proposed SMO and other changes to the planning scheme are implemented.

Requirements:

1. Commence monitoring of road maintenance records for the target areas listed in Table 7.4 in conjunction with the municipalities and VicRoads.

2. Monitor the changes to the designated residential zone affected by land salinity within the urban area of the City of Colac once the changes to the Colac Otway Planning Scheme have been implemented as a result of the SMO project.

8 Research requirements

As documented in this report, since the completion of the Regional Draft SAP in July 2003, a number of research projects have been completed or are currently being undertaken. The status of the original research projects listed in Background Report 6 is tabulated below (Table 8.1).

Research project	Priority	Comment
Disaggregate groundwater flow systems for the volcanic plains	High	Being undertaken by CSIRO. Due for completion June 2006.
Test Gravel Cap hypothesis for salinity in Morrisons – Sheoaks and Illabarook	High	Not commenced.
Review GSHARP model	High	Not commenced. GSHARP may now be superseded.
Improve shallow watertable model	High	Completed by SKM 2005. Needs more research on water quality.
Discriminate agricultural land asset value for GSHARP model	High	Not commenced. May no longer be required.
Complete stream salinity trends	High	Completed by CSIRO 2003. Being re-run 2006
Complete trend analysis for bore hydrographs	High	Partly undertaken in Bore Database project. More research required.
Expand discharge treatment options	High	Partly undertaken by SGSL projects. More research required.
Research impacts of discharge management.	High	Not commenced
Expand recharge control options	High	Not commenced
Research role of deep rooted perennial pastures	High	Undertaken by CRC Salinity in the Evergraze projects. More research required.
Research reasons for rising salt trends in Moorabool River	High	Stage one commenced 2006 by Ballarat University. Stages two and three still require funding.
Improving the cost-benefit assumptions	High	Not commenced
Improve knowledge of all groundwater flow systems	Medium	Partly addressed in CSIRO and Ballarat Uni research projects. Change to low priority.
Improve environmental assets in GSHARP model	Medium	Partly addressed with conservation significance in SAP finalisation. Needs more research.
Improve cultural and heritage assets in GSHARP model	Medium	Not commenced. May no longer be required.
Improve infrastructure assets in GSHARP model	Medium	Not commenced. May no longer be required.
Include municipal planning schemes in GSHARP model	Medium	Not commenced. May no longer be required.
Include Index of Stream Condition in GSHARP model	Medium	Not commenced. May no longer be required.
Analyse historical trends for land salinity	Medium	Partly undertaken by DPI and University of Ballarat projects.
Analyse historical trends for wetland salinity	Medium	Not commenced. Now a recommended monitoring action
Investigate salinity impact of raised bed cropping and pulse cropping	Medium	Partly undertaken by DPI
Research reasons for stream salinity trends	Medium	Not commenced
Improve parameters for Flowtube models	Medium	Partly addressed in CSIRO and Ballarat Uni research projects. Change to low priority.
Research impacts of salinity treatment to date	Medium	Not commenced. Change to high priority.
Investigate valuing of non-market benefits	Low	Not commenced

Table 8.1 Status of research projects listed in 2003

In addition to the research projects listed in Table 8.1, a number of projects were recommended in SAP Background Report 6 to set the RCTs. This report has now addressed many of those and the revised RCTs have also changed some of the research priorities that were originally listed.

Taking into account the completed research, the research underway, the revised RCTs, and the new knowledge and information listed in this report, the recommended research program has been revised as tabulated below (Table 8.2).

	Research project	Priority	Comment
1	Research reasons for rising salt trends in Moorabool River.	High	Stage one commenced 2006 by Ballarat University. Stages two and three still required.
2	Disaggregate groundwater flow systems for the volcanic plains.	High	Being undertaken by CSIRO. Scheduled completion June 2006.
3	Research the impact of raising the level of Lake Corangamite on the area of land salinity in the surrounding area.	High	If the CCMA Board adopts the recommendations of the GHD study, this research requires completion before June 2009.
4	Research groundwater dependent ecosystems for improved salinity management.	High	Commencing in January 2006 (CSIRO). Scheduled completion December 2007.
5	Research the threat of salinity on vegetation of high conservation significance.	High	The threat of salinity to vegetation of high conservation significance needs to be better understood to improve salinity management options.
6	Test Gravel Cap hypothesis for salinity in Morrisons – Sheoaks and Illabarook target areas.	High	This research needs to commence in conjunction with the establishment of the broadscale tree plantations in the Morrisons – Sheoaks target area.
7	Research options for discharge management.	High	Partly undertaken by SGSL projects. More research is required on possible engineering and agronomic options.
8	Research impacts of discharge management.	High	This research needs to commence in conjunction with the establishment of discharge management works in target areas.
9	Improving the cost-benefit assumptions	High	The on-site and off-site benefits for SAP implementation are poorly known. Research into the true value of improved water quality and biodiversity, etc. could vastly improve the cost-benefit analysis.
10	Research on-site and off-site impacts of salinity treatment to date.	Medium	Quantifying the effects of salinity treatment to date would greatly assist in calculating realistic RCTs and effectiveness of salinity investment.
11	Review the model for selecting priority areas for salinity management, including the layers and their values and weightings.	Medium	The GSHARP model may no longer be the most appropriate model to determine priority areas. A risk management model would be more appropriate. The revision of SAP target areas should be commenced in 2008.
12	Research options for salinity management using recharge control.	Medium	Aside from vegetation, engineering options may provide effective alternatives for recharge control.
13	Research role of deep rooted perennial pastures.	Low	Undertaken by CRC Salinity in the Evergraze projects.
14	Improve salinity process models, especially in relation to the cause and effect.	Low	Opportunities for co-investment to support on-going research by research organisations on the role of climate and soil hydrology in salinity processes.
15	Improve knowledge of all groundwater flow systems.	Low	Partly addressed in CSIRO and Ballarat Uni research projects. Opportunities to co-invest in on-going research.
16	Research the reasons for the historical trends for land and water salinity.	Low	Partly undertaken by DPI and University projects. Opportunities for co-investment in on-going research projects.
17	Investigate salinity impact of raised bed cropping and pulse cropping.	Low	Partly undertaken by DPI and PIRVic. Opportunities to co-invest in on-going research.
18	Improve parameters for numerical hydrology and land-use models.	Low	Partly addressed in CSIRO, PIRVic and University research projects. Opportunities to co-invest in on-going research.
19	Research improved methods for valuing of non-market benefits.	Low	Opportunities for co-investment to support on-going research by research organisations.

Table 8.2 Recommended SAP research projects.

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Appendix A RCTs in the Regional Draft SAP, 2003

RCT	Upper West Moorabool
1	Establish the cause(s) of rising salinity trends in the Lal Lal Reservoir by June 2005.
2	Maintain the EC as measured in the Lal Lal Reservoir (Tower surface) below 700 µS/cm until 2010.
3	Establish an appropriate end of valley target for the EC value measured at the Lal Lal gauging station (# 232210) on the West Branch of the Moorabool River by June 2006.
	Morrisons-Sheoaks
4	Establish the cause(s) of rising salinity trends in the Morrisons-Sheaoks target area by June 2005.
5	Maintain the EC as measured at the Sheoaks off-take below 800 µS/cm for 95% of the time until 2010.
6	Establish an appropriate end-of-valley target for the EC value for the Moorabool River as measured at the Batesford Gauging Station (# 232202) by June 2006.
	Pittong
7	Establish the suitable salinity targets to measure the level of risk to the ecology of the Woady Yaloak River system from either increasing or decreasing salinity by 2006.
8	Establish a target for EC measured in the Naringhil Creek at the edge of the Pittong target area by 2006
	Illabarook
9	Establish suitable salinity targets to measure the level of risk to the ecology of the Woady Yaloak River system from either increasing or decreasing salinity by 2006.
10	Establish targets for EC measured in the major tributaries to the Woady Yaloak River at the edge of the Illabarook target area by 2006
	Lismore – Derrinallum
11	Establish a target for salinity measured at appropriate sites in Lake Tooliorook by 2006.
12	Establish a target for EC measured at the gauging station in Browns Waterholes (# 234212) by 2006
13	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
14	In the Lismore-Derrinallum target area there should be no net gain in the area affected by secondary saline discharge by 2010.
	Lake Corangamite
15	Establish targets for salinity measured at appropriate monitoring sites in Lake Corangamite, Lake Gnarpurt, Lake Martin and Cundare Pool by 2005.
16	Establish target ranges of salinity for key environmental sites such as refugia by 2006.
17	Establish a target for EC measured at the Pirron Yallock gauging station (# 234203) by 2005
18	Establish suitable targets on primary saline sites (private and public land) to measure the level of risk to the ecology from either increasing or decreasing salinity by 2006.
19	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
20	In the Lake Corangamite target area there should be no net gain in the area affected by secondary saline discharge by 2010.

Table A1(a) RCTs set in the Regional Draft SAP, 2003 (continued over page)

RCT	Colac – Eurack
21	Reduce the area of land affected by salinity (saline discharge areas) within the residential zone of the City of Colac by 80% by 2010.
22	Establish targets for salinity measured at appropriate monitoring sites in Lake Colac, Lake Beeac and Lough Calvert by 2005.
23	Establish target ranges of salinity for key environmental sites such as refugia by 2006.
24	Establish suitable targets on primary saline sites (private and public land) to measure the level of risk to the ecology from either increasing or decreasing salinity by 2006.
25	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
26	In the Colac - Eurack target area there should be no net gain in the area affected by secondary saline discharge by 2010.
	Warncoort
27	Establish an appropriate end-of-valley target for the EC value of the Birregurra Creek at the Ricketts Marsh gauging station by 2006.
28	In the Warncoort target area there should be no net gain in the area affected by saline discharge by 2010.
29	Although the shallow saline groundwater has resulted in primary salinity, improved discharge management should aim at preventing the further spread of the saline area.
30	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
	Murdeduke
31	In the Murdeduke target area there should be no net gain in the area affected by saline discharge by 2010.
32	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
33	Establish suitable targets on primary saline sites (private and public land) to measure the level of risk to the ecology from either increasing or decreasing salinity by 2006.
	Modewarre
34	In the Modewarre target area there should be no net gain in the area affected by secondary saline discharge by 2010.
35	Establish a target for salinity measured at appropriate sites in Lake Modewarre, Gherang and Browns Swamps by 2010.
36	Establish an appropriate end of valley target for salinity measured in Thompson Creek at the edge of the Modewarre target area by 2006.
37	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
	Geelong – Lake Connewarre
38	In the Geelong – Lake Connewarre target area there should be no net loss in the area affected by primary salinity by 2010.
39	In the Geelong – Lake Connewarre target area there should be no net gain in the area affected by secondary salinity by 2010.
40	Establish a target for salinity measured at appropriate sites in the Lower Barwon wetlands and the Thompson Creek estuary by 2010.
41	Ensure that 80% of the roads in saline areas are managed to prevent deterioration at rates equivalent to non-saline areas by 2010.
	Lara
42	In the Lara target area there should be no net loss in the area affected by primary salinity by 2010.

Table A1(b) RCTs set in the Regional Draft SAP, 2003 (continued from previous page)

Appendix B Salinity trend analyses, 2003

Gauge Number	Station name	EC Records		Salt	Mean EC	EC trend
		Start	End	t/day	µS/cm	µS/cm/yr
232202	Moorabool River @ Batesford	Nov-76	Oct-01	78	1459	18.7 ± 7..0
232204	Moorabool River @ Morrisons	Nov-76	Jun-01	44	643	-0.8 ± 2.6
232210	Moorabool River West Branch @ Lal Lal	Dec-76	Jul-01	6	419	1.3 ± 1.0
232211	Moorabool River West Branch @ Mount Doran	Nov-76	Jul-90	21	473	10.9 ± 2.7
233200	Barwon River @ Pollocksford	Nov-76	Oct-01	521	2015	-33.6 ± 10.5
233211	Birregurra Creek @ Ricketts Marsh	Oct-76	Oct-01	286	10420	-156.1 ± 105.4
233214	Barwon River East Branch @ Forrest	Mar-78	Aug-01	3	150	-0.1 ± 0.3
233215	Leigh River @ Mount Mercer	Nov-76	Sep-01	82	1146	-1.4 ± 3.8
233218	Barwon River @ Inverleigh	Oct-76	Jun-01	330	2196	-21.7 ± 13.9
233223	Warrambine Creek @ Warrambine	Nov-76	Jan-84	10	4287	104.2 ± 236.4
233224	Barwon River @ Ricketts Marsh	Oct-76	Jul-01	99	897	-2.2 ± 5.5
233228	Boundary Creek @ Yeodene	Jun-85	Aug-01	4	597	12.8 ± 5.4
234200	Woady Yaloak River @ Pitfield	Nov-76	Jul-90	49	2138	-35.4 ± 35.1
234201	Woady Yaloak River @ Cressy (Yarima)	Nov-76	Sep-01	120	5105	5.0 ± 5.3
234203	Pirron Yallock Creek @ Pirron Yallock	Jan-77	Jul-01	33	1211	5.8 ± 7.4
235202	Gellibrand River @ Upper Gellibrand	Dec-76	Jul-89	8	139	0.4 ± 0.7
235203	Curdies River @ Curdie	Jan-77	Oct-93	183	1194	5.9 ± 7.6
235204	Little Aire Creek @ Beech Forest	Jan-77	Aug-01	2	98	-0.3 ± 0.2
235205	Arkins Creek West Branch @ Wyelangta	May-78	Aug-01	1	100	-0.1 ± 0.3
235208	Gellibrand River @ Carlisle	Dec-76	Feb-88	62	200	0.0 ± 1.3
235209	Aire River @ Beech Forest	Mar-91	Aug-01	3	117	0.0 ± 0.6
235210	Lardner Creek @ Gellibrand	Dec-76	Jun-01	6	154	0.2 ± 0.9
235212	Chapple Creek @ Chapple Vale	Dec-76	Jun-88	4	199	0.4 ± 1.3
235216	Cumberland River @ Lorne	Oct-76	Jun-01	1	18	-0.1 ± 0.2
235219	Aire River @ Wyelangta	Nov-76	Jun-88	16	125	-0.5 ± 0.7
235222	Anglesea River (Salt Creek) @ Anglesea	Aug-76	Nov-82	2	800	160.8 ± 90.0
235223	Scotts Creek @ Scotts Creek	Jan-77	May-87	18	1927	-0.8 ± 36.5
235224	Gellibrand River @ Burrupa	Dec-76	Jul-01	109	273	-0.4 ± 0.7
235226	St George River @ Allenvale	Nov-76	Jun-88	2	186	0.3 ± 1.4
235227	Gellibrand River @ Bunkers Hill	Dec-76	Aug-01	37	221	-0.6 ± 0.6
235229	Ford River @ Glenaire	Nov-76	May-87	8	169	-1.0 ± 1.0
235232	Painkalac Creek @ Painkalac Creek Dam	Oct-76	Apr-87	2	403	-19.6 ± 8.3
235233	Barham River East Branch @ Apollo Bay Paradise	Nov-77	Jul-90	9	201	0.6 ± 0.9
235234	Love Creek @ Gellibrand	May-79	Jun-01	5	445	-0.8 ± 3.0
235237	Scotts Creek @ Curdie (Digneys Bridge)	Jul-88	Jan-01	162	1468	21.7 ± 21.8
235239	Ten Mile Creek @ Kawarren	May-85	Jan-94	1	429	-12.2 ± 6.8
235240	Yahoo Creek @ Kawarren	May-85	Jan-94	1	439	-6.8 ± 5.3
235241	Porcupine Creek @ Kawarren	May-86	Jan-94	3	334	-8.5 ± 6.4

Table B.1 Results of salinity trend analysis, July 2003.

Appendix C Ecological Vegetation Class Bioregion Conservation Status

Ecological Vegetation Class Bioregion Conservation Status - Intersections with 2005 salinity polygons

Target Area	SAP Priority	Total mapped salt hectares	Ecological Vegetation Class	Number of polygons	Total Area hectares	Total Perimeter kilometres	Percentage of ma
Corangamite	1	4247.05	Aquatic Herbland/Plains Sedgy Wetland Mosaic	4	0.6	0.7	0.0
			Floodplain Riparian Woodland	43	64.2	34.5	1.5
			Grassy Woodland	9	2.2	1.9	0.1
			Plains Grassland/Plains Grassy Woodland Mosaic	20	12.4	7.4	0.3
			Plains Grassy Wetland	12	4.7	3.5	0.1
			Plains Grassy Woodland	31	38.0	23.7	0.9
			Plains Sedgy Wetland	13	22.2	6.3	0.5
			Stony Rises Woodland	31	60.6	18.9	1.4
			Swamp Scrub	4	24.3	8.0	0.6
			Water Body - Fresh	39	992.4	126.6	23.4
			Water Body - Salt	40	151.2	29.4	3.6
Morrisons - Sheoaks	2	62.9031	Grassy Dry Forest	1	0.1	0.2	0.2
			Plains Grassland	1	1.3	0.6	2.0
			Plains Grassy Woodland	14	3.1	2.5	5.0
			Valley Grassy Forest	4	0.6	0.7	0.9
Upper West Moorabool	3	15.2233	Grassy Woodland	2	0.8	0.6	5.0
			Plains Grassy Woodland	2	0.1	0.2	0.8
			Swampy Riparian Woodland	1	0.0	0.1	0.2
Colac - Eurack	4	4410.18	Grassy Woodland	11	6.5	4.4	0.1
			Plains Grassy Wetland	2	0.3	0.3	0.0
			Plains Grassy Woodland	33	52.8	21.4	1.2
			Plains Sedgy Wetland	9	3.0	2.5	0.1
			Swamp Scrub	24	10.3	7.4	0.2
			Water Body - Fresh	7	27.7	6.7	0.6
			Water Body - Natural or man made	2	0.5	0.6	0.0
			Water Body - Salt	28	637.5	46.8	14.5
Geelong - Lake Connewarre	5	4195.39	Cane Grass-Lignum Halophytic Herbland	3	84.3	7.9	2.0
			Coastal Alkaline Scrub	72	67.2	37.5	1.6
			Coastal Dune Scrub/Coastal Dune Grassland Mosaic	2	1.0	1.2	0.0
			Coastal Saltmarsh/Mangrove Shrubland Mosaic	57	1468.5	126.1	35.0
			Damp Sands Herb-rich Woodland	3	3.2	1.9	0.1
			Floodplain Riparian Woodland	6	10.8	7.4	0.3
			Grassy Woodland	37	13.2	10.3	0.3
			Lignum Wetland	3	1.1	0.8	0.0
			Mangrove Shrubland	22	37.9	12.3	0.9
			Plains Brackish Sedge Wetland	1	16.0	2.8	0.4
			Plains Freshwater Sedge Wetland	2	81.6	8.8	1.9
			Plains Grassland	14	11.3	7.3	0.3
			Plains Grassy Woodland	6	2.3	1.9	0.1
			Plains Sedgy Wetland	1	0.2	0.2	0.0
			Reed Swamp	2	513.5	9.9	12.2
			Seasonally Inundated Sub-saline Herbland	2	58.1	4.8	1.4
			Water Body - Fresh	18	76.6	52.5	1.8
			Water Body - Natural or man made	3	0.6	0.7	0.0
Illabarook	6	377.252	Cleared/Severely Disturbed	5	1.4	0.9	0.4
			Conifer Plantation	2	14.2	3.4	3.8
			Grassy Dry Forest	3	0.2	0.4	0.1
			Grassy Woodland	18	2.7	3.0	0.7
			Heathy Dry Forest	21	18.3	9.4	4.9
			Plantation (undefined)	1	3.7	1.0	1.0
			Riparian Woodland	3	0.2	0.5	0.1
			Valley Grassy Forest	22	16.8	9.0	4.5
Pittong	7	214.598	Grassy Woodland	10	3.3	2.4	1.5
			Plains Grassy Wetland	9	1.4	1.5	0.7
Lismore - Derrinallum	8	1859.55	Grassy Woodland	5	0.5	0.6	0.0
			Plains Grassland/Plains Grassy Woodland Mosaic	48	15.4	11.5	0.8
			Plains Grassy Wetland	9	2.7	2.2	0.1
			Plains Grassy Woodland	9	0.7	1.4	0.0
			Plains Sedgy Wetland	5	2.3	1.5	0.1
			Stony Rises Woodland	13	2.3	2.1	0.1
			Water Body - Fresh	17	6.1	4.2	0.3
			Water Body - Salt	7	0.9	1.1	0.1
Murdeduke	9	756.26	Floodplain Riparian Woodland	6	0.7	1.0	0.1
			Plains Grassland/Plains Grassy Woodland Mosaic	1	0.1	0.1	0.0
			Plains Grassy Woodland	7	0.8	1.0	0.1
			Plains Sedgy Wetland	4	1.1	0.9	0.1
			Swamp Scrub	3	0.7	0.7	0.1
			Water Body - Salt	10	8.0	4.5	1.1

Ecological Vegetation Class Bioregion Conservation Status - Intersections with 2005 salinity polygons

Target Area | SAP Priority | Total mapped salt hectares | Ecological Vegetation Class | Number of polygons | Total Area hectares | Total Perimeter kilometres | Percentage of ma

Warncoort	10	569.63	Conifer Plantation	1	0.4	0.3	0.1
			Grassy Woodland	9	3.5	2.3	0.6
			Plains Grassy Woodland	3	0.6	0.6	0.1
			Plains Sedgy Wetland	1	0.2	0.2	0.0
			Stony Rises Woodland	2	0.2	0.2	0.0
Modewarre	11	543.886	Damp Sands Herb-rich Woodland	3	0.2	0.4	0.0
			Grassy Woodland	26	5.5	5.2	1.0
			Lowland Forest	2	0.1	0.3	0.0
			Plains Grassy Woodland	2	0.2	0.3	0.0
			Plains Sedgy Wetland	1	0.8	0.4	0.1
			Swamp Scrub	21	17.5	9.3	3.2
			Swampy Riparian Woodland	35	5.9	7.6	1.1
			Water Body - Salt	1	2.6	1.2	0.5
Lara	12	1218.04	Coastal Saltmarsh/Mangrove Shrubland Mosaic	21	277.9	30.5	22.8
			Coastal Tussock Grassland	1	30.7	4.1	2.5
			Creekline Grassy Woodland	3	3.5	2.9	0.3
			Mangrove Shrubland	13	5.9	5.2	0.5
			Plains Grassland	24	39.0	11.6	3.2
			Plains Grassy Woodland	10	7.1	4.5	0.6
			Water Body - Salt	1	3.2	0.8	0.3