New South Wales
Government

Taking on the challenge

NSW Salinity Strategy

Salinity Targets Supplementary Paper

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Contents

Executive Summary

In August 2000, the NSW Government released the NSW Salinity Strategy, based on the recommendations of a Salinity Summit held in March 2000. The Strategy signals a new way of managing salinity in NSW.

In the past, we have divided salinity into different types (dryland, irrigation, urban and river) and based our management of salinity on these divisions. These programs have brought some localised outcomes. However, this divided approach has limited our ability to treat the issue as a whole.

The evolution towards the use of better tools in NSW began in 1997 when community consultation led to the setting of threshold levels and salinity ranges for NSW catchments. However, it wasn't until the 1999 Salinity Audit of NSW that we had the public awareness, level of understanding of salinity processes and modelling capabilities necessary to develop salinity targets.

Salinity targets will be the main tool for planning salinity management, guiding our choice and the location of actions on the ground, and measuring our performance.

Salinity targets will enable us to:

- quantify desirable salinity outcomes;
- manage the cumulative impact of actions at various sites;
- compare the environmental, economic and social benefits and costs of different actions; and
- choose the most cost-effective actions to treat the problem.

There are two types of salinity targets:

- end-of-valley target: a **water quality target** at the end reach of a river that expresses the overall salinity condition to aim for, and;
- within-valley target: a **water** or **land-based target** within a catchment that expresses the salinity level to aim for at that location.

Salinity targets will express the salinity conditions and actions we want in our catchments by 2010 and will lay the foundations for salinity management well into the future.

Based on recommendations of the Salinity Summit, the NSW Government has commissioned the recently established catchment management boards (CMBs) to recommend salinity targets. The first phase for CMBs in inland catchments is to review the NSW Government's interim end-of-valley salinity targets, by 1 March 2001.

To ensure that the interim targets are appropriate, CMBs and the NSW Government need to consider related strategies. Most important of these are the Murray-Darling Basin Ministerial Council’s Salinity and Drainage Strategy and the recently released draft Basin Salinity Management Strategy.

Both of these strategies aim to maintain salinity below the desirable limit for drinking water at Morgan, South Australia. Under these strategies, the NSW Government has undertaken to prevent any net increase in salinity in the Murray River passing to Victoria and South Australia. For those valleys in the Murray-Darling Basin (MDB), the end-of-valley salinity targets we set and our success in achieving them, will contribute to our commitment to the Murray-Darling Basin initiative.

CMBs in the MDB and relevant bodies in the Hunter Valley and Western Sydney, are working to make recommendations on within-valley salinity targets and actions by September 2001 in their catchment management plans (CMPs).

Salinity targets will provide the direction for developing other natural resource targets that impact on salinity, such as vegetation clearing. The CMBs' catchment management planning process will allow us to consider the connections between all these targets.

The NSW Government will conduct a comprehensive review of our performance in meeting salinity targets every five years, coinciding with the proposed audits for the Murray-Darling Basin Commission. These reviews will provide an understanding of progress over time: how salinity levels are changing and whether actions are slowing down the increase in salinity. They will also present information about the performance of the CMPs to improve salinity management.

Reviews will also give us new information about salinity processes that will improve our models, allow us to refine our predictions and trends and reassess the effectiveness of actions to address salinity.

Setting salinity targets

To set the end-of-valley and within-valley salinity targets we need to quantify the level of salinity we want at the end of the river and at significant locations in the catchment. To do this, we identify the risks that the predicted increases in salinity pose to our land and water-based assets and values, and define an acceptable level of risk. It is necessary to calculate the salinity levels this would represent and evaluate if this is achievable and acceptable.

We then need to decide on actions to achieve salinity targets, by examining locations for possible actions within the catchment and considering issues such as landscape features, biophysical attributes, timeframes, the effectiveness of actions on the hydrological balance and socio-economic impacts. We then identify and quantify the most effective combination of actions.

Chapter 1 Introduction

1.1 About the paper

This paper provides details on the use of salinity targets as a key tool for managing salinity in NSW. It discusses the role of salinity targets and the method for setting and reviewing them. The paper is written for:

- members of CMBs to help them make recommendations on salinity targets;
- members of the community wanting to know about salinity targets in their catchment; and
- those interested in the approach, rationale and science behind using targets to manage salinity.

While this paper focuses on salinity targets, the approach described can be modified and used for setting other natural resource management targets.

Introduction:	describes the current situation and the role that salinity targets will play in salinity management.
Chapter two:	explains the case for salinity targets in NSW and the links between NSW, the Murray-Darling Basin and national salinity strategies.
Chapter three:	examines how to set salinity targets and choose actions, and explains how the NSW Government developed the interim end-ofvalley salinity targets.
Chapter four:	describes how we will review salinity management and the targets.
Appendices:	include a summary of the technical terms and concepts in the paper and the interim end-of-valley salinity targets for inland catchments.

Figure 1: Quick guide to the paper

This paper is one of three of the NSW Government's supplementary papers to the NSW Salinity Strategy[1]. A discussion paper on offsets for vegetation clearing with salinity impacts and a supplementary paper on identifying salinity hazards will be published in December 2000.

1.2 Current context

Salinity levels in many catchments are increasing. If we accept 'business as usual', rising salinity levels are predicted to have severe costs to communities, economies and the environment[1]. In August 2000, the NSW Government released *Taking on the Challenge: The NSW Salinity Strategy*, based on the recommendations of a Salinity Summit[2]. The NSW Salinity Strategy is a bold attempt to manage salinity on a scale which has not previously been attempted. It proposes a comprehensive series of tools to slow down the increase in salinity in the long term.

One of the key mechanisms of this new way of managing salinity is salinity targets. The working group on targets at the Salinity Summit recommended the:

> *'Development of agreed valley based salinity targets implemented over time that incorporate the following considerations:*
> - *land use;*
> - *river water quality (electrical conductivity and salt loads);*
> - *range of targets; and*
> - *basin, catchment and local applications in priority impact areas (recharge and critical off-site impacts).[2]'*

This paper describes the process for achieving this recommendation.

1.2.1 Types of salinity targets

The NSW Salinity Strategy describes salinity targets in broad terms. During consultations after the release of the NSW Salinity Strategy, communities said it was necessary to revise the terms to avoid possible ambiguities. In response, and to align with the *draft Murray-Darling Basin Salinity Management Strategy 2001-2015*[3], the Government has subdivided the term 'management target', as shown in Table 1.

Table 1: Types of salinity targets

Terms used in the NSW Salinity Strategy (and the support package for CMB members[4])	**Corresponding terms used in this paper**
End-of-valley salinity target *(the catchment target for salinity)*	End-of-valley salinity target
Management targets	Within-valley salinity targets
	Actions

End-of-valley salinity target

An end-of-valley salinity target is a river-based target for salinity at a point in the lower reach of a catchment's main river. This target expresses the salinity condition we want a catchment in 2010. The end-of-valley salinity target expresses what communities consider is an acceptable and achievable level of salinity risk for important social, environmental and economic assets and values. An example of an end-of-valley salinity target is that 'median salt loads for the Namoi Valley, measured at Goangra, will not exceed 55,000 tonnes per year by 2010'.

Within-valley salinity targets

Within-valley targets express the salinity levels desired to maintain important social, environmental and economic assets and values for locations or areas within the catchment. Within-valley targets are upstream of the end-of-valley salinity target. We can describe them with indicators related to water or land. An example of a within-valley salinity target is that ‘the area of salt-affected land in the catchment will not increase by more than 10 percent by 2010’.

One aim of within-valley salinity targets is to set maximum salinity levels in landscapes that contribute significantly to rising salinity or are important for understanding salinity processes in the catchment. For example, we may want a within-valley salinity target at a mid-point of a catchment, where the impact of actions in the upper reaches (tablelands and slopes) is different from that in the lower reaches (plains). Within-valley targets express the main changes in salinity needed within the catchment to meet the end-of-valley salinity target. Within-valley targets can also be used to protect important assets or values, for example near a wetland.

There are a range of appropriate salinity indicators for within-valley salinity targets including electrical conductivity (EC), salt load, groundwater levels, recharge and area of salt affected land. For example, a target based on groundwater level could be used as an early indicator in the Gwydir, where, in general, groundwater levels are unlikely to reach the surface for another twenty years.

Actions

It is necessary to develop and implement actions, such as tree-planting, revegetation and water-use efficiency, to achieve salinity targets. The actions agreed to manage salinity in the catchment will be the group of actions that most effectively deliver the social, environmental and economic outcomes, and achieve the salinity targets. We will need to determine the most effective location and quantify each of these actions (for example, ‘introduce perennial pastures to 10 per cent of areas currently sown with annuals, by 2010’).

1.2.2 The role of catchment management boards

Participants at the Salinity Summit stated:

> *‘Catchment management boards, with appropriate funding and empowerment, in partnership with government, are the primary bodies to facilitate community consultation for the setting of targets and subsequent implementation of natural resource management including salinity’*

and that:

> *‘Salinity targets need to be given effect through an instrument i.e. catchment strategy / plan.’*

In response, the NSW Government has commissioned the newly established CMBs to undertake the direction setting for salinity management at a catchment level. They will carry out their work in two phases:

Phase 1: Recommend end-of-valley salinity targets

The first task for inland CMBs will be to examine the interim end-of-valley salinity targets in the NSW Salinity Strategy and make recommendations to the NSW Government on these targets (the interim end-of-valley salinity targets are in Appendix 4).

CMBs will consider and agree on targets for salinity that represent acceptable and achievable levels of risk to environmental, economic and social assets and values. In developing their recommendations, the CMBs will broadly identify important within-valley salinity targets and possible actions. They also may need to consider the relevance of other salinity strategies – including those in the Murray-Darling Basin (MDB) and national strategies.

The CMBs have been asked to recommend end-of-valley targets by 1 March 2001. The NSW Government will then assess the recommendations of CMBs and finalise the end-of-valley salinity targets.

Phase 2: Develop actions

The second task for CMBs is to develop a draft Catchment Management Plan (CMP) that:

- recommends within-valley salinity targets;
- recommends actions to meet within-valley and end-of-valley salinity targets, and;
- outlines the rationale for these recommendations.

CMB members will need to define the within-valley targets, both those which contribute directly to the end-of-valley salinity targets and those which achieve local salinity reductions or improvements. CMBs will then need to identify actions for achieving the targets.

The NSW Government has asked CMBs to submit their draft CMP by September 2001. The Government will assess the draft CMPs, which will then be exhibited for public comment. After public exhibition and any amendments, the CMPs will be submitted to Government for approval. For more information about the tasks of CMBs, refer to the CMB Support Package published by the Department of Land and Water Conservation (DLWC).

1.2.3 Coastal catchments

In coastal catchments other than the Hunter Valley, in-stream salinity may not be the most meaningful indicator of salinity, and the impacts of salinity in the catchment may not be meaningfully measured at the end-of-valley. In these cases, CMBs may choose to use within-valley salinity targets rather than end-of-valley salinity targets, as they can use a wider range of measures for salinity.

The NSW Government is conducting salinity audits of coastal areas where salinity is a problem. CMBs in these catchments will also develop salinity targets and CMPs. Even if a CMB chooses not to define an end-of-valley target, the process for setting within-valley targets and developing actions be similar to that for inland catchments.

Western Sydney is facing salinity problems that need to be managed in a way that takes into account the numerous local councils, high population and extensive infrastructure. The NSW Government is preparing salinity hazard maps of Western Sydney that will be released in 2001. Following their release, the NSW Government will work with the Hawkesbury-Nepean Catchment Management Trust to develop salinity targets for Western Sydney.

1.3 The role of salinity targets in salinity management

Salinity targets will play a fundamental role in the salinity management process in NSW over the next ten years. Targets will form the basis of adaptive salinity management, where we use reviews of our performance and new information to improve the way we manage salinity (see Figure 2).

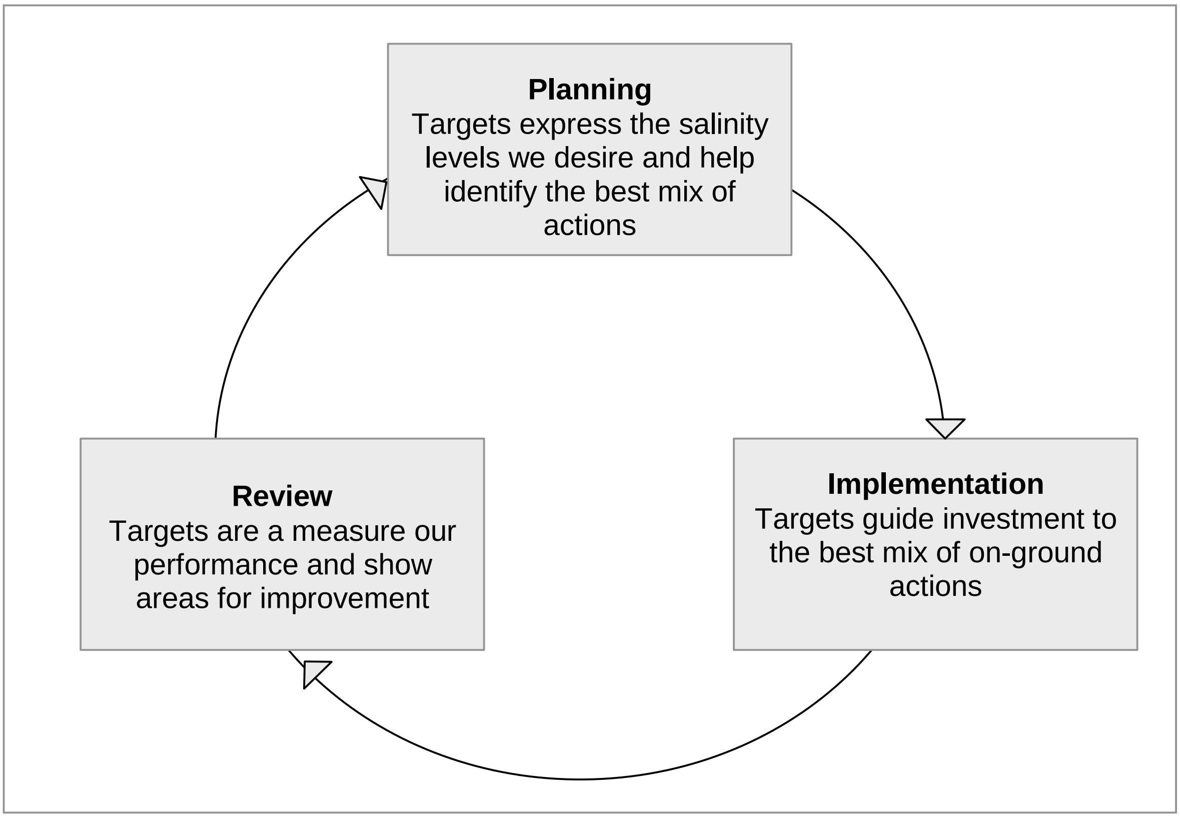

Figure 2: The role of targets in adaptive salinity management in NSW

1.3.1 Planning

Salinity targets will be the main tool to plan salinity management. People will use salinity targets to express the salinity conditions they want in their catchments and to help identify the most effective and acceptable mix of actions to achieve these conditions. Salinity targets and actions should represent a balance between environmental, social and economic benefits and costs. The targets will be the basis of the plan for managing salinity in the catchment, and form one part of a CMP.

The extent of our salinity information varies across the State from good to poor. Even if we do not have good information in some areas, we still can set targets and this will guide the type of information we need to collect in the future.

1.3.2 Implementation

Salinity targets and corresponding actions will guide investment in on-ground actions. Each CMP will include commitments by parties to implement the actions for which they are responsible. The targets will not be binding on land managers directly, but they may influence the regulation of activity by local and state governments. This paper does not cover the implementation of actions. The NSW Salinity Strategy outlines how the Government will use a mixture of market-based solutions, strategic investment, government advice and business opportunities to deliver actions.

1.3.3. Review

Because salinity mitigation is a long-term issue, the review of progress is critical. We will monitor and analyse:

- the rate of salinity increases;
- the implementation of actions; and
- the effectiveness of the actions in meeting economic, social and environmental outcomes.

Targets are intended to show how well the NSW Salinity Strategy is working, in the interests of putting resources into the most effective measures, and modifying the approach as new information reveals what is working well and what can be improved. There are many factors that may cause salinity to deviate from original predictions. If we do not progress as expected (whether exceeding or falling short of targets), the targets will draw attention to the rate of progress and we can change salinity management accordingly.

We will review targets as our knowledge of both salinity processes and the effectiveness of actions improves (see *Reviewing salinity management,* page 36).

1.4 Links with other natural resource targets

Salinity targets are one set of targets that the NSW Government is introducing to drive natural resource management. Under the Native Vegetation Reforms, the Government has made a commitment to develop and implement vegetation retention and revegetation targets across NSW. The NSW Government will develop state-level and interim vegetation targets and will take into account input from regional vegetation committees, CMBs and local government before approving final targets. The Government will define timeframes and accountabilities for achievement as part of the target setting process. Performance indicators for these targets will include rate of clearing and annual increase in area protected (vegetation retention targets), and area of land revegetated (revegetation targets).

CMBs, regional vegetation committees and the NSW Government will need to work together to ensure that vegetation and salinity targets are consistent with each other; and that combined targets drive actions that produce the maximum overall benefit. The CMPs will serve an integrating function, providing context for the targets recommended by regional vegetation and water management committees. The CMPs will build on planning work already undertaken by these committees and by the former catchment management committees.

The MDBMC is proposing targets as a key feature of all future natural resource management strategies in the MDB. The MDBMC has published the draft *Integrated Catchment Management in the Murray-Darling Basin 2001-2010*[5], which promotes natural resource strategies in the MDB level that are guided by targets and linked to state and catchment-based strategies. The new draft Basin Salinity Management Strategy is the first strategy under this integrated catchment management (ICM) approach.

Chapter 2

Background to salinity targets in NSW

2.1 The case for salinity targets

In the past, we have divided salinity into different types (dryland, irrigation, urban and river) and based our management of salinity on these divisions. These programs have brought some localised outcomes.

However, this divided approach has limited our ability to treat the issue as a whole.

Salinity targets offer a new approach to managing salinity. They will enable us to:

- quantify desirable salinity outcomes;
- manage the cumulative impact of actions at various sites;
- see environmental actions within their social and economic contexts and ensure that actions are socially and economically sustainable;
- compare the overall costs and benefits of different actions; and
- invest in actions that make the most difference.

In the past, governments and communities rarely used targets due to a lack of fundamental information. The evolution towards the use of targets in NSW began in 1997 when we set water quality objectives (WQOs) for salinity. The Salinity Audit of NSW[6] conducted in 1999, provided information on salinity trends. This, together with an increasing understanding of the impacts on assets and values, allowed us to develop the methodology to set salinity targets.

2.1.1. The Interim Environmental Objectives for Water Quality

The evolution towards salinity targets began in 1997 and 1998 when NSW communities and the Government participated in consultation to determine which 'environmental values' communities wanted to protect in their waterways. The community consultation led to a set of interim environmental objectives (IEOs) for water quality and river flow for every catchment in NSW[7].

The IEOs set out the environmental values that each catchment community chose to protect. Environmental values took into account not only the protection of the natural environment (for example, the protection of aquatic ecosystems), but also to some extent, social and economic considerations (for example, the protection of drinking water, primary contact recreation, aquatic foods and livestock and irrigation water supply) [see *Appendix 2*, page 48]. The IEOs for water quality are usually termed the Water Quality Objectives (WQOs).

The WQOs are given as threshold levels or a range of levels, including salinity concentrations, which are expected to protect agreed values. The numerical salinity criteria for the WQOs were based on levels recommended to protect the relevant environmental values outlined in the *Australian Water Quality Guidelines for Fresh and Marine Waters*[8] (see *The National Water Quality Guidelines*, page 18).

River, water and groundwater management committees have been guided by these in developing river and groundwater management plans.

The WQOs are useful guidelines for managing salinity, but they do not go far enough for managing salinity effectively. We need targets as well as WQOs for three reasons:

- In catchments where water quality is currently better than the WQO, such as the Murrumbidgee, we may wish to maintain existing water quality.
- In catchments where water quality is approaching or already exceeds the WQO, we may seek to slow the rate of degradation, halt it or even reverse it, if this is practicable in the circumstances. In some circumstances, the WQO may never be attainable, for example in the Castlereagh; in others it may serve only as a long-term target; yet in others, it may be a realistic short-term target.
- For effective salinity management, precise, numerical targets with set timeframes and specified accountabilities are needed. Also, the factors considered for the WQOs were not broad enough for the WQOs to form salinity targets. Factors that need (further) consideration include the predicted salinity trends; the variability of natural systems over time and space; the cumulative impacts of salinity within a catchment; and inter-state obligations.

The WQOs will inform the development of the salinity targets and are a benchmark against which water quality can be measured.

2.1.2 The salinity audits

In the mid 1990s, work by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the DLWC[9,10] on historic trends in salt concentration and salt load indicated that there was an increasing salinity problem in streams in the Murray-Darling Basin (MDB). The conclusions reached during this work led to the *Salinity Audit of the Murray-Darling Basin: A Hundred Year Perspective*[11], to assess the extent of the problem.

This Audit went beyond earlier work in that it took account of climatic variations and diversions. It used modelling to predict future trends, rather than just describing historical trends; and it looked at the potential ecological impacts (for example, on wetlands) of increasing salinities and salt loads. The Salinity Audit of the MDB predicted significant increases in river salinities and salt loads in the Murray and Darling Rivers and the major catchments of these rivers from 1998 to 2020, 2050 and 2100. It improved our salinity information and our predictive capacity on a basin and catchment scale and gave us the information needed to set and review salinity targets.

The Salinity Audit of the MDB was based on predictions undertaken by each state government. In NSW, the predictions were based on the DLWC’s Salinity Audit of NSW which used analyses of regional groundwater levels, in-stream salinities and salt load trends and modelling the mobilisation and movement of salt. The basic assumption was that these rising salinities and salt loads are mainly caused by rising groundwater levels, induced by land use practices.

Trends in groundwater levels were determined by comparing groundwater levels from the late 1980s or early 1990s with groundwater levels recorded at the time of bore construction. Only data from boreholes in fractured rock aquifers were used. Future groundwater levels were estimated by linearly extrapolating the trends.

The approach then involved comparing the 'potential'amount of salt contained in the water delivered to the land surface from groundwater with the actual amount carried in the tributary rivers to the Murray and Darling Rivers between 1975 and 1995. The 'potential' salt load estimates represent an upper limit of the possible salt loads accumulating in the landscape. However, not all this salt will be transported to streams by surface run-off or flow from the ground. It was assumed that what is already getting into the stream is the result of all the relevant processes affecting the delivery of this salt. Therefore, the current pattern of stream flow and salt load identified in the existing measured data already describes the relevant relationships.

This relationship was then used to extrapolate from current salt loads and salinities to future salt loads and salinities, based on rates of change established in the potential salt load from the increased groundwater rising to within two metres of the ground surface.

It was also necessary to incorporate river flow conditions in the predictions using the 1975 to 1995 data record. The salt balances in each of the major NSW catchments for "current" conditions were evaluated by combining salt balances for sub-catchments of 500-1,500 km^2 in area, as this allowed for variations in space and time to be adequately taken into account. A statistical relationship between measured flow and salt load was found for all sub-catchments where flow and salinity data were available as well as for several sites along the main river. For catchments where suitable data were not available, the water and salt balances were computed by transposing model forms from other similar catchments.

A last balance point was determined for each catchment below all the contributing sub-catchments but above the point in the river where diversions to major irrigation districts substantially influence the flow. The salt load at the end of each system was calculated from the ratio of the flow measured at the last balance point and at the end of system. Therefore the salt load going to the irrigation districts or out the end of each river is proportional to the flow.

Once the salt balances for "current" conditions were finalised, predictions of salt load and salinity were derived for 2020, 2050 and 2100 with adjustments to the Cap (1993/94 development conditions and management practices). It was assumed that the extensive low-lying alluvial areas in the western low rainfall areas where runoff is negligible do not contribute salt load to streams except during rare flood events, and therefore were excluded from the groundwater-delivered salt load calculation.

2.2 Links with the Murray-Darling Basin Commission

In the MDB, the Basin states (including NSW) are accountable for a number of natural resource management activities under the Murray-Darling Basin Agreement. Accountabilities for salinity were first defined in *The Salinity and Drainage Strategy* (S&D Strategy) of 1988[12]. These accountabilities are expanded under the recent draft Basin Salinity Management Strategy.

2.2.1 The Salinity and Drainage Strategy

The S&D Strategy was developed to coordinate the management of salinity in the Murray and lower Darling Rivers to address land salinisation and waterlogging in the MDB. It was a significant breakthrough in the management of natural resources in Australia, as it marked the first occasion on which state governments agreed to jointly tackle a specific environmental problem across their borders, including spending funds outside their jurisdiction.

The S&D Strategy aimed to reduce salinity in the 'shared rivers' of the MDB: the Murray River downstream of Hume Dam and the Darling River below Menindee Lakes. Its foundation is a commitment from the governments of New South Wales, Victoria, South Australia and the Commonwealth to ensure that salinity at Morgan in South Australia should be less than 800 EC, 95% of the time.

Under the S&D Strategy, each state is accountable for ensuring that land and water management planning in irrigation areas, activities affecting point sources, and specific works implemented since January 1988, such as drainage schemes and dams, do not lead to an overall increase in salinity in the shared rivers. states are not accountable for the impacts of drainage works constructed before 1 January 1988, growth in diversions between 1988 and 1993/94 or the gradual increase in salinity from tributary rivers and groundwater along the main stem of the Murray River.

The governments of NSW, Victoria and the Commonwealth also agreed to jointly fund suitable salt interception and drainage diversion schemes to reduce average salinity at Morgan in South Australia by 80EC. In exchange, NSW and Victoria can undertake developments that increase the average salinity at Morgan by 15 EC each. The works program to achieve the 80 EC reduction has not yet been completed but, to this end, the MDBMC has recently approved further schemes. Although the works have successfully reduced salinity at Morgan, they have led to an increase in salinities in some rivers receiving water from drainage schemes.

The MDBMC introduced a system of salinity credits and debits to manage the state accountabilities. A state receives a salinity credit for any works or planning measures that reduce average salinity at Morgan by more than 0.1 EC, and a debit for any works or measures that increase the average salinity at Morgan by more than 0.1 EC. The credit or debit is equal to the expected increase or decrease in salinity. Each state must remain in credit to ensure that they do not contribute to an increase in salinity at Morgan.

What's EC?

As salt conducts electricity, one of the most widely used and convenient method of measuring the salinity in water is by electrical conductivity (EC). The higher the EC, the higher the salinity. To give an indication of EC levels, Sydney drinking water ranges from 70-320ECs and sea water is approximately 50,000ECs. To protect 'environmental values', critical EC levels include:

- 280-800 EC for sensitive crops;
- 800 EC for good quality drinking water in terms of taste; and
- 1500 EC for protection of aquatic communities (however, there is no simple threshold below which impacts are negligible or above which impacts are significant).

See Appendix 1 for more information.

2.2.2 The draft Murray-Darling Basin Salinity Management Strategy

When the S & D Strategy was introduced, dryland salinity was considered to have a modest impact that could be offset by the S & D Strategy's works program. In 1999, the Salinity Audit of the MDB showed that the impacts of dryland salinity are more severe than was realised. This led to the development of the draft Basin Salinity Management Strategy 2001-2015 in September 2000.

The draft Basin Salinity Management Strategy broadens states' existing accountabilities. It proposes that from 1 January 2000, states should also be accountable for the impacts of future developments on salinity from:

- activities that affect dryland salinity (that is, diffuse sources), and;
- impacts in dryland areas that are the legacy of past land use and water management decisions.

The draft Basin Salinity Management Strategy extends the life of the target for the Murray River at Morgan until at least 2015 to protect the shared waters of the Murray and lower Darling Rivers. It also extends accountability arrangements to South Australia and Queensland and introduces the use of end-of-valley salinity targets in each state to help maintain the Morgan target. While the draft Basin Salinity Management Strategy is intended to apply basin-wide, like the S&D Strategy, its emphasis is on the shared rivers.

For valleys within the MDB, achievement of end-of-valley salinity targets under the NSW Salinity Strategy will contribute to meeting state obligations under the draft Basin Salinity Management Strategy. However, as Table 2 shows, the MDBMC estimates that meeting the NSW interim end-of-valley salinity targets will not be sufficient to fully protect the Morgan target from the impacts of increasing dryland salinity.

Table 2: Indicative impacts to the shared rivers after meeting end-of-valley targets
Salinity impact to the shared rivers measured at Morgan at 2015[11]

	Without intervention The Salinity Audit of the MDB prediction (EC)	Outcomes of in-valley actions to meet target conditions (EC)	Shortfall after accounting for within-valley actions (EC)
South Australia total	**+50**	**-30**	**20**
Victoria total	**+16.5**	**-10**	**6.5**
New South Wales			
Murrumbidgee	+6	-4	2
Lachlan	0	0	0
Bogan	+3.2	-2.2	1.0
Macquarie	+4.3	-2.9	1.4
Castlereagh	+0.2	-0.1	0.1
Namoi	+6.4	-5.6	0.8
Gwydir	+0.1	-0.1	0
Macintyre/Gil Gil	+0.1	-0.1	0
NSW total	**+20.3**	**-15**	**5.3**
Queensland total	**+1.0**	**n.a.**	**1.0**
Murray River at Morgan	+88	55	33

The MDBMC predicts that NSW will have a 5.3EC shortfall after accounting for the impacts of actions relating to the end-of-valley salinity targets. Our options to meet the predicted shortfall include increasing our end-of-valley salinity targets, contributing to additional jointly-funded salt-interception schemes on the Murray River, or reducing salinity in the first instance along the Murray and lower Darling rivers.

The MDBMC is also proposing that Governments jointly fund works to offset the salinity impact from future development in irrigation areas. Protocols for apportioning salinity credits gained by these schemes between offsetting impacts of dryland salinity and offsetting impacts of possible new developments, and the implications for cost sharing have yet to be negotiated.

Similarities and differences between NSW and MDBC targets

The NSW end-of-valley salinity targets and the MDBC targets are comparable and compatible, and have been derived on a consistent basis. However, some minor differences need to be recognised when switching between the two strategies. Table 3 summarises the key considerations. The interim end-of-valley salinity targets in the NSW Salinity Strategy are consistent with the end-of-valley salinity targets in the draft Basin Salinity Management Strategy, although the latter are set for 2015 and use average salt loads instead of percentiles.

Table 3. Similarities and differences between NSW and MDBC Targets

	The NSW Salinity Strategy	The Murray-Darling Basin draft Salinity Management Strategy
Timeframe	Set with reference to 2010	Set with reference to 2015
End-of-valley targets	End-of-valley targets in terms of 50th and 80th percentiles for EC and 50th and 80th percentiles of salt loads at specified sites.	For the MDB overall: a 95th percentile value of 800 EC for the Murray River at Morgan (SA). End-of-valley targets are also set for each of the major catchments within the MDB. For EC, these are in terms of 50th and 80th (95th at Morgan) percentiles (as for the NSW Strategy). For salt load, these are annual average (mean) loads (NSW uses 50th and 80th percentiles).

The MDBMC has chosen to use the mean to monitor salt load at Morgan as an indicator for the MDB. As discussed in *Accounting for climatic variability* (page 44), the mean gives a simple indication of the expected general level of salinity and is useful to indicate trends in a large system, such as at a basin scale. The mean is also significant when measuring values over a long period of time, as fluctuations tend to 'flatten out'. However, as there are limitations in using the mean at a smaller scale, it is more meaningful for NSW to use 50th and 80th percentiles for salt load, as well as EC. For each end-of-valley salinity target, the NSW and MDBC targets are consistent, representing two points on the same cumulative probability curve (see Figure 9, page 46 for illustration).

2.2.3 The Cap on water diversions

As part of the MDBMC Cap on diversions, NSW has agreed it will constrain future diversions to those which would have occurred had development remained at the 1993/94 level. The benchmark is derived from models that simulate the 1993/94 level of water resource development, water management policies and practices and the operating rules in each of the Basin's rivers. It is recognised that actual water usage will fluctuate from year to year within prescribed limits, in response to climatic variability and as such, the Cap is expressed as a long-term average.

Notwithstanding the Cap, NSW valleys have adopted a number of environmental flow rules aimed at achieving flow and river health improvements in many of the NSW rivers. In this context 'improvement' is measured against flows that are simulated in the Cap model. These flow rules result in a diversion regime that is below Cap.

A feature of the environmental flow management process includes the adaptive management response to information gathered under the monitoring program. If the monitoring program detects that long-term growth in diversions has occurred, the water access rules will be gradually adjusted in such a way that the long term diversions will fall back into balance with the environmental flow diversion regime.

Salinity management actions such as reafforestation may change the streamflow volumes and flow patterns. In order to maintain the river health targets it may be necessary for changes in the environmental flow regimes, which in turn may reduce water available for consumptive use. These measures will only be put in place if necessary, as a result of the issue being dealt with through the river planning process.

The NSW and Victorian governments' recent decision to restore environmental flows to the Snowy River may have some small effect on river salinity in the Murray and Murrumbidgee Valleys, as stated in the Snowy Water Inquiry Final Report[13]. The package of measures (yet to be developed) to offset the changes in Snowy flows, will include offsets to both water quantity and quality. These measures will be in addition to actions needed to meet within-valley and end-of-valley salinity targets for the Murrumbidgee and the target at Morgan.

2.3 The National Water Quality Guidelines

A major step in developing salinity management on a national scale occurred in 1992, when the Australian and New Zealand Environment and Conservation Council (ANZECC) published the *Australian Water Quality Guidelines for Fresh and Marine Waters*. The Guidelines, developed under the umbrella of the National Water Quality Management Strategy, presented levels indicating the concentrations of chemicals which, if exceeded, might cause water quality problems.

Building on the 1992 Guidelines, ANZECC and the Agriculture and Resource Management Council of Australia and New Zealand will shortly release the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. In addition to providing trigger levels (as in the 1992 Guidelines), the new Guidelines will provide a more integrated, risk based decision framework that focuses on issues rather than on concentrations of specific chemicals. The Guidelines encourage resource managers to work through a decision tree to determine whether the trigger levels are appropriate to their particular situation.

The Guidelines focus on water and its associated components (such as sediments and aquatic ecosystems) and do not apply to land or vegetation. They are not mandatory, but instead provide a framework which natural resource managers can use to implement a broad national management strategy at a local level. The new Guidelines will be a valuable tool for CMBs and water management committees to use in setting and refining water-based salinity targets that are appropriate to their particular catchments. This will be particularly relevant when within-valley salinity targets are being developed.

Chapter 3 Planning salinity management

This chapter describes how to set salinity targets and how the NSW Government developed the interim end-of-valley salinity targets. It then examines how to choose actions.

3.1 Setting salinity targets

Setting these targets is the first stage in developing a target-based approach to manage salinity.

3.1.1 Target locations

a. End-of-valley targets

To set end-of-valley salinity targets, we first need to identify a location which is a meaningful and measurable representation of the salinity conditions at the end of the catchment. The location will be an indicator of the overall salinity conditions in the catchment. In inland catchments and for the Hunter Valley, the end-of-valley location will be at the end of the catchment. In other coastal areas, end-of-valley targets will not be required.

The locations of end-of-valley targets will need to be free from, or able to account for, localised impacts. For example, they will need to be free from impacts from unmixed single-point sources of saline discharge and be above, or account for, backwater effects.

The NSW Government has proposed locations for the end-of-valley salinity targets for inland catchments. These represent conditions at the end of major NSW tributaries of the Murray and Darling Rivers. The exception is the Lachlan River, where the target location is at Forbes due to limitations of data availability. For a detailed discussion of the rationale for the locations for each inland catchments (see *The interim end-of-valley salinity targets,* page 25).

b. Within-valley targets

Within-valley targets are water or land-based targets within a catchment that express the salinity levels that are desired for a location. They are upstream of end-of-valley salinity targets.

Within-valley salinity targets serve three aims. They can be used to express desired salinity levels for:

- landscapes that contribute significantly to rising salinity;
- locations that are important in the functioning and our understanding of, salinity processes in the catchment, and;
- locations to protect local assets and values, such as wetlands or water supply.

Locating within-valley targets involves identifying the locations and landscapes for each of the above considerations within a catchment.

3.1.2 Links between salinity targets

a. Risk assessment

For each location, we go through a risk assessment process, starting with the end-of-valley and move up the catchment to each within-valley target location (this process is explained fully in *3.1.3 Risk assessment*, page 22). This leads to end-of-valley and within-valley salinity targets for the catchment, although they may be revised during the following steps.

We may find that salinity is not a threat at a particular location and conclude that if we live at that location, we do not need to worry about salinity. In some cases, these areas may cumulatively add to an impact downstream, and we may wish to help reduce that impact.

b. Routing targets back down the catchment

Having set within-valley salinity targets up the catchment, we need to 'route' back down the catchment to examine whether a target (or targets) meet the next target downstream. To begin with, we may need to use a model to understand how salt and water move from the land and groundwater to a river. We can do this using models such as CATSALT and FLAG. We then need to examine, or 'route', how water and salt moves downstream through a river. Routing involves considering:

- travel times of water and salt from one place to another;
- additions and removals of water and salt within a system;
- delays due to storage effects, such as dams, weir pools and river channels;
- the effects of storages on flow patterns; and
- the effects of storages on the mixing of salt in water.

Routing is most conveniently done using computer based models, such as the Integrated Quality-Quantity Model (for more information see *Appendix 3,* page 49).

Routing the targets back down the catchment may produce a salinity level for the end-of-valley that differs from the end-of-valley salinity target we identified in step (a). If routing produces a higher salinity level, then we need to:

- set higher within-valley salinity targets to maintain an acceptable level of risk to assets and values at the bottom of the catchment; or
- review the end-of-valley salinity target we identified in step (a).

If routing produces a lower salinity level, then we can:

- reduce the end-of-valley salinity target to the lower salinity level, or;
- maintain the end-of-valley salinity target we identified in step (a).

c. Scoping the magnitude of action

The next step is to identify the amount or magnitude of action we need, to achieve the within and end-of-valley salinity targets. We then examine if this is an achievable and acceptable magnitude of action and refine the salinity targets accordingly. A detailed analysis and decision-making about actions is more meaningful later in the process (see *Deciding on actions*, page 33). The aim of this step is to get an indication of the magnitude of action the salinity targets require.

For example, the Government is proposing that one of the interim end-of-valley salinity targets for the Murrumbidgee Valley is that the median salt load in 2010 be 5000 tonnes lower than the prediction. We can get an idea of the magnitude of action this target represents by considering the impact of a number of possible actions.

The Salinity Audit of NSW outlined that salinity problems are severe in several locations in the Murrumbidgee Valley, including the area around Wagga Wagga (urban salinity) and a number of areas upstream, such as the Kyeamba, Muttama, Jugiong creeks and Yass River subcatchments. Addressing these areas could help achieve the interim end-of-valley salinity target. Current modelling suggests that 60,000 hectares of land planted to trees in high salt wash off areas of tributaries of the mid-Murrumbidgee catchments, could achieve an approximate 4 per cent reduction in salt load at Wagga Wagga, with a 1 per cent impact (reduction) in flows, mostly during winter months.

Also in Wagga Wagga, the local council pumps groundwater to lower the level of groundwater and reduce the impact of salinity on infrastructure. This saline groundwater is then discharged into the Murrumbidgee River. The daily amount of salt discharged in the river is 9 tonnes. Instead of discharging the groundwater into the river, a salt processing plant could use the groundwater to produce products for the chemical industry. This would reduce the salt load in the Murrumbidgee River at Wagga Wagga by 3300 tonnes annually.

To scope the magnitude of action, identify:

- the areas in the catchment that are contributing to salinity (recharge and discharge areas);
- the decrease in salinity needed in these areas, to meet the within-valley and end-of-valley targets; and
- actions that could lead or contribute to, the change in salinity needed in each area (actions to manage salinity are listed in Figure 3, page 22).

If the magnitude of action needed is unachievable, or poses unacceptable social or economic change, then we need to reconsider the salinity levels we are willing to tolerate or the magnitude of change that we consider acceptable and/or achievable. The following section outlines the considerations required.

River flow:

- flow rules for regulated and unregulated streams
- dilution flows
- wetland flushing.

Recharge management:

- retention of native vegetation
- use of deep rooted crops, native grasses and pastures
- adoption of agroforestry
- increase in commercial plantation activities
- water use efficiency measures in irrigation and urban landscapes
- salt land agronomy
- rehabilitating abandoned mine sites.

Discharge management:

- point-source discharge management
- salt interception schemes
- groundwater pumping
- new technologies to protect infrastructure
- establishing salt-tolerant species.

Figure 3: Actions to manage salinity

3.1.3 Risk assessment

For each location, we need to consider the risk that salinity in water (rivers, groundwater) and on land poses. We start with the location of the end-of-valley target and move up the catchment to the locations of within-valley salinity targets.

a. Predicted salinity trends

For each target location, the first step is to identify the predicted salinity trend and levels. Information on the current and predicted salinity EC and salt load trends from 1998 through to 2100 is in the Salinity Audit of NSW. Other sources of information include DLWC's Statewide Keysites Program[14] (monthly EC measurements); DLWC's database of continuous flow and EC measurements; and monitoring data from other water quality programs, including those undertaken by local government (with varying sampling frequencies).

The soon-to-be-released National Land and Water Resources Audit identifies current areas of salt-affected land and predictions for each catchment to 2050. The rate of increase differs from catchment to catchment, with some showing problems within 20 years and others within a 50 year timeframe. The audit also examines the impact of increases on a range of assets, such as cropping and nature conservation areas.

b. Risk to values and assets

The next step is to identify the risks that predicted salinity levels pose to values and assets at that location. An asset is a physical entity within the catchment, such as:

- aquatic and terrestrial ecosystems;
- indigenous cultural heritage sites and artefacts;
- wetlands;
- farming areas; and
- built infrastructure.

Values are the importance, merit or worth we place on these assets. For example, the importance of drinking water or land for irrigation or cultural heritage use.

Salinity may impact on our environmental, economic and social values and assets. While each catchment and location will have its own particular set of impacts, some common types of impacts may be revealed by considering the following questions:

- Will the output of major land use sectors be affected?
- What costs will be incurred to maintain clean drinking water?
- Will key aquatic and land-based environmental assets be affected?
- Will the operation and maintenance of water supply infrastructure be affected?
- What costs will be incurred to maintain fixed assets (eg buildings & roads)?
- Will in-stream food sources be affected?
- Will any significant cultural practices, heritage sites and/or artefacts be affected?
- Will any recreational or leisure activities be limited or incur additional costs?
- Are their any beneficiaries of increasing salt loads or concentrations?
- How will the costs of increasing salt be distributed throughout the community?
- Will changes in water quality and land use affect community cohesion?

The next consideration is what is the risk of these impacts occurring. This is in terms of the magnitude, frequency and time frame over which the impacts may occur, and their spatial distribution within the catchment. In some instances these impacts may be quantifiable, either in detail or in rough magnitude. In other cases, it will be necessary to consider these effects in qualitative terms.

A useful starting point for this process is the WQOs. Through the WQOs, communities have already identified values to protect water-based assets and the broad salinity thresholds needed to protect them. A key question is: in the future, to what extent will the cumulative impacts of predicted salinity mean that the WQOs will be exceeded at different locations in the catchment (see Figure 7). The soon-to-be-released National Water Quality Guidelines will help communities carry out a local risk analysis and tailor the general trigger levels to their local conditions (see *2.3 The National Water Quality Guidelines*, page 18).

If salinity poses an unacceptable level of risk to assets and values, then continue with these steps. If the risk to assets and values is considered acceptable, then move to the next within-valley location and return to step (a) of *Risk assessment*.

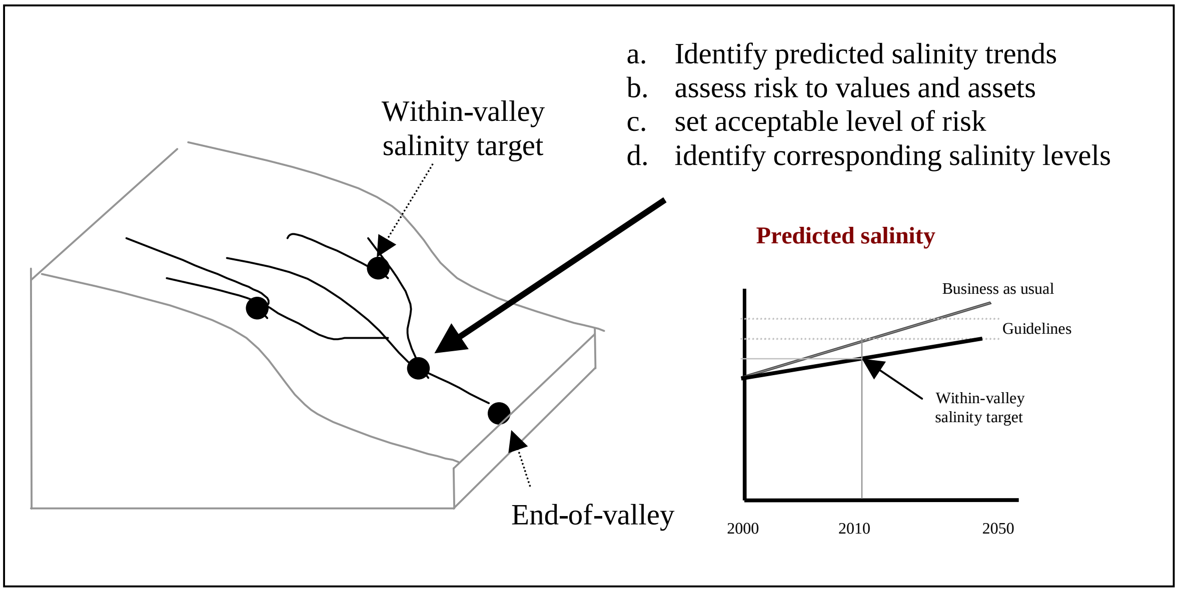

Figure 4: Assessing risk at a location

c. Acceptable level of risk

For each location, we then need to identify what is an acceptable level of risk to our assets and values. This involves considering how often we want certain assets and values to be available. For example, how often, if at all, are we prepared for our town water supply to be above 800EC?

Ecosystems, irrigated crops and land may be particularly sensitive to the sequencing and exposure to concentrations of salt. Many organisms display differing sensitivities to salt exposure, salt levels and duration of high salinity exposure. Using the 50th and 80th percentiles helps us to set acceptable levels of risk.

We also need to agree on an acceptable level of risk from increasing rates of salt build-up in places such as sensitive wetland systems. The issue of salt build up is particularly important in ‘terminal’ (that is, non flow-through) wetlands, where evaporation can result in extremely high salt concentrations.

d. Corresponding salinity levels needed

After considering the level of risk we are prepared to tolerate for assets and values, we need to suggest salinity levels that would keep the risk to that asset or value at an acceptable level. These salinity levels form the salinity targets that we route back down the catchment, as explained in *3.1.2. Links between salinity targets,* (page 20).

There are a range of interacting factors that need to be considered. From an ecological point of view, we need to look at a full range of percentile values and express desired salinity in terms of 50th and 80th percentiles, to ensure that valued ecosystems are not subjected to ranges or exposures outside their tolerances. However, recovery rates of organisms are not well known and we will need to make judgements based on the best available information and review these decisions as new knowledge comes to light.

State, Basin and national policies will also impact on the salinity targets we can set. So, as well as the considerations outlined above, at each location we need to examine government policies that may impact on factors such as the values and assets we want or need to protect and salinity levels needed.

3.2 The interim end-of-valley salinity targets

3.2.1 Introduction

The interim end-of-valley salinity targets were developed by NSW Government experts in predicting, modelling and analysing salinity trends, including those who managed the Water Quality Objective consultation process in NSW. They based the interim targets on the methodology outlined in the previous chapter, with particular reference to:

- current and predicted or analysed trend salinity information (Statewide Keysites Program, salinity audits of the MDB and NSW and other available monitoring data);
- salt load and movement predictions generated by models;
- information gathered as part of the development of water quality and river flow objectives for NSW, and;
- the Australian Water Quality Guidelines for Fresh and Marine Waters.

Map 1 (page 26) shows the locations of the interim end-of-valley salinity targets.

3.2.2 Barwon-Darling river system

The end-of-valley salinity target site nominated in the NSW Salinity Strategy for the Darling River is Menindee (upstream of Menindee Lakes). This marks the start of the 'shared rivers' component of the Darling River under the Murray-Darling Basin Agreement and is usually the point of hand-over of operational responsibility from NSW to MDBC. Menindee is not a salinity target site in the draft Basin Salinity Management Strategy, but it is listed as a 'reportable indicator site' since it will also include contributions from Queensland.

This location may need to be reviewed, given the possible backwater influence of Menindee Lakes operations on EC and salt loads at this site. If this location is not considered to be satisfactory, then it can be moved upstream to Wilcannia, for example. If the target site is changed then we will have to ensure that the implications of this for water, salinity and salt balances are understood and negotiated. This will be particularly important in terms of what NSW and Queensland are held accountable for when "handing over" to the MDBC.

Within the Darling River, the salt load target is considered more meaningful than the EC target because the CMB can have some control over the incremental salt load contribution between their end-of-valley and upstream locations, but can have little or no control over ECs, as these will be largely driven by upstream influences.

The Salinity Audit of the NSW predicted that median ECs at Menindee would rise from 312 EC in 2000 to 375 EC in 2010, and 620 EC by the year 2100. Corresponding 80th percentile for EC are 2-3 times higher than this. An 80th percentile interim end-of-valley salinity target value of 800 EC is proposed for the year 2010.

The Salinity Audit of NSW predicted that under a 'no intervention' scenario, median salt loads at Menindee would increase from 132,500 tonnes per year in 2000 to 170,000 tonnes per year ten years later, and to 305,000 tonnes per year by 2100. The corresponding 80th percentiles for salt load are 2-3 times higher. The NSW Government is proposing an interim end-of-valley salt load target of 160,000 tonnes for the median and 530,000 tonnes for the 80th percentile.

Map 1: Location of interim end-of-valley salinity targets for inland catchments

2.2.3 Bogan Valley

The Bogan River rises on the catchment divide with the Macquarie River, adjacent to areas with the same geology that have high salinities, and receives diversions of flow from the Macquarie.

With the possible exception of the Castlereagh River, the Bogan demonstrates a much greater variability in salinity levels than other inland river systems. This is largely due to the extended periods of no flow which are experienced in the Bogan (see *Reviewing salinity management*, page 36).

The estimates for the Bogan in the Salinity Audit of NSW were calculated on flows and salinities measured at Gongolgan and, hence, include both the local catchment and contributions from the Macquarie River. If we do not take action, it predicted that the median annual EC for the Bogan River at Gongolgon would increase from 442 EC in 2000 to 650 by 2010, and to 1400 EC by the end of the 21st century.

In setting the interim end-of-valley targets for the Bogan, the aim was to slow down the rate of increase in salinity and keep the 80th percentile salinity below 1500 EC, to protect the level of service of the Nyngan town water supply and the aquatic ecosystems in the river. The NSW Government is proposing to bring the 80th percentile back down to 1450 EC (1998 levels).

If we take no further action, the Salinity Audit of NSW predicted that median salt loads at Gongolgon will increase from 24,600 tonnes per year currently to 35,000 tonnes per year by 2010, and 75,000 tonnes per year by 2100. Eightieth percentiles for salt load are approximately double these. The Government's interim targets are 30,000 tonnes (median) and 55,000 tonnes (80^{th} percentile).

There was limited data available to develop the salinity predictions and interim targets for the Bogan River and we will need to collect additional data to improve our estimates.

3.2.4 Castlereagh Valley

Due to extended periods of no flow, salinity levels in the Castlereagh River are more variable than in other inland river systems (the 80th percentiles for EC are about five times the median levels).

The Salinity Audit of NSW predictions for the Castlereagh Valley were based on flow and EC measurements for Coonamble and have not accounted for any additional salt load contributions downstream of that site. As a result, there is a need to establish an end-of-valley target towards the bottom of the Castlereagh and reassess the targets once we have more information.

If we take no action, the Salinity Audit of NSW predicted that median EC levels in the Castlereagh would rise from 304 EC in 2000 to 325 EC by 2010, and 700 EC by the end of the 21st century. The high current and predicted 80th percentile for EC are of concern in relation to protecting environmental values in the catchment, including supply of drinking water and protection of aquatic ecosystems. Hence, it is important to hold the 80th percentile line at 1500 EC.

The Salinity Audit of NSW predicted that if we take no action, median salt loads will increase from 18,400 tonnes per year currently to 19,200 tonnes per year by 2010, and 38,300 tonnes per year by 2100. Eightieth percentiles for salt loads are nearly double these.

In setting the interim end-of-valley salt load targets for the Castlereagh, we are proposing to bring salt loads back to 1998 levels to limit the loads leaving the system.

3.2.5 Gwydir Valley

If we take no further action, the Salinity Audit of NSW predicted that median EC levels in the Mehi River near Collarenebri will increase from 383 EC in 2000 to 400 EC within 10 years, and 550 EC by the year 2100. Corresponding 80th percentiles for EC are almost double the median. Protection of irrigated crops is a major issue and while the predicted 80th percentile EC level is still below 800 EC at 2020, our long term aim is not to exceed this. Hence, only a minor increase is proposed.

In the Salinity Audit of NSW, the braided nature of the lower reaches of the Gwydir system and insufficient monitoring of high flows during the period of interest, resulted in a situation where the observed flow record was substantially incomplete. Therefore, translating salt loads to the end of the system involved some additional modelling.

The end-of-valley salt load target incorporates load contributions from the Mehi and Gwydir stems to the Darling River. Because the Mehi River carries by far the major component of flow to the Darling River from the Gwydir catchment, the appropriate end-of-valley site for loads is the Mehi River near Collarenebri. The Gwydir River connects with the Darling River only under extreme high flow conditions.

Salt loads at the downstream end of the Gwydir system are low relative to the other inland catchments, mainly because the flows are small. The Salinity Audit of NSW predicted that without action, median loads would increase from 6,600 tonnes/year in 2000 to 6,800 tonnes per year in 2010 and 9,000 in a hundred years time.

The Gwydir Wetlands are an environmentally significant wetland system near the downstream end of the Gwydir catchment. In setting the salt load targets, we have recognised the need to protect these wetlands, and have tried to slow down the predicted rate of increase so that salt loads in 2010 are at 1998 levels.

3.2.6 Hunter Valley

The NSW Government is currently carrying out a salinity audit of the Hunter Valley to determine if background salinity levels are increasing. The salinity trend for the last decade has been showing an improvement in EC levels as a result of increased river regulation and minewater discharge management. Recently, a series of wet winters have mobilised salt and led to higher than normal EC levels.

The Hunter Valley Salinity Trading Scheme targets only relate to those times when the mines can discharge[15].

The community and Government need to jointly establish an end-of-valley target for overall salinity management, located at the end reaches of the river. The NSW Government recommends that we locate the end-of-valley target at Greta, as salinity monitoring has been undertaken at Greta over a long period of time and it is upstream of tidal influences.

Salt loads are an issue in the MDB because of the large amount of salt which is redistributed into the landscape through water diversions and flow into wetlands. In the Hunter system, salt redistribution is not significant and so salt load targets may not be required. Instead, emphasis should be placed on EC targets.

3.2.7 Lachlan Valley

Under most conditions, the Lachlan River is a terminal system, meaning that it does not usually connect to the Murrumbidgee River (and hence the Murray River), except during extreme floods. Because of this, and the fact that data availability is poor at the lower end of the system, the Government has set the Lachlan Catchment interim end-of-valley salinity target at Forbes. An additional benefit of using Forbes is that, because the main salinity problem areas in the Lachlan Catchment are upstream of Forbes, we can better gauge our success in managing these areas than if our target site was at the more remote, downstream end of the catchment.

It was not possible during the Salinity Audit of NSW to adequately account for all the flows and salinity downstream of Forbes due to the highly braided nature of the system. There were insufficient flow and EC data at Condobolin to provide an accurate assessment using the Salinity Audit of NSW models. Since publication of the Audit, the DLWC has developed an accepted water balance model of the Lachlan; however, due to the lack of salinity data, we are unable to establish the salt balance with confidence.

Since Forbes is upstream of all the major diversions for irrigation in the valley, (whereas in all other valleys the target is set at the end-of-valley), the Lachlan salt loads should not be compared directly with those for the other valleys.

For water quality in the Lachlan River, the Salinity Audit of NSW predicted that if we take no action, the median annual EC at Forbes would rise from 388 EC in 2000 to 430 EC by 2010, but then increase to 880 EC by 2100. Over the same 100 year period, median annual salt loads at Forbes are expected to rise from 234,800 to 546,500 tonnes per year.

Salt loads are an important consideration in relation to environmentally significant wetlands, such as the Great Cumbung Swamp near the downstream end of the Lachlan catchment. They are also important in terms of irrigation, because of the potential for salt build up in irrigation areas. We have set median and 80th percentile targets accordingly.

Data from the Salinity Audit of NSW showed that there are several areas where salinity problems are locally severe. These include Boorowa River, Crookwell River and Hovells Creek subcatchments, as well as other parts of the upper Lachlan catchment. A number of significantly sized towns draw water from rivers which are under threat from salinity.

3.2.8 Macintyre Valley

In the 100 year timeframe of the Salinity Audit of NSW, groundwater changes in NSW were not expected to impact on salinities and salt loads in the Macintyre River at Mungindi. However, analysis by the Queensland Department of Natural Resources does suggest a trend. NSW and Queensland will need to jointly investigate the reasons for this difference.

According to the NSW analysis, median EC levels are, and will remain at around 230 EC at Mungindi over the next 100 years. Similarly, median salt loads are expected to remain constant at around 68,000 tonnes/year.

In setting interim end-of-valley targets for the Macintyre, irrigation was considered to be the main environmental value to be protected. Given that the current 80th percentile salinity value is 630 EC, the Government is proposing that we provide a buffer below the 800 EC threshold for medium sensitivity crops. In doing so, we will also assist with achieving targets at Menindee and provide downstream benefits along the Barwon-Darling river system.

3.2.9 Macquarie Valley

The Salinity Audit of NSW predicted that median EC levels will rise from 500 EC currently to 750 EC by 2010 and 1750 EC by the end of the 21st century if we take no further action. In the short term (10 years), these predictions suggest potential problems with the quality of irrigation water supplies, since the predicted 80th percentile level for the year 2010 exceeds the 800 EC level considered to be the upper end of the range for medium sensitivity crops. The interim targets have been set at a level to protect irrigation.

In the longer term (50-100 years), if we take no action, median EC levels are predicted to exceed levels which could seriously affect aquatic ecosystems of the river itself and the internationally recognised Macquarie Marshes at the downstream end of the system.

The Salinity Audit of NSW predicted that if we take no action, median annual salt loads leaving the Macquarie Valley will increase from 32,100 tonnes per year in 2000 to 45,000 tonnes per year by 2010 and 109,000 tonnes per year by the year 2100. Salt loads entering the Macquarie Marshes are also of concern, given the potential for concentration of salt in parts of the system as the wetlands dry out after flood events. However, the Marshes are a mainly flow through (rather than a terminal) system, and the impacts are more likely to be localised to individual areas where water concentrates into pools and evaporates, leaving salt behind.

The interim end-of-valley targets for the Macquarie Catchment will help to protect town water supplies in the Macquarie and Bogan catchments.

Data from the Salinity Audit of NSW indicated several areas where salinity problems are locally severe. These include the Talbragar and Little subcatchments. Managing salinity in these areas will be a major part of meeting the end-of-valley targets for the Macquarie.

Because the downstream end of the Macquarie system is braided, it was necessary to account for flows other than those in the main stem (Macquarie River at Carinda) when calculating end-of-valley salt load targets. The targets have been based on an estimated total flow out of the end of system of 1.97 x (flow at Carinda).

3.2.10 Murray and lower Murray-Darling

Under the draft Basin Salinity Management Strategy, a 95th percentile value of 800 EC at Morgan, South Australia, has been set as a target to protect the 'shared rivers' (the Murray River below Hume Dam and the Darling River below Menindee Lakes). Although not strictly speaking a NSW 'end-of-valley target', the MDBMC's Morgan target could in effect be used as such for the Murray and lower Murray-Darling catchments in NSW. However, it should be noted that within-valley targets are essential to minimise local increases in salinity.

Salt loads and ECs in the lower Darling River are driven largely by upstream contributions (from Queensland and NSW) over which the lower Murray-Darling CMB has little control. Similarly, for the NSW section of the Murray River, salt loads and ECs are affected by substantial contributions from Victorian tributaries, but these are also outside the control of the Murray CMB. Hence, it would be difficult to separate out which part of any end-of-valley salinity target set could be meaningfully used by these CMBs to drive salinity actions in their own areas. Instead, the most appropriate approach for the Murray and Lower Murray-Darling CMBs would be to develop within-valley salinity targets as indicators of the catchment conditions that they want locally.

The MDBMC has identified that even after the end-of-valley salinity targets are met in all Basin states, this will not maintain the Morgan target. Hence, there is scope for the Murray and lower Murray-Darling catchments in NSW to contribute to maintaining the Morgan target, as well as protecting local assets and values.

The Murray and Lower Murray-Darling CMBs will need to liaise with upstream CMBs as well as corresponding groups in Victoria and Queensland to ensure that any decisions made are compatible with the needs of the Murray and lower Darling.

3.2.11 Murrumbidgee Valley

Salinity, in terms of EC, is relatively low in the lower Murrumbidgee River and is predicted to remain so over the next 100 years. The Salinity Audit of NSW predicted that if we take no action, the median annual EC at Balranald would show a slight increase from 233 EC in 2000 to 250 EC in 2010, and to 350 EC by 2100. In that respect, the Murrumbidgee is potentially a good quality source of water to the Murray River. However, despite having relatively low ECs, the Murrumbidgee currently carries the highest salt load (due to large flows) of the NSW MDB rivers. According to the Salinity Audit of NSW, median annual salt loads at the end of the Murrumbidgee system are expected to increase from 139,000 tonnes per year under current conditions, to 150,000 tonnes per year by 2010 and 204,000 tonnes per year by the end of the 21st century.

The irrigation industry in the Murrumbidgee catchment relies on good quality water to protect crop growth. In the Coleambally and Murrumbidgee Irrigation Areas, saline groundwater which has been pumped out to help control rising groundwater levels is currently ‘shandied’ with lower salinity surface water to provide irrigation supplies. Opportunities for this approach would be reduced if surface water quality deteriorated.

The Government’s interim end-of-valley targets propose slowing down the trend to the extent that it is realistic to do so, to prevent unacceptable increases in salt loads entering the Murray River.

3.2.12 Namoi Valley

The Salinity Audit of NSW predicted that, if we take no action, median ECs for the Namoi River at Goangra will rise from 521 EC in 2000 to 625 EC by 2010, and to 1120 EC by the year 2100. Eightieth percentiles for EC are almost double the median.

Ideally, we would set an 80th percentile target of 800 EC for the bottom end of the Namoi to protect environmental values, such as irrigation of sensitive crops and protection of floodplain values. However, this is unrealistic in the short term given current levels. Instead, the NSW Government is proposing 1000 EC as a 2010 target, with the long-term aim of reducing this to 800 EC.

The Namoi is one of the major contributors of salt load to the Barwon-Darling system. The Salinity Audit of NSW predicted that median annual salt loads at Goangra will increase from 50,000 tonnes per year in 2000 to 60,000 tonnes per year in 2010, and to 130,000 tonnes per year by the end of the 21st century.

The Salinity Audit of NSW found that the main potential contributors of salt to the Namoi system are the Peel River downstream of Chaffey Dam (in particular, Goonoo Goonoo Creek) and the Mooki River.

3.2.13 Other coastal catchments

End-of-valley water quality targets are not meaningful indicators of success in the management of salinity for coastal catchments other than in the Hunter Valley, as higher rainfall patterns in coastal catchments flush salt through these river systems and the major salt-producing areas are generally a fraction of the catchments.

For these coastal catchments, salinity should be considered predominantly as a land degradation issue, requiring within-valley salinity targets. These will be recognised statewide on the same basis as those formulated for the MDB area.

Within the Sydney-South Coast Region, we currently know that salinity affects the Far South Coast, Upper Shoalhaven and parts of the Hawkesbury Nepean to varying degrees (both spatially and in severity). There has been limited research and investigation in the Upper Shoalhaven and Western Sydney areas. Overall, a comprehensive picture of the salinity situation is yet to be drawn.

Within the Hunter region, outside the Hunter Valley, salinity affects the Avon River in the Manning catchment and some areas in the Karuah catchment.

In the North Coast, salinity impacts are localised and affect many properties in the area between Walcha and Torryburn.

Outbreaks of dryland salinity have been recorded throughout the Clarence catchment with the major concentration of scalds occurring on the sedimentary geology throughout the central and lower Clarence area. Scalding is particularly evident around Grafton, where salinity concentrations have exceeded the tolerance levels of even salt-tolerant grasses, such as couch grass.

CMBs in these coastal catchments must begin to address salinity. Activities should include investigating the potential for local and regional planning instruments to regulate the management of salinity, particularly in affected urban areas such as Western Sydney. For areas affected by dryland salinity, within-valley salinity targets could take the form of identifying and planning for land use of potential recharge and discharge areas.

An overall audit is planned for coastal catchments for 2001 and 2002.

3.3 Deciding on actions

To set the end-of-valley and within valley targets, we scoped the actions that could achieve the salinity targets, in terms of the range of actions, their magnitude and possible locations within catchments. It is now necessary to examine more accurately where each action could be located within the landscape. We then compare the relative effectiveness of actions and groups of actions against the targets and environmental, social and economic criteria over both the short and long-term.

We will want to continually review our choice of actions as markets lead to innovative, cost-effective solutions and as our information about salinity processes and the cost-effectiveness of actions improves.

3.3.1 Locating and assessing individual actions

The first step is to identify potential locations for an action within the landscape and assess its effectiveness. To do this, we need to consider the following:

a. Landscape features

A particular action will be appropriate within particular landscape features (such as recharge or discharge areas and areas of salt stores). For example, salt interception schemes are appropriate for discharge areas while perennial pastures focus on recharge areas. To locate an action within a landscape, we need to identify the areas with the appropriate landscape features for that action. An understanding of salt storage is also important as we will want to place actions that reduce salt mobilisation in areas which are mobilising the greatest amount of salt.

b. Biophysical attributes

The effectiveness of actions depends on attributes such as soils, rainfall amount and pattern and climatic variability. These biophysical attributes will vary within catchments, landscapes and properties.

c. Timeframe

Different actions will reduce salinity over different timeframes. Actions in discharge areas can reduce wash-off and impact quickly on salinity. If we are looking to locate an action within a recharge area, the impact of actions are likely to take longer.

For actions in recharge areas, the nature of the groundwater system will influence the timeframe in which an action will impact on salinity. In local groundwater systems, which may be thought of as property-scale systems occupying higher relief sites, response times may be relatively short and it may take five to ten years to establish a new equilibrium at this scale. Intermediate groundwater systems, which are generally overlain by clusters of local systems which contribute flow around the margins, will take longer to reach a new equilibrium. Response times may be 50 to 100 years or more depending on the flow length. Regional systems are generally deep with flow lengths of greater than 50 km and may take more than 1000 years to equilibrate. To meet a ten-year salinity target using actions in recharge areas, it may be worthwhile considering locating actions in areas that have a local groundwater system.

d. Other environmental benefits

We should consider locating actions so they have maximum benefits for other environmental issues. For example, re-establishing vegetation around existing stands of native vegetation can provide valuable biodiversity benefits.

e. The effectiveness of actions on the hydrological balance

The amount of water leaking to groundwater has increased significantly under European farming practices. Actions such as agroforestry, plantation forestry, grazing and cropping practices and vegetation management, have a differing ability to reduce leakage and reverse this trend.

The relative bio-physical effectiveness of actions can be assessed by ranking their ability to reduce leakage and impact on the hydrological balance. For example, modelling and physical measurements from experiments across Australia indicate clear differences between the impact of vegetation types on leakage at a catchment scale. The response of salinity to vegetation can be ranked according to how long it remains green and over what season and its rooting depth density and distribution. That is, summer active vegetation is more effective than winter active vegetation, perennials are generally superior to annuals and deep-rooted species can access and intercept more water than shallow rooted species.

f. The interaction of EC and salt load targets

Actions to meet desired salt load levels could involve a quite separate strategy to those for EC. As a result the actions and the landscape features targeted for salt load will not always be the same as those targeted for EC management.

EC targets are most likely to be met by a combination of recharge reduction, point source discharge management (as in the case of the Hunter Valley) and flow management.

Salt load targets can be more easily met simply by controlling salt-laden runoff. This is mainly generated from areas immediately surrounding flow-lines in a catchment. These areas usually have deeper soils and high economic yield potential for a range of land uses. Thus forestry may be viable in lower rainfall catchments on lower slopes to reduce wash off, when it would not be viable in recharge areas. Issues of reduced water yield affecting downstream users should be evaluated.

Actions for one target may be at odds with the other. For example, dilution flows may reduce EC but could increase salt loads. Conversely, extract water will extract salt thereby lowering the salt load, but will not affect the EC value. Planting trees in the upper catchments could reduce salt load by reducing runoff, but lead to an increase in EC in the short to medium term.

g. Socio-economic impacts

The effectiveness of actions is as dependent upon social, cultural and economic factors, as on bio-physical characteristics. Actions (and even proposed actions) to address salinity will lead to changes in people's everyday lives, perceptions and/or expectations. These impacts need to be considered to ensure changes in land use are socially and economically sustainable. Socio-economic impact considerations include the return to investment and the temporal and spatial distribution of costs and benefits of an action.

h. Technique

The technique for considering these factors will depend in part, on whether the related salinity target is land or water-based. To locate and assess actions to meet land-based targets such as area of salt-affected land, the process will involve overlaying maps and information related to key considerations (landscape features, bio-physical attributes, socio-economic factors etc). To locate and assess actions that aim to meet water-based targets, such as EC or recharge, we will need to use modelling to examine the complex physical relationships.

Further comments about the above considerations are presented in CSIRO's *Effectiveness of Current Farming Systems in the Control of Dryland Salinity*[16] and *A Revolution in Land Use: Emerging Land Use Systems for Managing Dryland Salinity*[17].

3.3.2 Comparing the effectiveness of actions

The next step involves comparing the environmental, social and economic effectiveness of each action. The bio-physical effectiveness of actions may be assessed by ranking them according to their impacts on the within-valley and/or end-of-valley salinity targets and will be relative to the current land use at the proposed location.

Socio-economic comparison of actions involves assessing socio-economic factors such as: what people can and cannot live with; whether changes will impact community identity, lifestyle, behaviours, attitudes, social justice issues and cultural sustainability; the relative returns to investment; and temporal and spatial distributions of costs and benefits.

3.3.3. Choosing the most effective combination of actions

Choosing the most effective combination of actions will be an iterative process whereby different combinations are developed, compared and refined. In some areas there may be an individual action that is clearly the best to meet a particular salinity target. In many cases, however, we will want to examine the effectiveness of different combinations of actions. Groups of actions, for example, may provide a suitable mix of short and long-term benefits.

We should initially consider actions that have a net benefit and no net cost. For example, some actions to slow down salinity can give land managers a return greater than current practices. In the next instance, we should consider actions that have no net cost followed by actions that have a cost.

When assessing the relative merits of individual and combinations of actions, we need to take into account cumulative impacts – the incremental effects of these actions as they accumulate over time and space. This approach is particularly useful to assess the combined impacts of many small actions in a catchment.

A key element in this approach is an understanding of the relationships between land use actions and comparisons of the resultant environmental and socio-economic impacts.

The NSW Government, with other local and federal bodies, will provide a combination of models and expert panels to compare the relative effectiveness of actions. Computer-based models will be used to compare the relative effectiveness of different combinations of actions and quantify the amount of action needed. They can predict the expected performance of long and short-term planning scenarios, operational rules and practices and can potentially be applied at a range of scales.

The decisions we make about actions will reflect our existing knowledge about salinity and our current ability to impact on salinity. Improvements in our knowledge will increase our understanding of the effectiveness of actions the range of actions available and our modelling capacity. These developments would call for a review of our actions (see *Reviewing salinity management*, page 36 for more detail).

3.3.4 Quantifying the action needed

Once the most effective combination of actions has been identified, we calculate the amount of each action that is needed to meet the within-valley and/or end-of-valley target.

Chapter 4

Reviewing salinity management

The Salinity Summit recommended that

‘salinity targets be regularly reviewed with scope for modification and augmentation as required.’

Review is the process of measuring and considering past performance and identifying means for improvement. The NSW Government will conduct annual summary reviews and a comprehensive review every five years of our performance in meeting salinity targets, coinciding with the proposed audits for the MDBC. These will indicate our progress and provide new information about salinity processes and the effectiveness of actions. They will help us refine our predictions and the best actions to address salinity. The findings of our reviews will feed back into the planning process.

Reviewing salinity management in NSW involves monitoring, analysing, evaluating performance and reporting.

4.1 Monitoring

Monitoring involves the observation and recording of data showing performance against environmental, economic and social indicators. The NSW Government will monitor two main elements: within-valley and end-of-valley salinity targets, and actions targets.

Monitoring salinity targets will show changes in river and land-based salinity. To monitor end-of-valley salinity targets, the NSW Government will:

- measure EC using conductivity probes capable of continuous measurement of EC at each end-of-valley location; and
- estimate salt loads by measuring stream flow through a gauging station equipped to continuously measure water levels and multiplying this with the continuous EC readings above.

To monitor within-valley salinity targets, the NSW Government will record data at appropriate locations using the most appropriate method. For example, we can record data for a within-valley target relating to the area of salt-affected land by regularly reviewing predicted “hot spots”, field validation of reported outbreaks and using groundwater modelling and remote sensing. The Government will upgrade and, where necessary install, new equipment to support monitoring needs.

The NSW Government will collect data to indicate the extent to which we are implementing the actions. In most instances, it will be relatively straight forward to see whether the actions have been accomplished (for instance, whether the agreed number or area of trees have been planted).

Monitoring the impact of actions will be more complicated. As the impact of some actions will be gradual and/or have a time lag, monitoring may not immediately show the benefits of these actions. In many cases, the NSW Government will need to monitor secondary indicators, such as the reduced rate of infiltration (less recharge), and then model the predicted reduction in salinity at 2010.

Other secondary indicators could include:

- groundwater level;
- changes in the extent and condition of native vegetation, both as a result of clearing applications and dieback; and
- changes in land-use.

The NSW Government will also collect social and economic data to monitor the impact of salinity targets and actions. For example, the ‘return on investment’ from actions and changes in the structure and make-up of regional economies and communities will provide ongoing information to help us refine future salinity management decisions.

We are only beginning to understand the complexity of the physical and chemical factors leading to salinisation at a catchment scale. As outlined in previous sections, we are using models extensively in salinity management to replicate and understand the natural processes leading to increased salinity. Existing models, including those used to assess salinity trends in the salinity audits and those that predict the effect of actions on reducing salinity, rely heavily on past monitoring data and on assumptions about the behaviour of water and salt. The Government’s increase in the intensity and complexity of monitoring will improve the quality of data available, enabling us to refine the assumptions we use in models about:

- how salinity is moving throughout the catchment, and;
- how human activities are affecting salinity trends.

This will help us to develop more sophisticated modelling capabilities, in turn improving our ability to analyse salinity changes, identify the effectiveness of actions and predict future trends.

4.2 Analysis

Analysis involves using numerical methods to better understand salinity trends and relationships in the monitored data. The NSW Government will analyse data from monitoring programs, research projects and other sources. We need to analyse data to adjust for external factors (such as climate variability and changes in resource condition or management practices) so we can compare predicted and actual performance.

Salinity targets are complex to design and hence, analyse. Most are based on measurements of physical, chemical and biological parameters that are affected to a significant degree by climatic changes. We need to make adjustments to monitoring data to adequately take into account seasonal and year-to-year changes in climate, such as temperatures, rainfall and runoff volumes, that obscure the underlying trends.

Analysis allows us to differentiate between the actual salinity trend and variations due to short-term climatic conditions. For example, if monitoring data shows that groundwater has risen during a number of particularly wet years, we need to know to what extent the rise in groundwater is due to a natural short-term response to the climate, as opposed to a longer-term trend. This type of analysis is usually done using models. In setting the targets, we accounted for this climatic variation by using percentiles.

Also, specific sites may require additional analysis. For example, many end-of-valley target sites in the MDB are affected by backwater from the Darling River. Also, some of the streams for which we have set salinity targets stop flowing for varying periods of time. In some cases, stream water settles in pools and evaporates, leading to a increase in salinity at that point. When the stream begins flowing again, the water can mobilise the salt causing a highly saline ‘slug’ of water to flow downstream. Both these events will affect EC and salt loads and we may need to adjust our data when streams stop flowing to ensure our evaluations are meaningful.

We will need to analyse the extent to which an action impacts on salinity and compare this with our predictions. Also, we used models to set targets to establish the relationship between groundwater and river salinity, and route the impact of salinity increases down the catchment. As we gather more data, we need to analyse the accuracy of our predictions about these relationships. This will improve our understanding of how our actions are impacting on salinity and our ability to predict salinity trends.

Finally, we need to analyse data to calculate the extent to which upstream salinity targets are contributing to the downstream salinity targets and, for the MDB, how the end-of-valley targets are contributing to the target at Morgan.

4.3 Evaluating performance

Evaluation involves the appraisal of trends and relationships and interpreting their meaning in a biophysical, economic, social, cultural and environmental context. If we do not progress as we expected, either exceeding or falling short of our salinity targets, we will assess why and make necessary changes to our salinity management. For example, we may exceed or fall short of the targets due to:

- fluctuations in commodity markets and terms of trade that have a major influence on land use and management decisions as well as the financial capacity of land managers;
- actions in the CMPS not being undertaken due to lack of resourcing and/or land manager support;
- the mix of actions having a greater or smaller impact than predicted;
- unexpected actions in the catchment impacting on salinity, and;
- delays in the impact of actions being greater or less than expected.

The NSW Government will evaluate our performance in light of factors such as these and look at options to improve performance. Many of the actions will require voluntary participation by land managers, including those actions where there is a distinct financial benefit. The Government cannot control this participation, but will, if necessary evaluate impediments to participation and review incentive, extension and education programs.

4.4 Reporting

Reporting involves the publication of a written account of monitoring, analysis and performance evaluation. The DLWC will publish the comprehensive findings of salinity monitoring, analysis and evaluation in the State of the Catchment reports every five years. It will also publish a summary of findings every year in annual progress reports.

These two documents are a fundamental part of the NSW Government’s new system for reviewing regional natural resource plans (the Framework for Reporting and Evaluating Natural Resource Management). It aims to provide a basis for consistent reporting on the performance of natural resource management programs. The set of bio-physical indicators on the pressures and condition of catchments used in these reports will also be used in other reporting process, such as State of the Environment reports.

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Acronyms and glossary

ANZECC	Australian and New Zealand Environment and Conservation Council
CMB	Catchment Management Board
CMP	Catchment Management Plan
DLWC	Department of Land and Water Conservation
EC	Electrical Conductivity
ICM	Integrated Catchment Management
IEO	Interim Environmental Objective
IQQM	Integrated Quantity and Quality Model
MDB	Murray-Darling Basin
MDBC	Murray-Darling Basin Commission
MDBMC	Murray-Darling Basin Ministerial Council
S&D Strategy	Salinity and Drainage Strategy
WQO	Water Quality Objective

Adaptive management	A management approach that involves monitoring the outcomes of a project or issues and, on the basis of the monitoring, improving the way they are managed.
Agroforesty	Land management practice in which farmers cultivate trees in addition to their other agricultural activities.
Aquatic ecosystem	All living and non-living elements, and the relationship between them, of a water-based environment.
Aquifer	An underground layer of soil, rock or gravel able to hold and transmit water. Bores and wells are used to obtain water from aquifers.
Balance point	The location at which a salt balance is assessed.
Biodiversity	The variety of life forms, the different plants, animals and micro-organisms, the genes they contain and the ecosystems they form.
Biophysical	A word that jointly refers to the biological and physical elements of an environment.
Catchment	The area of land drained by a river and its tributaries.
Catchment management boards (CMBs)	Boards set up in December 1999 to enhance the capacity of total catchment management to substantially improve the quality and sustainability of our state's natural resources and environment. Members include community and Government representatives.

CATSALT	A water and salt balance model that can be used to simulate runoff and salt mobilisation and washoff behaviour in medium sized catchments (500 – 1,500 km^2), based on daily rainfall and evaporation data. It is also suitable for investigating the effects of land use changes on these behavioural characteristics.
Cumulative impacts	The incremental effects of a group of actions as they accumulate over time and space.
Dieback	A general term for a significant decline in tree health and numbers, especially native trees, caused by a variety of agents including insect attack, disease and pollution.
Dryland salinity	Salinity caused when the replacement of native vegetation with crops and pastures that have shallower roots and different water use requirements, leads to more water flowing into groundwater system and the increased mobilisation of salt. This saline water rises to near the ground surface in low-lying areas or at the break of slope, and/or flows underground directly into streams.
Ecosystem	Communities of organisms and their physical environment interacting as a unit.
End-of-valley salinity target	A "big picture" target that is an overall indication of our desired salinity conditions and also how much salt we are aiming for at the end of the catchment or valley. End-of-valley salinity targets are water quality target at the end reaches of a river.
Evapotranspiration	The loss of water through its conversion into vapour from land plants.
FLAG	A CSIRO developed modelling system that identifies areas in the landscape at risk of being affected by shallow groundwater tables based on topographic data provided by the 25 m digital elevation model. Maps of areas at risk of salinity can be derived using the FLAG results in conjunction with mapped soil salinity data. FLAG maps are used as in input layer to spatially distribute surface salt stores in the CATSALT modelling framework.
Grab sample	The taking of a water sample from a river as an indication of quality at a specific point in time.
Groundwater	Water that occurs beneath the ground held in or moving through saturated layers of soil, sediment or rock.
Hydrologic	Relating to the distribution and movement of water.
Indicators	Any physical, chemical or biological characteristic used as a measure of environmental, social or economic conditions.
Irrigation salinity	A localised rise in the level of groundwater and the associated mobilisation of salt, caused by the application of large volumes of irrigation water, compounded by the replacement of native vegetation by plants with different water use patterns.
Landscape	An area of land and its physical features. A term we use to describe an area has common features. For example, Dubbo may be in a range of landscapes, depending on whether we are looking at the type of agricultural production, vegetation, or landforms.
Point source discharge	The release of saline water from a specific location, such as drainage schemes.
Recharge	The portion of rainfall or river flow that percolates down through the soil and rock formations to reach the groundwater.
Regional Vegetation Committees	Committees established by the NSW Government to develop plans for native vegetation, made up of government and community representatives.

Regulated rivers	Those rivers proclaimed under the *Water Act 1912* as having their flows controlled by the major Government rural dams. The term regulation means that the flows along the length of the river are controlled or regulated by releases made from major dams to meet the needs of licensed uses.
River salinity	Increasing concentrations of salt in rivers and creeks caused by saline discharges from dryland, irrigation and urban salinity.
Salinisation	The process by which land becomes salt-affected.
Salinity	The concentration of sodium chloride or dissolved salts in water, usually expressed in electrical conductivity (EC) units or milligrams of total dissolved solids per litre (mg/L TDS).
Salt balance	A method used to account for the total salt in a system. It accounts for incoming and outgoing salt and the salt stored in a system. At every point in a system, the calculation needs to balance.
Salt interception schemes	Salt interception schemes divert groundwater or irrigation drainage water to ‘contained’ disposal sites.
Salt land agronomy	Land management practice in which farmers cultivate plants, principally salt bush, to reduce salt washoff and improve grazing productivity of salt-affected land.
Shared rivers	A term used in reference to the Murray-Darling Basin that refers to the Murray River below the Hume Dam and the Darling River below Menindee Lakes.
Subcatchment	Areas of land drained by a river’s tributaries within a catchment.
Unregulated rivers	All rivers that are not regulated, including rivers where the flow is controlled by dams or weirs constructed by urban water suppliers or private users.
Urban salinity	Rising groundwater and the associated mobilisation of salt in urban areas, caused by to clearing and the application of additional quantities of water due to watering gardens and parks; leaking water, sewerage and drainage pipes; and the obstruction or modification of natural surface and sub-surface drainage paths.
Water Management Committees	Committees set up to develop plans related to water management, made up of community and Government representatives.
Water Quality Objectives	Numerical concentration limits or requirements established to support and protect the designated environmental values of water at a specific site.
Wetlands	Land areas along fresh and salt water courses that are flooded all or part of the time, leading to the development of a characteristic suite of plant and animal communities and determining the type and productivity of soils.
Within-valley salinity target	A water or land-based target within a catchment that expresses the salinity level to aim for at a location or for an area.

Appendices

Appendix 1: Technical terms explained

This part of the paper looks at the indicators NSW will use to set end of valley and other water based salinity targets, explains some of the technical terms used and discusses how the targets will be expressed.

Indicators

There are a number of indicators we can use to gauge the amount of salt in water: the two main indicators used in the NSW Salinity Strategy are electrical conductivity and salt load.

a. Electrical Conductivity

Electrical conductivity is a measure of the ability of a liquid to carry an electric current, usually expressed in microsiemens per centimetre (µS/cm) or EC units. We often use electrical conductivity (EC) as an indicator of water salinity (the concentration of salts dissolved in water): the higher the EC the higher the salinity. Measuring salt in rivers is not an easy process. However, of the methods available, monitoring EC is the most cost-effective.

Because the relationship between electrical conductivity and salinity varies depending on which salts are present in solution, an understanding of what the salt mix is for a particular water body is necessary to convert EC to salt concentration in milligrams per litre (mg/L) accurately, so that we can calculate salt loads. The most common conversion factor is between 0.6 and 0.68 , that is EC x 0.6(8) = salinity (mg/L). The NSW Government will refine the salt load targets as our understanding of the chemical composition at each target site improves.

b. Salt Load

Salt load is calculated from data on salinity and stream flow and is a measure of the quantity of salt that passes a particular monitoring point during a specified period of time. Salt load estimates are vital because they indicate the amount of salt being stored in the landscape, washed from land, or entering the system from groundwater. If we only used salt concentration (measured as EC) as an indicator of salinity, we would not have a sense of the total quantity of salt in the system. Salt loads also indicate the potential rate of salt build up in places where salt might accumulate, such as wetlands and depressions on floodplains. Load estimates are important in predicting the impacts of salinity further downstream in the system.

To assess salt loads accurately we need to continuously monitor both EC (which is converted to salt concentration) and stream flow. We can also derive estimates from '*grab sample*' salinity and flow measurements taken at approximately monthly intervals, but these are not as accurate. Salt load is often expressed in kg/day, tonnes/day or tonnes/year.

1.2 Accounting for climatic variability

Because of the highly variable climate in NSW, rivers tend towards two extremes: either periods of low flow, or periods of high flow and flooding.

Figure 5 shows the high variability in flow for the Namoi River at Gunnedah over four and a half years. This natural variability affects the salt concentration and load carried by the river.

Figure 6 shows the salt load variability for the Namoi over the same period of time. The relationship between salt load and river flow variability is particularly direct because salt load is driven predominantly by river flow. We tend to have high levels of salt load for short periods of time (during high river flows) and lower salt loads over longer periods of time (during long low river flows).

While EC is also strongly influenced by flow (Figure 7) there are a variety of sometimes conflicting factors that determine what the final EC levels will be under particular flow conditions. These include dilution, the source of flow (including catchment runoff, groundwater and tributary inflows, storage releases and rainfall), preceding climatic conditions, wash-off and evaporation. The EC level at a particular place and time will depend on which combination of these factors is operating and which (if any) predominate.

For example, during a high flow event electrical conductivity may decrease because of dilution by flood flows; but conversely, it may increase because extra salts are introduced into the water body via catchment run-off, or erosion of salt laden stream banks. Electrical conductivity will also vary depending on whether the measurement is taken on the rise or the fall of the flood, and what the preceding climatic conditions were. Factors such as saline groundwater inflows and the concentration of salts in pooled areas due to evaporation can be particularly significant during low flow periods.

In most inland river systems, the variability in flow is typically much more (sometimes over 10,000 times) than the corresponding variability in electrical conductivity. Thus the dominant influence of flow variability drives the variability in load, and a much tighter relationship is seen between flow and load than between flow and electrical conductivity.

The variable flow patterns and associated variability in salinity are characteristic of many rivers in NSW. To be meaningful, our salinity targets need to accommodate this variability. For this, percentiles and medians are more useful than mean values and so are the statistics that NSW has used in setting salinity targets

Mean

The mean is also known as the average – the value when all records are added together and divided by the number of records. The mean gives a simple indication of the expected general level of salinity or salt load over a given period of time.

Namoi River at Gunnedah June 1995-January 2000

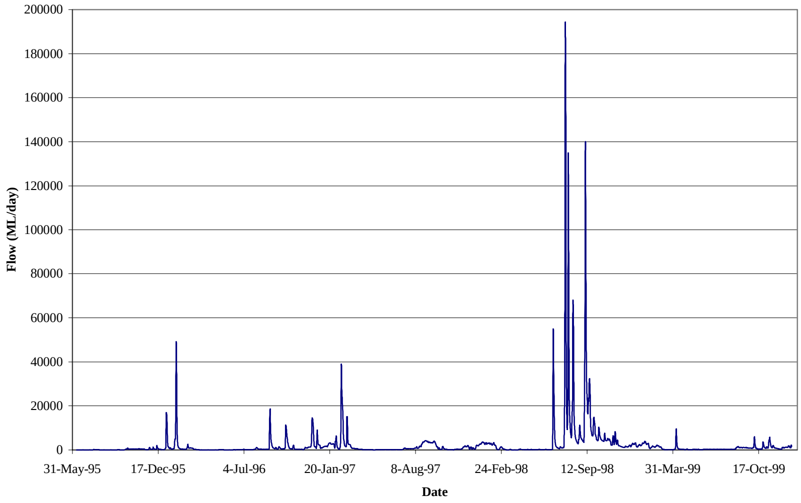


Figure 5: Stream Flow

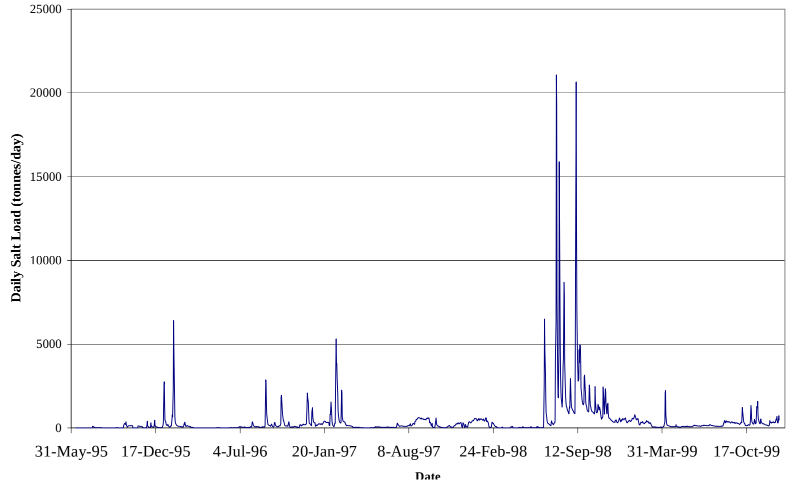


Figure 6: Salt load

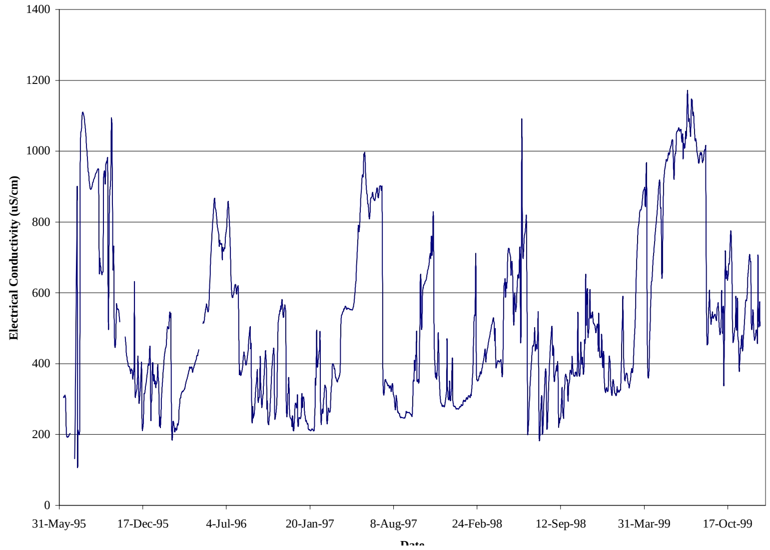


Figure 7: Electrical Conductivity

Percentiles and medians

The percentile value represents the proportion of time or probability, that a certain salinity or salt load value will not be exceeded. For example, an 80th percentile for EC in a certain river is the level that EC is below 80% of the time (ie it is exceeded only 20% of the time). The 50th percentile (also called the median) would be the EC level that is not exceeded 50% of the time.

Using the available data, a probability curve can be developed that shows the likelihood that a certain threshold value (EC or salt load) will be met (or conversely, be exceeded) at a particular river site. For example, Figure 8 and Figure 9 show the cumulative probability curves for estimated daily electrical conductivity and salt loads based on the 4½ years of data from June 1995 to January 2000 presented on page 45. The percentile values are on the vertical axis. The probability curve can also be used to show the relationships between the mean value and the percentile values.

Cumulative non-exceedance probability (percent) of daily values
for the Namoi River at Gunnedah June 1995 - Jan 2000

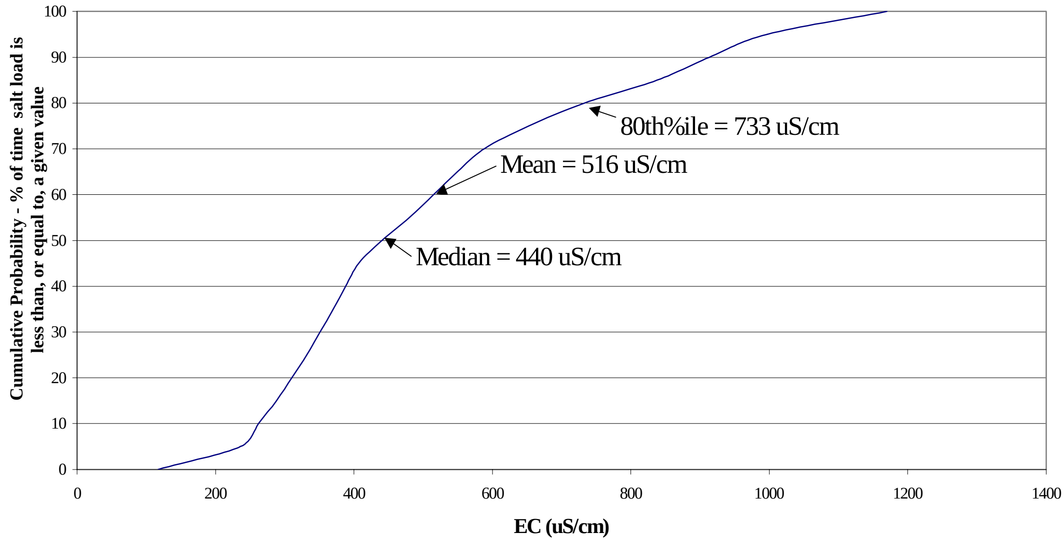


Figure 8: Electrical conductivity

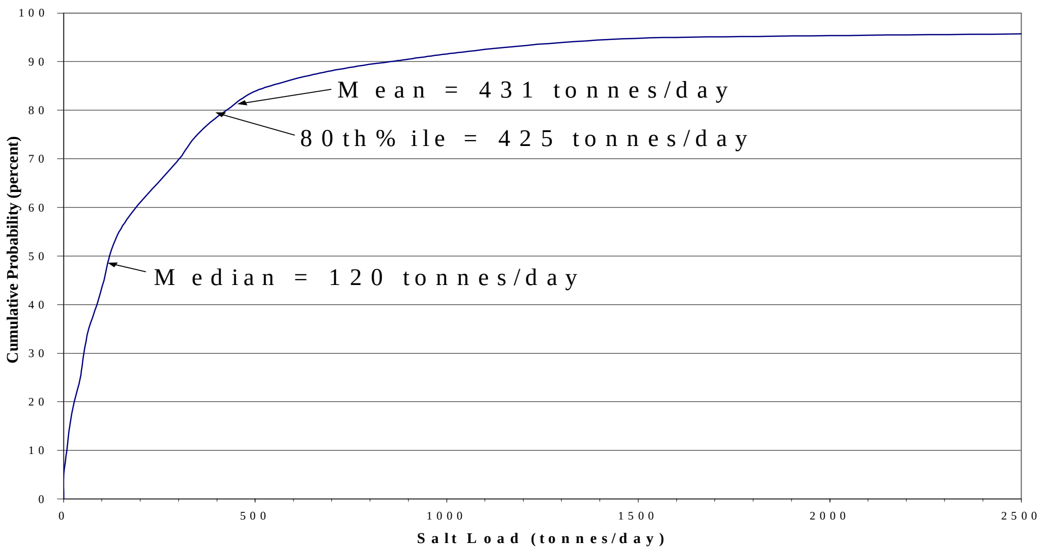


Figure 9: Salt load

Figure 8 for EC values, indicates that there is a 50% chance that daily EC values would be less than or equal to 440 EC over the period of interest: the 50th percentile, or median, value is therefore said to be 440 EC. It also shows that there is an 80% chance that daily EC values would not exceed 733 EC over the period - therefore, the 80th percentile in this case is 733 EC. Similarly, with salt loads in Figure 9, the 50th percentile salt load value is 120 tonnes per day, while the 80th percentile is 425 tonnes/day.

An important feature clearly shown by both these figures is that the mean (average) is quite a different descriptor of the data than the median and that differences in their numerical values depend on the distribution of the particular dataset. In the cumulative EC plot, for example, the mean is somewhere near the 60th percentile value of the data, whereas in the salt load plot it is more like the 80th percentile (and is therefore only exceeded roughly 20% of the time). It is unusual for the mean to be greater than the 80th percentile - usually for Australian rivers the mean is between the 50th and 80th percentile. In the example above, the high mean for salt load is caused by a brief period of extremely high flows during July-September 1998. It illustrates how the mean can be influenced by extreme events and also the dangers of basing decisions on short periods of records.

In setting catchment scale salinity targets under the NSW Salinity Strategy, we are using both the 50th and 80th percentile values. The 50th percentile is used to indicate the mid-range level of salinity in an area. The 80th percentile represents the higher end of the salinity range and is useful to show extreme events that may have been experienced either over a sustained period or on a number of occasions, therefore potentially affecting aquatic ecosystems or human activities. The 80th percentile is more useful than the maximum value as the maximum may only give a sense of infrequent events that come and go very quickly.

At a catchment scale, using percentiles for targets gives us the ability to set targets for frequencies of certain EC and salt load levels and express more precisely the values we want to protect. It acknowledges that sometimes certain salinity level will be exceeded because of events outside our control, such as climate.

As already outlined, electrical conductivity can be measured using readily available instrumentation and established procedural standards, and salt loads can be calculated from salinity and stream flow data. Within the framework of setting salinity targets, however, there is always some degree of inaccuracy and inherent variability involved in any measurements and this is expressed as a band of confidence (or confidence interval) surrounding the measured results (see Figure 10). In general, an upper and lower confidence limit are used, expressing the likelihood that the real value lies somewhere between the two bands.

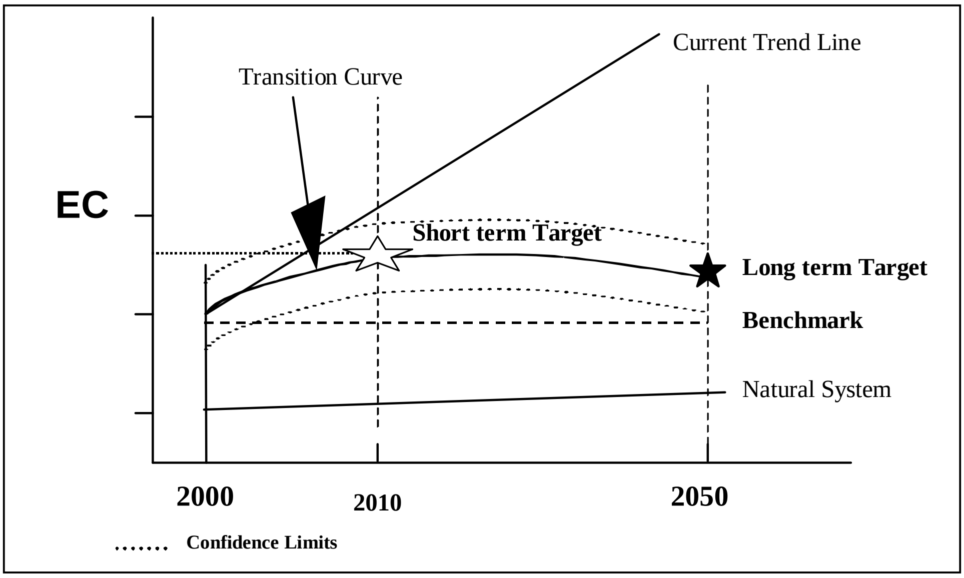
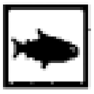


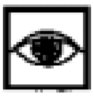
Figure 10: Salinity targets strategy framework

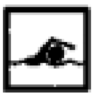
Appendix 2: The environmental values considered in setting the NSW Interim Environmental Objectives (IEOs) for water quality.

Protection of:


Aquatic ecosystems

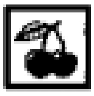

Aquatic Foods (to be cooked before eating)

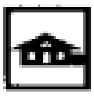

Visual amenity

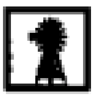

Primary contact recreation

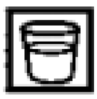

Secondary contact recreation

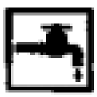

Livestock water supply


Irrigation water supply


Homestead water supply


Drinking water – groundwater


Drinking water at point of supply – disinfection only


Drinking water at point of supply – disinfection only

Appendix 3: The Integrated Quality Quantity Model (IQQM)

The New South Wales Department of Land and Water Conservation is developing and implementing the Integrated Quantity and Quality Model (IQQM) to provide an improved hydrologic modelling tool that gives stakeholders information on the impacts of water resources management policies or policy changes. IQQM is needed because short term variability of flows (that is, variability of flows over a few days or hours) is important for many current water management issues and we also need to be able to consider interactions between water quantity and water quality. The previous generation of operational hydrologic models is unable to address these issues, while IQQM is specifically designed to address them.

IQQM is a planning model that is designed to be applied to river systems with and without dams, and is capable of addressing water quality as well as water quantity issues. The water quality parameters it can model include salinity, pesticides, temperature and dissolved oxygen.

The model simulates river system behaviour, including water quality, for periods that can range from a few months up to hundreds of years. It does this by computing how the river system behaves in response to factors, such as rainfall and evaporation, day by day for the entire period to be modelled. There is provision for computations for modelling some processes to be undertaken at intervals of as little as one hour, to enable these processes to be adequately represented.

IQQM comprises eight main modules:

- River system model,
- Rainfall-runoff model (Sacramento Model),
- Gate operation model,
- Climate model,
- Graphical output tools,
- Statistical analysis tools,
- Data retrieval and utilities, and
- System set up (for configuring IQQM for a computer).

The NSW Government has used IQQM in the major inland river systems of NSW, including the Border Rivers, and the Murrumbidgee, Namoi, Gwydir, Lachlan, and Macquarie River systems. It has also used IQQM in coastal systems, such as the Clarence and Hunter, and in smaller systems such as parts of the Snowy and Tooma Rivers, and the Cox's River.

IQQM has provided reliable and robust information to support decisions on sharing water between competing users, including the development of environmental flow rules. It has also been applied in a number of water quality studies, including salinity routing applications in support of the NSW Salinity Strategy.

Appendix 4: The interim end-of-valley salinity targets

Table 1 - Trends and Interim End-of-valley Salinity Targets for 2010

Valley	*Percentile*	Predicted salinity (in ECs) if we do not change our water & land management			Predicted % of 2000 level	NSW 2010 interim target		Equivalent MDBC 2015 interim target		Predicted salinity (in ECs) if we do not change our water and land management		
		1998	2000 interpolated	2010	2010	EC	% of 2000 level	EC	Predicted % of 2000 level	2020	2050	2100
Murrumbidgee at Balranald	50	230	233	250	107	245	105	250	108	270	290	350
	80	290	297	330	111	320	108	330	112	370	400	460
Lachlan at Forbes	50	380	388	430	111	410	106	420	108	480	700	880
	80	520	528	570	108	550	104	560	106	620	950	1250
Bogan at Gongolgon	50	400	442	650	147	550	125	600	137	900	1200	1400
	80	1450	1563	2125	136	1450	93	1450	93	2800	3750	4000
Macquarie at Carinda	50	450	500	750	150	500	100	540	108	1050	1450	1750
	80	620	683	1000	146	800	117	860	126	1380	1920	2420
Castlereagh at end-of-valley	50	300	304	325	107	315	104	320	105	350	680	700
	80	1500	1512	1575	104	1500	99	1500	99	1650	3000	3200

Table 1 continued - Trends and Interim End-of-valley Salinity Targets for 2010

Valley	*Percentile*	Predicted salinity (in ECs) if we do not change our water & land management			Predicted % of 2000 level	NSW 2010 interim target		Equivalent MDBC 2015 interim target		Predicted salinity (in ECs) if we do not change our water and land management		
		1998	2000 interpolated	2010	2010	EC	% of 2000 level	EC	Predicted % of 2000 level	2020	2050	2100
Namoi at Goangra	50	500	521	625	120	550	106	565	108	750	950	1120
	80	900	938	1125	120	1000	107	1030	110	1350	1620	1950
Gwydir near Collarenebri	50	380	383	400	104	390	102	395	103	420	520	550
	80	720	723	735	102	730	101	735	102	750	900	950
Macintyre at Mungindi	50	230	230	230	100	230	100	230	100	230	230	230
	80	630	630	630	100	630	100	630	100	630	630	630
Barwon-Darling at Menindee	50	300	312	375	120	350	112	370	118	450	540	620
	80	750	783	950	121	800	102	810	103	1140	1460	1720

Table 2 - Trends and Interim End-of-valley Salt Load Targets for 2010

Valley	*Percentile*	Predicted salt loads (in tonnes per year) if we do not change our water and land management			Predicted % of 2000 level in 2010	NSW 2010 interim target		Equivalent MDBC 2015 interim target		Predicted salt loads (in tonnes per year) if we do not change our water and land management		
		1998	2000 interpolated	2010		Salt load (tonnes/yr)	% of 2000 level	Salt load (tonnes/yr)	% of 2000 level	2020	2050	2100
Murrumbidgee at Balranald	50	136,800	139,000	150,000	108	145,000	104	149,000	107	166,500	180,500	204,000
	80	301,800	306,500	330,000	108	325,000	106	334,200	109	366,500	397,000	448,000
Lachlan at Forbes	50	229,800	234,800	260,100	111	240,000	102	242,600	103	290,500	428,300	546,500
	80	273,400	279,800	311,700	111	290,000	104	295,100	105	349,900	516,400	660,200
Bogan at Gongolgon	50	22,500	24,600	35,000	142	30,000	122	32,700	133	48,000	63,500	75,000
	80	43,500	47,100	65,000	138	55,000	117	59,000	125	91,000	121,500	143,000
Macquarie at end of system	50	29,500	32,100	45,000	140	35,000	109	36,500	114	65,500	89,000	109,000
	80	49,000	54,200	80,000	148	65,000	120	70,400	130	107,000	147,000	180,000
Castlereagh at end of system	50	18,200	18,400	19,200	105	18,200	99	18,400	100	20,100	36,500	38,300
	80	31,000	31,300	32,600	104	31,000	99	31,300	100	34,100	62,100	65,200

Table 2 continued- Trends and Interim End-of-valley Salt Load Targets for 2010

Valley	*Percentile*	Predicted salt loads (in tonnes per year) if we do not change our water and land management			Predicted % of 2000 level in 2010	NSW 2010 interim target		Equivalent MDBC 2015 interim target		Predicted salt loads (in tonnes per year) if we do not change our water and land management		
		1998	2000 interpolated	2010		Salt load (tonnes/yr)	% of 2000 level	Salt load (tonnes/yr)	% of 2000 level	2020	2050	2100
Namoi at Goangra	50	48,000	50,000	60,000	121	55,000	111	58,000	116	81,000	100,000	130,000
	80	132,000	138,000	165,000	120	158,000	114	167,000	121	200,000	240,000	290,000
Gwydir at end of system	50	6,500	6,600	6,800	104	6,500	99	6,600	100	7,000	8,500	9,000
	80	20,500	20,600	21,000	102	20,600	100	20,800	101	22,500	28,500	31,000
Macintyre at Mungindi	50	68,000	68,000	68,000	100	68,000	100	68,000	100	68,000	68,000	68,000
	80	171,000	171,000	171,000	100	171,000	100	171,000	100	171,000	171,000	171,000
Barwon-Darling at Menindee	50	125,000	132,500	170,000	128	160,000	121	173,800	131	215,000	265,000	305,000
	80	460,000	474,200	545,000	115	530,000	112	557,900	118	630,000	750,000	840,000

* Salt load figures in Table 2 for the Namoi have been updated since the NSW Salinity Strategy was published, based on new information received.

Appendix 5: Average salt loads (tonnes/year) corresponding to interim end-of-valley salinity targets

Valley and location	2000	2010 'do-nothing'	2010 target
Murrumbidgee at Balranald	188,000	209,000	196,000
Lachlan at Forbes	234,000	264,000	238,000
Bogan at Gongolgon	37,000	54,000	45,000
Macquarie at end of system	48,000	71,000	53,000
Castlereagh at end of system	19,700	20,600	19,500
Namoi at Goangra	71,000	88,000	79,000
Gwydir at end of system	12,400	12,900	12,300
Macintyre at Mungindi	95,400	95,400	95,400
Barwon-Darling river system at Menindee	260,800	334,000	316,000