Australian Government

MURRAY–DARLING BASIN AUTHORITY

MURRAY-DARLING BASIN AUTHORITY

Salinity Targets Review

Water Quality and Salinity Management Plan Objectives and Targets

Report 4 (of 4)
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SUMMARY OF ABBREVIATIONS AND UNITS

Table ES-1 Summary of abbreviations

BSMS	Basin Salinity Management Strategy
BSO	Basin salinity operations
BSP	Basin scale planning
EoVT	end-of-valley target
MDB	Murray–Darling Basin
MDBA	Murray–Darling Basin Authority
NWQMS	National Water Quality Management Strategy
RCI	resource condition indicator
RCL	resource condition limit
SKM	Sinclair Knight Merz
WQSMP	Water Quality Salinity Management Plan

Table ES-2 Units

Salinity units	Within this document both Electrical Conductivity (EC in μScm^{-1}) and salt concentration (in mg/L) are used to quantify river salinities. The rate of conversion at salinities less than 2,000 EC is assumed to be 1 EC = 0.6 mg/L. The basis for this conversion factor is discussed within MDBA (2010a).

1. EXECUTIVE SUMMARY

Introduction

In 2009, the Murray–Darling Basin Authority (MDBA) instigated the development of a Murray–Darling Basin *Water Quality and Salinity Management Plan* (*WQSMP*) as part of the Basin planning process required under the *Water Act 2007* (Cwlth). SKM was commissioned to carry out a project that would:

- review the existing end-of-valley targets under the *Basin Salinity Management Strategy* (*BSMS*) and Schedule B to the Murray–Darling Basin Agreement (*Water Act 2007*) with the expectation of providing directions on future end-of-valley targets and potential directions to integrate the existing arrangements with the basin planning process
- develop a process for the setting of salinity objectives and targets for inclusion in the *WQSMP*
- recommend salinity objectives and targets for inclusion in the *WQSMP*.

This is the final report in a series of four reports that provides recommendations on salinity objectives and targets for the Water Quality and Salinity Management Plan and proposed directions for the integration of existing valley accountability arrangements into the salinity objectives and targets proposed for inclusion within the Basin plan.

The Act requires that the objectives and targets be developed with regard to the *National Water Quality Management Strategy* (*NWQMS*). Accordingly, salinity objectives are framed in terms of environmental values or beneficial uses. Within this report, the term 'environmental values' has been adopted specifically to describe those values associated with aquatic ecosystems, raw drinking supplies, and irrigation supplies.

The following environmental values, identified within the *NWQMS*, are not considered within the scope of the setting of basin or valley scale salinity objectives and targets, but are considered elsewhere by the MDBA in the Basin planning process:

- recreational and cultural values
- industrial values
- values within off-stream wetlands (however, salinity of diversions to such wetlands are considered)

The approach proposed to setting objectives for the *WQSMP* is underpinned by the principle that, in the first instance, salinity objectives should be those that protect the highest possible environmental value. Objectives deemed to be in line with these high level objectives for aquatic ecosystems, raw drinking water and irrigated agriculture are as follows:

- raw drinking water — water salinity should be maintained to enable water in the Murray–Darling tributaries to be suitable for domestic use where there are treatment plants and water is extracted for human use
- ecological values — water salinity supplied from rivers and streams should be suitable to maintain the ecological character of ecosystem communities
- irrigated agriculture — water salinity should be maintained at salinity levels below that which will adversely affect existing crop productivity under best management practices for irrigation.

For each of these environmental values there is deemed to be a resource condition limit (RCL) which is the salinity value (or tipping point) beyond which an increase in salinity will compromise the environmental values. The RCL may therefore be the recommended target, unless existing salinities are lower than the RCL, in which case the principle of no deterioration in existing water quality is expected to be adopted as the basis for the target.

In regard to aquatic ecosystems at the Basin and at catchment scales, there are a multitude of organisms that are sensitive to salinity, and considerable variability exists in terms of mortality and reproductive health both between species and at different stages within the life cycle. In light of this variability, an RCL of 500 mg/L is proposed for aquatic ecosystems. This is a relatively conservative RCL. Determination of a higher RCL would warrant greater knowledge and understanding of ecosystems.

The requirement for raw drinking water is consistent for all populations, irrespective of urban or rural locations, and has been selected in accordance with the *Australian Drinking Water Guidelines* definition of 'good' water quality; currently, 'good' is defined as 500 mg/L (NHMRC and NRMMC 2004). The palatability of higher salinity water is not considered to be 'satisfactory'.

RCLs for irrigated agriculture have been considered separately for different parts of the basin and are presented in Appendix A. The RCL for each area reflects the sensitivities of the most salt sensitive irrigated crop providing at least 10% of irrigated production to a region. The proposed RCLs are compared in Appendix A with five year rolling average peak salinity upper and lower bounds that are analogous with long term dry and wet periods, both of which variously drive salinity spikes depending upon the landscape involved and the flow regime available for dilution. This data essentially provides and an indication of the likelihood of the proposed RCLs being exceeded in any five year period.

In line with the MDBA expectation that targets be SMART (i.e. specific, measurable, achievable, relevant and time based), it is proposed that the targets be expressed in terms of an average daily salinity in order to provide the basis for river operators and investment proposals to focus works and measures towards tangible and practical outcomes for environmental values.

Monitoring sites for assessing progress against targets is proposed for 22 sites across the basin which broadly cover key environmental values within each valley. The location of raw drinking water offtakes was not a factor considered in the selection of monitoring sites; urban treatment plants are required to undertake rigorous monitoring of water diversions, thus there is potential for arrangements to be developed for access to this data rather than instigating a parallel monitoring program.

It is anticipated that monitoring data could be utilised to assess performance against targets by considering the percentage of days that salinity exceeds the target at each of the chosen sites over the preceding 12 month and five year periods. A broad assessment of the types of salinity mitigating actions and their limitations is provided in the main report to guide the MDBA in its decisions to adopt the proposed objectives and targets. These types of actions can broadly be described as land use/ catchment actions, including agronomic or vegetation based catchment actions, salt interception schemes, and flow manipulation.

In considering the recommended targets proposed within this report, the MDBA will need to consider the likelihood of these targets being exceeded, given the salinity trends under current conditions, the applicability of the above mitigation options for each environmental value, and the investment necessary to achieve these targets. Targets may be required to be set higher than the RCL if the investment necessary to achieve the objectives exceeds likely benefits.

The existing salinity targets under the *BSMS* provide a planning framework for managing long term salinity outcomes over a variable climatic regime. It is proposed that the Basin salinity operational (BSO) targets be developed that are aimed at valley scale environmental values. They would complement the existing framework, which is termed Basin salinity planning (BSP) within this report. BSP is essentially a re-framing of the existing *BSMS* accountabilities for valley outcomes and the Basin target at Morgan. This framework, which comprises Basin scale planning and Basin salinity operations approaches, will require guidance material in the same way as the *BSMS* utilised Operational Protocols.

If the integration of these approaches, as described here, is adopted, it is proposed that the BSO and BSP components should be integrated into a single source document. Accordingly, a coordinated protocols and guidelines document will then be required to be prepared to provide guidance and support for implementation.

Recommendations

1. that the MDBA consider the following proposed objectives in the development of the *WQSMP*:
    a. raw drinking water — water salinity should be maintained to enable water in the Murray–Darling tributaries to be suitable for domestic use where there are treatment plants and water is extracted for human use
    b. aquatic ecosystems — water salinity supplied from rivers and streams should be suitable to maintain the ecological character of ecosystem communities
    c. irrigated agriculture — water salinity should be maintained at salinity levels below that which will adversely affect existing crop productivity under best management practices for irrigation
4. that the MDBA consider the proposed targets for the *Water Quality and Salinity Management Plan* (Appendix A) as a means of measuring progress against the objectives
5. that the authority note that there is a high to very high likelihood, based on an analysis of stream flow and modelling data, of not achieving some of the recommended targets given historic catchment salt export trends
6. where the likelihoods are high to very high, that the authority consider:
    a. implementing investigative studies at appropriate spatial scales to better understand sources, pathways and sinks of salt and associated water quality threats where RCLs are not currently likely to be consistently achieved
    b. cost effective catchment or river management options to mitigate risks
    c. identifying accountabilities and associated commitment to the investment necessary to offset risks, and hence the associated investment necessary to achieve these targets
    d. utilising enabling language within the Basin plan to allow water resource planning arrangements to set salinity objectives and targets that reflect the water quality constraints of the prevailing local hydrogeological conditions
5. that the MDBA consider the proposed Basin salinity planning, accountability and operational management framework within the Basin planning process, with a view to either:
    a. modifying Schedule B to the Murray–Darling Basin Agreement
    b. incorporating Schedule B elements into the Basin plan, taking into account the proposed framework provided in this report

3. that the BSP (the previous *BSMS*) and the BSO be integrated as part of the Basin planning process into single source document under the *WQSMP*; this would provide a single basis for the subsequent preparation of protocols and guidelines, and recognise the complementary nature of the two approaches
4. that as part of the water resource planning process, jurisdictions should:
    a. consider the appropriateness of works or measures to achieve targets, including the need for works to mitigate salt mobilisation and/or the need for regular flows to encourage salt exports and maintain a long term salt balance within the lower reaches of river
    b. review existing end-of-valley target values in light of updated understandings of the legacy of history, and so enable inclusion of valley scale resource condition indicators in the development of water resource plans.

2. PURPOSE OF REPORT

In 2009, the Murray–Darling Basin Authority (MDBA) instigated the development of a Murray–Darling Basin *Water Quality and Salinity Management Plan* (*WQSMP*) as part of Basin planning process required under the *Water Act 2007*. Within the context of this initiative, SKM was commissioned to carry out a project that would:

- review the existing end-of-valley targets under the *Basin Salinity Management Strategy* (*BSMS*) and Schedule B to the Murray–Darling Basin Agreement (*Water Act 2007*) with the expectation of providing directions on future end-of-valley targets and potential directions to integrate the existing arrangements with the Basin planning process
- develop a process for the setting of salinity objectives and targets for inclusion in the *WQSMP*
- recommend salinity targets and objectives for inclusion in the *WQSMP*.

This is the final report in a series of four reports that documents the outcomes of the project.

The three companion reports provide significant input background to the higher level policy directions provided within this report. These companion reports are as follows:

- *Salinity Targets Review: Environmental values and data analysis* (MDBA 2010a)
- *Salinity Targets Review: A framework for, and review of sites, monitoring and targets* (MDBA 2010b)
- *Salinity Targets Review: A process for developing objectives and targets* (MDBA 2010c).

Key material provided in this report to guide the setting of objectives and targets under the *WQSMP* and future valley arrangements is presented in Table 2-1. Where a companion report provides more detailed supporting documentation, an appropriate reference is also provided.

Table 2-1 Key material to guide the setting of salinity objectives and targets

Project Output	Source of information
A process for salinity objectives and targets	MDBA (2010c)
A proposed suite of Environmental Values to be protected by objectives and targets	MDBA (2010a)
Proposed objectives and targets	MDBA (2010c)
Location of target monitoring sites	MDBA (2010c)
Analysis of likelihood of salinity threat at key sites	MDBA (2010a)
Integration of existing end-of-valley arrangements into the Basin plan	MDBA (2010b)
Implications for Schedule B and the *BSMS* Operational Protocols.	This report

3 SCOPE

The following provides an outline of the scope of the requirements for the development of salinity targets and objectives and a process for developing these, as documented in Report 3 (MDBA 2010c).

Under the Australian Government's *Water Act*, the MDBA is charged with developing a Basin plan, including a *WQSMP*. The plan must:

- identify the key causes of water quality degradation in the Murray–Darling Basin
- include water quality and salinity objectives and targets for the Basin's water resources.

The scope of this report is limited to issues around objectives and targets (i.e. the second requirement of the *WQSMP* as prescribed in the act). The key causes of water quality degradation are being documented elsewhere by the MDBA.

The approach in this project has been to provide a process to derive water salinity objectives and targets that will have application to the development of the Basin plan and subsequent reviews of targets. Five yearly reviews are a further requirement of the act.

In considering the recommendations on objectives and targets, the authority will necessarily need to consider trade-offs between water quality and quantity outcomes for competing uses. Targets ultimately included in the Basin plan may therefore be decided within a broader framework that considers a range of Basin plan objectives and the level of investment necessary to deliver upon those objectives.

The act requires that the objectives and targets be developed with regard to the *National Water Quality Management Strategy* (*NWQMS*). The approach of the *NWQMS* is to 'consider the ranges of environmental resources, economic opportunities and community preferences associated with their water resources' (*NWQMSIG* 1998).

In keeping with these guidelines, salinity objectives can be framed in terms of environmental values or beneficial uses. Within this report, the term 'environmental values' has been adopted to specifically describe those values associated with aquatic ecosystems, raw drinking supplies, and irrigation supplies.

Recreational, industrial and cultural values are also identified as environmental values under the *NWQSMP*; however, the MDBA office has advised that:

- the implications of water salinity changes are considered minimal for recreational and cultural values, with other elements of the Basin plan considering these values
- industrial values are best managed through the rigorous application of local planning provisions rather than through Basin-scale planning arrangements.

Management of off-stream values for assets such as off-stream wetlands involve other management prerogatives. For example, the Basin plan must promote the conservation of declared Ramsar wetlands and take into account the ecological character descriptions of:

- all declared Ramsar wetlands within the Murray–Darling Basin
- all other key environmental sites within the Murray–Darling Basin.

The salinity of such sites is a function of the wetting, drying and flushing of wetlands, which will vary temporally and spatially for any given wetland and its watering regime. Accordingly, the extent to which salinity objectives and targets are proposed for off-stream environmental values is limited to the salinity

of diversions or supply to off-stream wetlands. In the event that the MDBA decides to include water salinity targets within off-stream wetlands, the targets may need to consider specific species and the dynamics of the water salinity that will arise from periodic inundation and the subsequent drying phase.

The impact of groundwater salinity on environmental values was also considered to be beyond the scope of this project (MDBA 2010a). Significant changes in groundwater salinities induced by land and water management changes are usually minimal within planning timeframes. A notable exception is the impacts of groundwater extraction, which substantially alter groundwater gradients and fluxes. Basin planning issues associated with achieving groundwater resource salinity objectives and targets are best considered within other elements of the Basin plan, i.e. the determination of sustainable diversion limits for groundwater.

4. PRINCIPLES

Key principles adopted in the development of the process for the setting of objectives and targets (MDBA 2010c) are that:

a. The starting point for the setting of salinity objectives should be the highest possible qualitative environmental value for aquatic ecosystems, raw drinking water and irrigation supplies. Accordingly, salinity targets that measure progress against objectives should reflect the resource condition limit (RCL) which is the threshold salinity below which these highest possible environmental values will be maintained (i.e. the upper limit to acceptable impacts).

b. Salinity related threats differ across different landscapes. The Basin planning process should drive action in those catchments where the most significant threats arise and changed management actions have the highest potential to achieve cost effective improvements in water salinity.

c. The setting of objectives and targets should have regard to existing salinity trends at specific locations. Targets should, wherever possible, reflect no deterioration in existing water salinity.

d. Within the context of risks to agricultural productivity arising from high salinities in water supplies, river salinity targets relating to agricultural values should assume irrigator adoption of best management practices.

e. It is recognised that there is tension between setting objectives based upon the highest possible environmental values and the cost effectiveness of actions to prevent or mitigate salinity impacts to deliver these values. The setting of objectives is, therefore, an iterative process.

f. The determination and review of salinity targets should be conducted with due recognition of the process of continuous improvement. Whilst targets should be based upon the best available science, the *Water Act* provides a process that will allow updates over time. Targets recommended in this report should therefore not be viewed as necessarily achieving every economic, environmental and social objective.

5 EXISTING ARRANGEMENTS

The requirement to develop a suite of recommended salinity objectives and targets to satisfy the requirements of the act is significantly assisted by the progress and achievements of the Basin scale salinity management under the *BSMS* and Schedule B to the *Murray–Darling Basin Agreement*. These achievements are documented in the BSMS *Mid-Term Review* (MDBC 2007) and include an accountability framework that links basin wide land and water management decisions to basin outcomes at Morgan in South Australia. Within the context of salinity targets, the strategy has been a major driver for the development of an extensive stream salinity monitoring program that has provided significant benefits in the form of understandings of the Basin's water and salt balance. It has also achieved the development of a suite of modelling tools that enable planners to assess the salinity impacts of catchment actions on in-river water quality.

Potential commonalities between the existing *BSMS*/Schedule B framework and the requirements for the *WQSMP* for salinity objectives and targets are that the former provides an existing suite of valley scale targets across the Basin and a robust monitoring network. End-of-valley targets were derived from concerns arising from the 1999 Salinity Audit (MDBMC 1999) that significant salt loads were being mobilised within the dryland landscape, and that this posed a substantial risk to future river salinity. Subsequent technical work suggests that these perceived risks from rain fed agricultural and forestry systems are significantly less than that predicted in the 1999 audit (MDBA 2010b).

Consideration was given as to whether the form and location of the *BSMS* end-of-valley targets and Basin salinity target (at Morgan) should be the platform for delivering objectives under the Basin plan, as their location is, in many situations, likely to be well aligned with future water resource planning arrangements; they were intended as 'important indicators of catchment and basin health' (MDBMC 2001).

The strengths and weaknesses of these existing arrangements are documented within a companion report (MDBA 2010b). The conclusions of that report were that there are limitations within the existing arrangements, as the *BSMS* objectives and targets do not adequately address the MDBA's intention that the *WQSMP* aims for water salinity be suitable to meet all uses of the basin's water resources.

Specific limitations to the existing valley targets framework, as it relates to the needs of the *WQSMP*, include the following:

a. *BSMS* end-of-valley targets are expressed as simulated salinity outcomes over the variable climate sequence of 1975–2000 (the benchmark period). This expression of targets was intended to assess progress in salinity management over a period covering both wet and dry years. Actual outcomes for the *NWQMS* environmental values within the stream on a day-to-day basis have no direct relationship with whether or not *BSMS* end-of-valley targets are achieved. Monitoring networks inform understanding of salt load exports and, in some cases, flow/salinity relationships and the development of modelling tools; however, simulated outcomes have little relevance to day-to-day salinity outcomes for environmental values.

a. The quantum of the *BSMS* targets are essentially a legacy of a past understanding of the threats posed from dryland salinity. As improved knowledge has indicated that these threats are not as great as envisaged in 1999 (MDBA 2010b), the quantum of the targets requires adjustment which would be subject to substantial modelling and prior agreement on an appropriate benchmark period.

a. There were explicit directions/recommendations arising from the BSMS *Mid-Term Review* (MDBC 2007) addressing the need to consider real time targets that may either complement or replace the existing target arrangements. It is considered necessary that the *WQSMP* requirements for objectives and targets take heed of these *Mid-Term Review* recommendations.

6 A PROCESS FOR SETTING SALINITY OBJECTIVES AND TARGETS IN THE BASIN PLAN

The *NWQMS* emphasis on environmental values as the basis for water quality management is proposed as the platform for the setting of salinity objectives and targets. The need for this approach to be integrated within the broader salinity management arrangements provided by the existing *BSMS* is discussed in Section 9.

The approach proposed to set objectives and targets for the *WQSMP* (MDBA 2010c) is underpinned by the principle that, in the first instance, salinity objectives should be those that protect the highest possible environmental value. These objectives have been established for the supply of raw drinking diversions, diversions for irrigated agriculture and supply to aquatic ecosystems as follows:

- Raw drinking water — water salinity should be maintained to enable water in the Murray–Darling tributaries to be suitable for domestic use where there are treatment plants and water is extracted for human use.
- Aquatic ecosystems — water salinity supplied from rivers and streams should be suitable to maintain the ecological character of ecosystem communities.
- Irrigated agriculture — water salinity should be maintained at salinity levels below that which will adversely affect existing crop productivity under best management practices for irrigation.

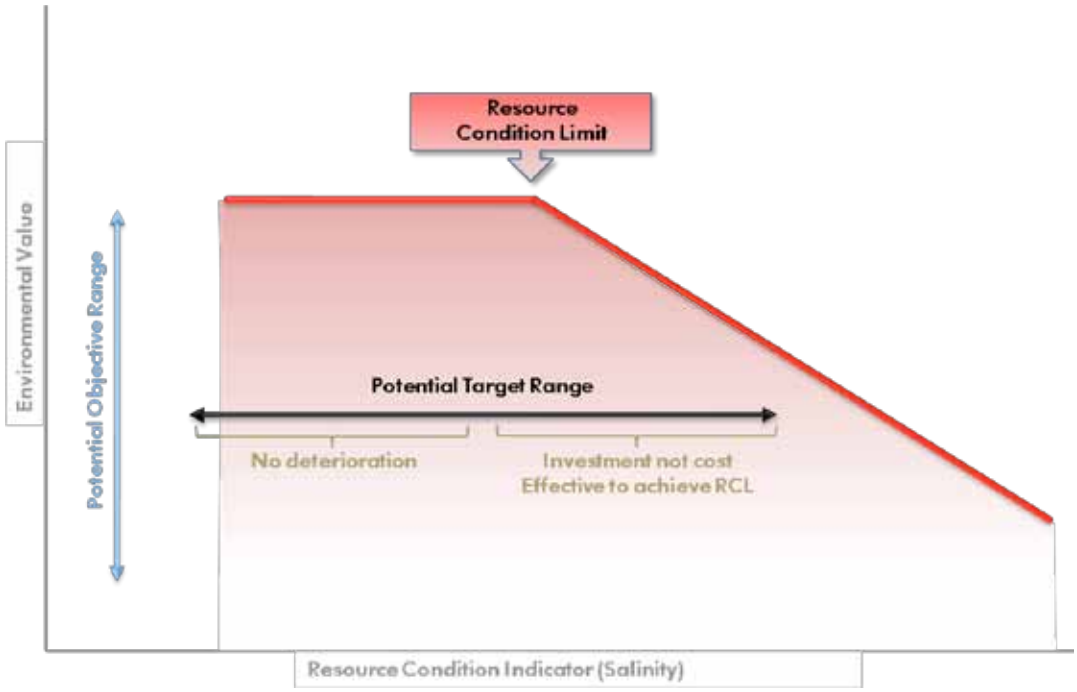
In order to develop targets to achieve salinity objectives, a relationship is required between the environmental value (i.e. the objective) and the level of salinity. For the purpose of this report, this relationship is termed the response function. Where there is sufficient data, the response function reveals the reduced environmental values that will arise from an increased salinity. The 'highest possible qualitative environmental value' is termed the resource condition limit (RCL). This RCL is the salinity value (expressed in this report as mg/L) beyond which there will be a decline in the environmental value. It is anticipated that the RCL will form the basis for targets subject to:

- existing salinities not being below the RCL (which would invoke the no deterioration principle)
- cost effective mitigation options being available if current salinities exceed the RCL.

A generic illustration of the response function upon which the RCL is based for the earliest determinations of targets is presented as Figure 6-1. It shows that:

- The RCL for an environmental value is the tipping point where increasing salinity leads to a decline in the environmental value. With respect to ecological environmental values, it is analogous to the 'limits of acceptable change' (DEWHA 2008), which is intended to prevent a change in the ecological character. However only selected sites (such as Ramsar sites) have had thorough assessments of their 'character'. Hence the achievements of this iteration of what can be achieved in terms of 'acceptable change' and 'ecological character' from salinity objectives and targets are preliminary and will require refinement under future reviews.
- A target salinity may be lower than the RCL, in line with the principle that seeks to avoid a deterioration in existing water quality.
- Alternatively, a target salinity may be set at a salinity higher than the tipping point (subject to acceptance of a lesser objective value) in the event that:
  - the investment requirements to achieve the RCL exceed the associated benefits
  - the salt being mobilised from a landscape are beyond those levels that can be addressed within the planning timeframe (i.e. the time-lags to achieve a target are considered to be too great).

Figure 6-1 Generic response function linking environmental values (i.e. *WQSMP* objectives) and salinity



It should, however, be noted that response functions (including the defined RCLs) are invariably simplistic representations of the more complex relationship between values and salinity in biophysical systems. However, a degree of simplification is necessary to construct a practical operational environment that can be assembled within a strategic and policy framework.

The basis underpinning RCLs for raw drinking water and aquatic ecosystems have been documented in a companion report (MDBA 2010c). In summary, the directions on these RCLs are as follows:

- No specific aquatic biota are proposed as the focus for salinity objectives and targets, as there is no single taxa that provides an RCL for the system as a whole. At basin and catchment scales, there are a multitude of organisms that are sensitive to salinity, and considerable variability exists in terms of mortality and reproductive health both between species and at different stages within the lifecycle. Variability in tolerance also exists within species across different catchments, for different salt compositions, and over different exposure times (Watson *et al.* 2008). In light of this variability, recognising that exceedance of 500mg/L occurs within natural systems on occasions, and relying upon professional judgement, it is proposed that an RCL be set at 500 mg/L. However, the following issues and caveats should be recognised:
  - There is increasing complexity in the response function for biota as salinity increases. Complexity arises because additional parameters become important in adequately describing the tolerance and resilience of organisms. Variables of increasing importance include the length of time biota are exposed to a threshold salinity and, possibly, the time of year of exposure as it relates to important vulnerabilities within particular points within a lifecycle.
  - Theoretically, there is a range of RCLs that can deliver the same ecological values; however, RCLs at the higher end of the spectrum will require additional conditions to manage the impacts of complexity. For example, conditions will be required on the duration, frequency, concentration, chemical composition and timing of salinity pulses.

  - With increasing complexity, there is increasing uncertainty as to whether the response function adequately describes the relationship between a salinity threshold, ecological values, and the ultimate ecological character that will emerge.
  - The need for conditional requirements to enable the adoption of a higher RCL increases the likelihood of non-compliance with all the attributes underpinning a target, and hence increases the risk that the desired environmental values (i.e. objectives) will not be achieved.
  - Selection of an RCL at the lower end of the spectrum:
    i. reduces the necessity for a complex response function
    ii. delivers greater certainty in terms of achieving the desired environmental values.
  - For catchments that do not routinely generate variability around 500 mg/L or higher, the process provided for the setting of targets (Figure 6-2) provides for a target based upon the no deterioration principle, thus the target will reflect this lower variability rather than 500mg/L.
  - A Basin scale RCL of 500 mg/L should be recognised as a 'first step' with potential for future improvements as the knowledge base expands. Improved knowledge is required and is likely to lead to adjustments in future reviews of targets, as required every five years.
  - Valley or sub-catchment scale RCLs are advisable as an input into the development of future targets, along with linked research priorities in the development of water resource plans. Such local scale RCLs should be tailored for local ecosystem types within particular river reaches.

- The requirements for raw drinking water are consistent for all populations, irrespective of urban or rural locations, and have been selected in accordance with the *Australian Drinking Water Guidelines* definition of 'good' water quality; currently, 'good' is defined as 500 mg/L (NHMRC and NRMMC 2004). RCLs could be set at higher salinities without affecting human health; however, the palatability of higher salinity water is not considered to be 'satisfactory' and hence would not fully protect the environmental value.

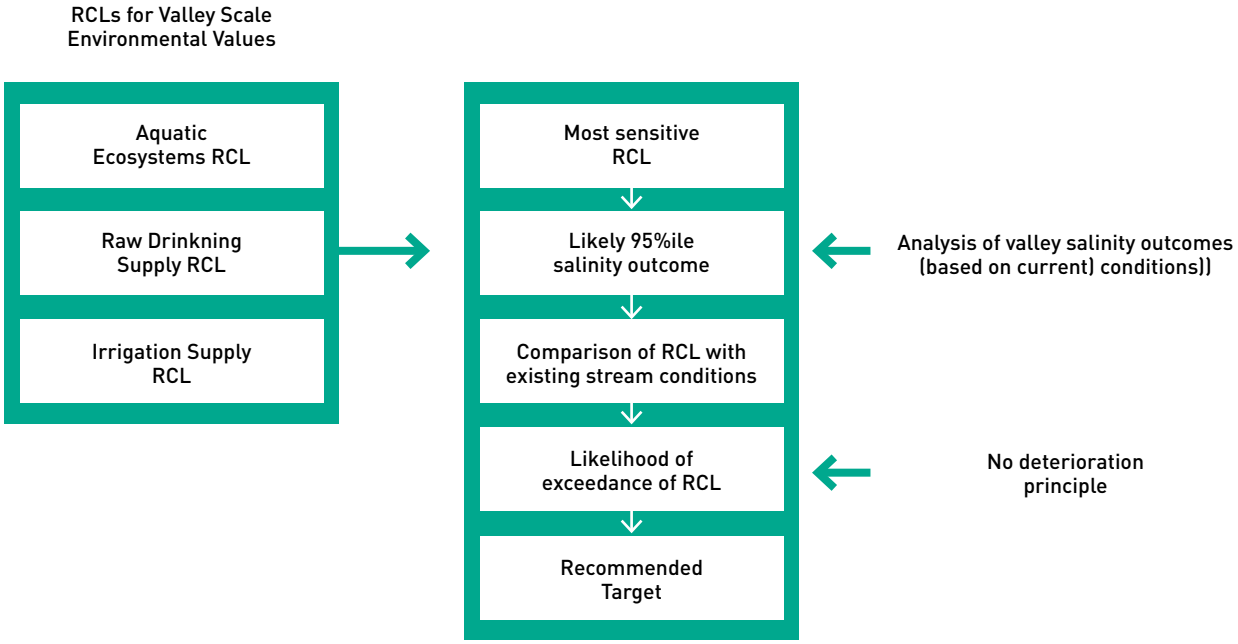
As for aquatic ecosystems, sensitivities of irrigated agriculture are also variable. In the case of crops, variability is strongly influenced by the soils, annual rainfall, water management and the crop type and varieties involved. However, prominent agricultural salinity values are more easily assessed than are aquatic ecosystems, as agricultural values are more site specific and are generally able to be quantified in economic terms. For irrigated agriculture, complexities in establishing RCLs have been considered within the existing *Basin Salinity Management Strategy* cost functions (RMCG 2009), which are utilised in the calculation for salinity registers. This cost function methodology considers the variability in crops grown within the southern basin, their sensitivities, and the extent to which salts are retained within the soil or leached beyond the root-zone.

Given the availability of data (albeit imperfect) on various crop sensitivities, leaching requirements and crop distribution within the broad irrigation areas identified in MDBA (2010a), RCLs for irrigated agriculture have been considered separately for different parts of the basin. The RCL for each area reflects the available information on the most salt-sensitive irrigated crop providing at least 10% of irrigated production to a region.

Details on the determination of RCLs for irrigated values are provided within MDBA (2010c), with the selection of sites broadly based upon identified irrigation areas involving public diversion infrastructure. One notable exception is the inclusion of a target site for private diversions in the Namoi, because the relatively high salinity indicates the likelihood of high salinities that may adversely impact upon irrigated agriculture.

The approach to deriving recommended targets (Appendix A) from these RCLs for each site is illustrated within Figure 6-2.

Figure 6-2 Derivation of recommendation for target



It should also be noted that the approach documented in Figure 6-2 differs slightly from the theoretical process provided in Report 3 (MDBA 2010c), reflecting the lack of information necessary to conduct a full risk assessment. However, the process does provide for an assessment of likelihood of exceedance and broadly involves:

- selecting the most sensitive environmental value for each target site (i.e. the lowest RCL)
- assessing the RCL against actual salinity upper and lower bounds
- assessing the implications for a target based upon the lowest RCL (i.e. is it likely to be exceeded)
- providing a recommended target on the basis of the lowest value of either the RCL or the upper bound 95th percentile salinity stream outcome. The upper bound salinity was used rather than the lower bound salinity in recognition of the fact that, where an RCL is not under threat, the adoption of the 'no deterioration' principle should recognise historic higher salinities during periods when there is higher salt mobilisation or reduced flow regime to provide dilution benefits.

In accordance with the principle that existing water salinity should be considered in the adoption of objectives and targets, it will be necessary for the MDBA to to take into account the following matters prior to adopting the recommended target of 500 mg/L at each urban offtake as well as those presented in Appendix A. More specifically, the MDBA will need to consider:

- historic river salinities within the context of
  - whether they are significantly below the RCL, in which case targets should be based on the current salinities in the river

  - whether they are at medium to high likelihood of exceedance of the RCL, establishing a need to explore opportunities for cost effective mitigation[1].

- the likely timeframe for the achievement of RCL, particularly within the context of time lags between when catchment actions are implemented and in-river salinity outcomes
- tradeoffs and synergies between salinity objectives and other Basin planning or natural resource management objectives
- In areas where the data analysis (MDBA 2010a) indicates that the likelihood of the recommended target being exceeded is very high, determination of risk at a local scale (which would require local investigations) may be low if the consequences are not significant. Exceedance of an RCL for raw drinking water supply will be of little consequence if a treatment plant dilutes stream supplies from other sources such as, for example, low salinity groundwater supplies or supplies from alternative catchments.

1 It should be noted that the likelihood of exceedance presented in Appendix A reflects an analysis using a five year rolling average. Analysis using a 12 month rolling average would produce different statistics.

7 MONITORING AND EVALUATION OF PROGRESS AGAINST TARGETS

Upon determination of the appropriate targets, it will ultimately be necessary to determine how progress against targets is to be evaluated and to specify sites where monitoring is required as a basis for this evaluation.

Different types of targets have been considered within a companion report (MDBA 2010b). In line with the MDBA expectation that targets be SMART (specific, measurable, achievable, relevant and time based), it is proposed that the targets be expressed in terms of an average daily salinity; this will provide the basis for river operators and investment proposals to focus works and measures towards tangible and practical outcomes for environmental values. This approach to the expression of targets is consistent with the *Mid-Term Review*, highlighting the potential value of real time targets.

In recognition that salt is a natural phenomenon within the Basin, and therefore salinity spikes within the river system are inevitable, it is proposed that the measure of performance against targets be assessed as the percentage of days that salinity exceeded the target salinity over the preceding 12 month and five year periods. Performance over two specified time periods is considered warranted, because:

- An assessment over a 12 month period provides an evaluation of performance over the normal annual reporting period.
- An assessment over a five year period provides an evaluation of performance within the context of the prevailing climatic cycles, where higher salinities are generally expected during extended wet periods and low salinity generally expected during extended dry periods; however, in some tributaries, and even in the lower Murray, salinity spikes can arise as a consequence of saline base flows and a low flow regime.

The program for monitoring and evaluating (M&E) the effectiveness of salinity targets should provide an assessment of whether progress against targets is satisfactory. One option would be to continue the existing *BSMS* approach, in which targets are not to be exceeded more than 5% of the time over the two specified time periods; however, it should be noted that there are significant gaps in understanding of the implications of exceedance of the RCL for aquatic ecosystems in terms of mortality and resilience.

A parallel project commissioned by the MDBA on the monitoring and evaluation of the *Water Quality and Salinity Management Plan* may provide additional guidance on this issue. However, irrespective of the scope of the M&E element of the Basin plan, it is anticipated that some level of monitoring for salinity will be deemed essential to assess progress against targets.

In the selection of specific sites for inclusion within the Basin plan, it is proposed that they be prioritised towards the location of aquatic ecosystem and irrigated environmental values. Whilst these sites will also provide information on implications for raw drinking water outcomes, urban offtakes are scattered extensively across the Basin (MDBA 2010a), thus monitoring site selection is not specifically aligned with this environmental use. Rather, progress against the drinking water target (500mg/L) should be based on the rigorous monitoring obligations of urban supply agencies, with arrangements for access to this monitoring data undertaken as part of plan implementation.

Monitoring sites associated with defined irrigation or ecological environmental values have been selected on the following basis:

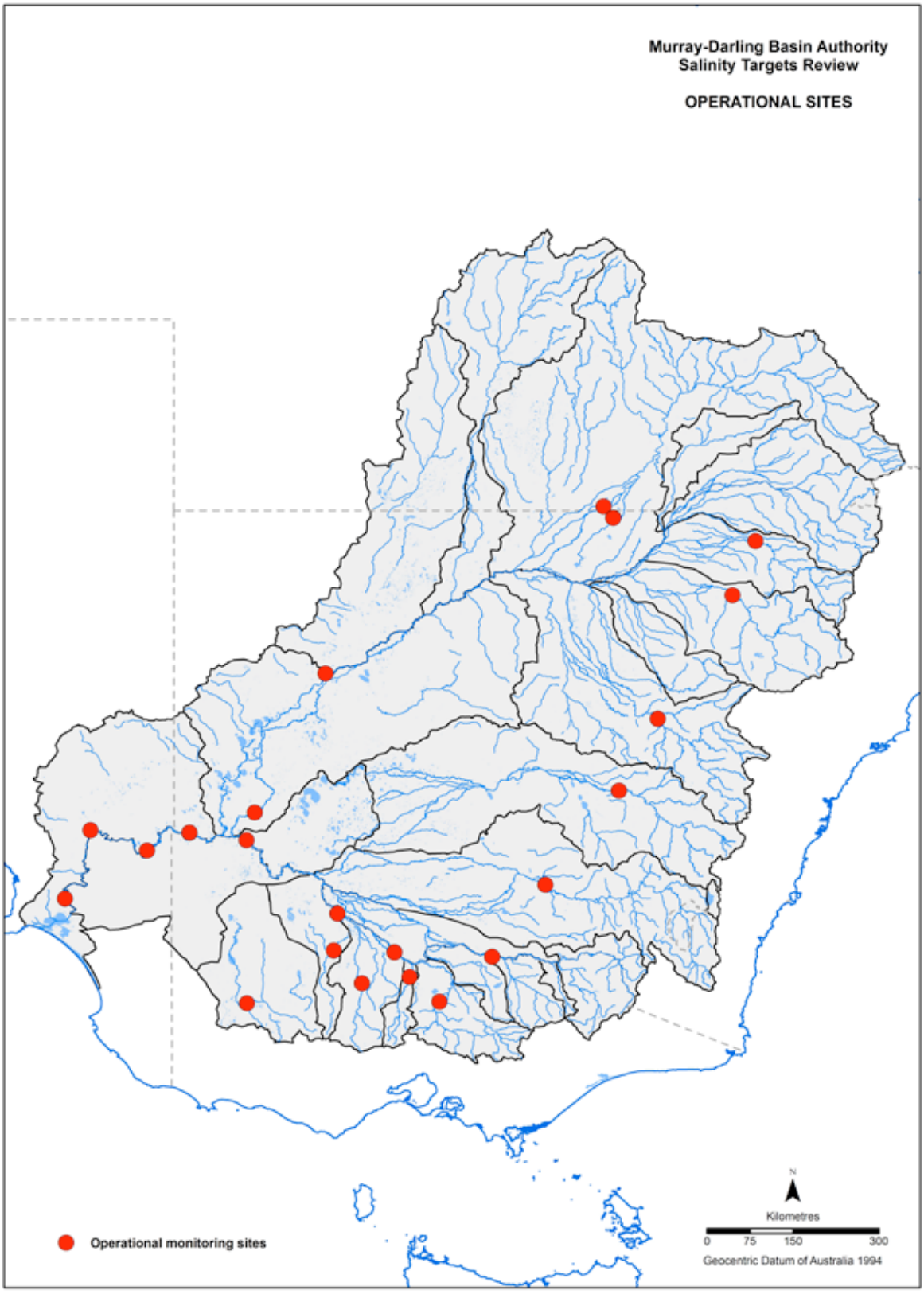
a. At least one designated monitoring site was warranted within any river valley that harboured a defined irrigation or ecological environmental value identified within Report 1 (MDBA 2010a).

b. The preferred site for any valley warranting monitoring under (a) would be the existing *BSMS* end-of-valley target in order to build synergies and efficiencies in the monitoring regime.

c. If the site identified under (b), was in the general vicinity of most ecological and agricultural environmental values mapped in Report 1, and complied with the broad attributes identified in Report 2 (MDBA 2010b), then it was adopted. If not, then an assessment of alternative existing upstream monitoring sites was assessed.

Twenty-two operational sites have been selected through this process. The location of these is summarised in Appendix A and plotted in Figure 7-1. Some of these sites coincide with end-of-valley monitoring sites, as identified in Report 3 (MDBA 2010c).

Figure 7-1 Location of proposed monitoring sites



8 MATTERS FOR CONSIDERATION IN ADOPTING RECOMMENDED TARGETS

The investigation of cost effective options to mitigate the likelihood of not achieving RCL are beyond the scope of this project. However, a broad assessment of the types of actions and their limitations is warranted to guide the MDBA in their decisions to adopt the proposed objectives and targets and to initiate investigative studies into appropriate works and measures for sub-catchments where water quality targets are not likely to be consistently achieved. These broad types of actions are summarised below.

Land use/catchment actions

These actions would include agronomic or vegetation based catchment actions in low dilution or high salt exporting sub-catchments where the predominant land use is rain fed agricultural systems. Alternatively, however, such actions could include on-farm or irrigation system reconfiguration or efficiency improvements. Impediments to the cost effectiveness of such actions are likely to include the following:

- Salt mobilisation in dryland areas normally occurs across large sections of the landscape. The diffuse characteristics of such salt mobilisation means that treatment areas must be targeted at very large spatial scales to be effective, and time lags in terms of stream water quality outcomes are likely to be significant.
- There are significant uncertainties in the quantification of individual or aggregate water salinity outcomes arising from actions, particularly for diffuse source actions in rain fed agricultural systems.
- Farm management decisions arise in response to a range of different forces, including market and climatic conditions, which are often significantly stronger than government supported programs that are not underpinned by a strong regulatory framework, as is the case for rain fed agricultural systems (Cooke 2008).

Salt interception

The BSMS *Mid-Term Review* indicated that there is limited scope for new salt interception schemes to improve Murray River water quality within the economic framework underpinning the salinity registers. The benefits of salt interception in terms of protecting raw drinking water sources and aquatic ecosystems have not been investigated, as these values are not considered within the *BSMS* cost functions.

Flow manipulation

River operations that achieve river salinity outcomes through management of dilution flows have the potential for short term management responses, but they require optimisation with other beneficial uses of water and hence need to be considered in the MDBA's wider assessment of trade-offs between environmental watering and SDL objectives.

Spatial variation

In considering these options to achieve salinity targets, it is essential to recognise the dynamics of salt retention/accumulation and mobilisation in different parts of the landscape so that the approach to achieving targets is planned rather than reactive. For example, within the upper catchments, actions are likely to be better focused towards retention of salts rather than addressing mobilisation, as there is likely to be less water available to provide dilution opportunities and the flushing of salts may compromise the ability to achieve downstream targets.

In the lower parts of the Basin (i.e. the Lower Murray), preventive works or measures to mitigate mobilisation will also have application, such as reducing rootzone drainage that has the potential to displace saline groundwater to the river. However, even with such works, highly saline groundwater accessions will continue, as they are an inevitable consequence of the hydrology of the basin, the river being the only conduit for the export of salt. The management of such salt accumulation in the river will therefore be best achieved by providing for average salt load exports necessary to achieve a salt balance with salt imports.

Summary

In light of the above, the water resource plans should consider:

- the appropriateness of works or measures to mitigate salt mobilisation and/or encourage salt export
- whether works or measures proposed to achieve a local target are likely to compromise the achievement of downstream targets
- the scale and magnitude of such works and measures
- the timeframe between the initiation of works and measures and the achievement of required salinity targets.

9 A POTENTIAL FRAMEWORK FOR SALINITY PLANNING, ACCOUNTABILITY AND OPERATIONAL MANAGEMENT

In considering future salinity management arrangements that integrate both the successes of the existing accountability arrangements and the need for more contemporary targets that reflect real salinity outcomes, as mooted by the BSMS *Mid-Term Review* (MDBC 2007), it is critical to preserve the success in existing valley arrangements. These existing arrangements have delivered basin wide acknowledgment of jurisdictional responsibilities for land and water actions and partnerships between communities and governments at a jurisdictional and basin scale. However, these achievements should be recognised as being largely within the context of long term valley scale contributions to basin scale water quality outcomes rather than as providing day-to-day outcomes for particular assets. Their achievements have been in providing reference points upon which to reflect the potential for the cumulative impact of diffuse salt mobilisation and dilution impacts from large watersheds over a variable climatic regime. It is arguable that these existing arrangements have not provided an effective basis for the formulation of targets because of the following limitations:

- Progress cannot be assessed in any meaningful way, given that most land use actions are dispersed widely over large areas and the benefits/disbenefits are unable to be effectively quantified with any degree of certainty.
- An assessment of progress in stream salinity outcomes is derived from simulations of a pre-2000 period, and outcomes are, therefore, not related to results of current monitoring programs.
- They lack relevance to intervention works, particularly to landowners whose land and water management decisions affect cumulative impacts on downstream water uses.
- They were formulated on the basis of uncertain predictions on future salt load accessions to streams and the ability of catchment communities to address this legacy of history.

A way to build on the significant strengths of the existing valley arrangements and overcome the current limitations would be to reframe the existing modelled approach away from the concept of 'targets' towards resource condition indicators that provide a reference point for long term valley or basin scale outcomes over a variable climatic sequence (i.e. the benchmark period). In other words, the strengths of the existing valley arrangements would be framed within the context of a planning tool rather than as targets which have an operational context. The basis for targets required under the *WQSMP* would be at a local scale and would be expressed in terms of day-to-day outcomes, with progress evaluated against monitored data.

The application of these future management arrangements may therefore be broadly categorised as lying within the following two elements:

- Basin scale planning (BSP)
- Basin salinity operations (BSO).

Broadly, the BSP element would cover those functions that support long term salinity outcomes over a variable climate. BSO would focus much more closely on activities directed towards short term outcomes. This summary is presented in Table 9-1.

Table 9-1 Summary of planning and operational contributions to management

	Accountabilities	Contributions to management
Planning	• Long term impacts which may not be realised at the river for years or decades. • Performance evaluated through simulation over a (benchmark) variable climate sequence.	• Addresses long term valley and Basin scale objectives and outcomes. • Provides indicators that guide long term planning and co-ordinated jurisdictional actions. • Guide investment for actions that will deliver long term reductions in salt mobilisation.
Operations	• Short term impacts of actions • Performance evaluated against monitoring outcomes.	• Address specific environmental values • Provides targets that are locally relevant to competing uses of water. • Guide investment aimed at achieving short term improvements in river salinity

It is anticipated that this framework would provide future salinity management arrangements that would:

a. preserve the key concept of a basin-wide planning approach to salinity management, particularly that salt mobilised anywhere in the Basin has the potential to affect downstream environmental uses

b. support continuous improvement and adaptive management through expansion of the knowledge base, particularly five year rolling valley reviews

c. preserve the accountability arrangements for significant actions currently guided by Schedule B

d. replace the concept of valley scale targets with valley RCIs that, as discussed in MDBA (2010c), better reflect their role in planning and the difficulties in the selection of indicator values and the uncertainties in evaluating progress against the selected values

e. include targets that are measurable, relevant and achievable:
   - reflecting the operational needs of competing uses
   - enabling simple evaluation of progress against objectives
   - enabling clear and transparent communication of progress to stakeholders
   - providing the potential for greater linkages between environmental value objectives and investment

f. ensure that within valley monitoring to assess progress against targets is available to inform the continued development of valley scale assessment modelling tools that have been instigated under the *BSMS*, and so continue to contribute to Valley and Basin Scale planning.

Within the context of existing Schedule B activities and mandatory requirements of the *WQSMP*, the relative weighting of importance of activities between the two broad elements (BSP and BSO) is presented in Appendix B. It identifies that the application of the framework under the provisions of the act (currently both Schedule B and the mandatory obligations of the *WQSMP*) would need to provide for some activities that have a significant influence on both short and long term outcomes.

10 IMPLICATIONS FOR SCHEDULE B AND THE OPERATIONAL PROTOCOLS

The Basin salinity management framework proposed in the previous section will require guidance material in the same way as the *BSMS* utilised operational protocols.

The Basin scale planning (BSP) component broadly corresponds with the existing *BSMS*, which is assumed to continue in operation. However, the existing *BSMS* protocols cannot continue in their present form, because:

- The technical content requires amendment for a number of reasons, including the findings of the BSMS *Mid-Term Review*. Details are given in Appendix C.
- Under the *Water Act* (*2007*), the present protocols become a legal instrument and will need to be re-written in a suitable form.

The Basin scale operations (BSO) component does not presently exist and will need to be written as part of the *WQSMP*. It will also be a legal instrument and will require supporting guidance material in the form of protocols and guidelines. Until the new material is produced in legal form, the extent to which further protocols (which must also be in legal form) are required is not yet known. Further supporting technical and operational detail will then need to be provided in the form of guidelines. Guidelines will not be legal instruments and should be 'user-friendly'.

The preferred approach is for the BSP (old *BSMS*) and the BSO (new material for the *WQSMP*) to be integrated and written as a single source document. This would provide a single basis for the subsequent preparation of protocols and guidelines and recognise the complementary nature of the two approaches. It would also be consistent with the requirement, under Clause 152 of the Agreement, to review the Schedule to ensure there are no inconsistencies with the *WQSMP*.

Should combining the framework (Section 9) within the *WQSMP* be unachievable within the current time constraints for the development of the Basin plan, then an alternative is to keep the *BSMS* independent for the time being (noting that its protocols will still require revision) and proceed with documenting the BSO as part of the *WQSMP*.

The production of separate documents of protocols and guidelines for the same topic has the potential to be confusing. It is proposed that a coordinated protocols and guidelines document be prepared which is capable of being read and used on a standalone basis. This can be done by taking each topic in turn and presenting the protocol, immediately followed by the guideline material for that topic.

More detail on the above may be found in Appendix C.

11 RECOMMENDATIONS

2. It is recommended that the MDBA consider the following proposed objectives in the development of the *WQSMP*:

   a. Raw drinking water — water salinity should be maintained to enable water in the Murray–Darling tributaries to be suitable for domestic use where there are treatment plants and water is extracted for human use.

   b. Aquatic Ecosystems — water salinity supplied from rivers and streams should be suitable to maintain the ecological character of ecosystem communities.

   c. Irrigated agriculture — water salinity should be maintained at salinity levels below that which will adversely affect productivity of existing crops under best management practices for irrigation.

2. It is recommended that the MDBA consider the proposed targets for the *Water Quality and Salinity Management Plan* (Appendix A and 500 mg/L at each urban supply offtake) as a means of measuring progress against the objectives.

3. It is recommended that the authority note that, based upon an analysis of stream flow and modelling data, there is a medium to high likelihood of not achieving some of the recommended targets given historic catchment salt export trends.

4. Where the likelihoods are high to very high, it is recommended that the authority consider:

   a. implementing investigative studies at appropriate spatial scales to better understand sources, pathways and sinks of salt, and associated water quality threats where RCLs are not currently likely to be consistently achieved

   b. cost effective catchment or river management options to mitigate risks

   c. identifying accountabilities and associated commitment to the investment necessary to offset risks and the associated investment necessary to achieve these targets

   d. utilising enabling language within the Basin plan to allow water resource planning arrangements to set salinity objectives and targets that reflect the water quality constraints of the prevailing local hydrogeological conditions.

5. It is recommended that the MDBA consider the proposed Basin salinity planning, accountability and operational management framework within the Basin planning process, with a view to either:

   a. modifying Schedule B to the *Murray–Darling Basin Agreement*

   b. incorporating Schedule B elements into the Basin plan, taking into account the proposed framework provided in this report.

6. It is recommended that the BSP (old *BSMS*) and the BSO be integrated, as part of the Basin planning process, into a single source document under the *WQSMP*. This would provide a single basis for the subsequent preparation of protocols and guidelines and recognise the complementary nature of the two approaches.

7. It is recommended that, as part of the water resource planning process, jurisdictions should:

   a. consider the appropriateness of works or measures to achieve targets, including the need for works to mitigate salt mobilisation and/or the need for regular flows to encourage salt exports and maintain a long term salt balance within the lower reaches of river.

   b. review existing end-of-valley target values in light of updated understandings of the legacy of history, and in doing so enable inclusion of valley scale resource condition indicators in the development of water resource plans.

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APPENDIX A SUMMARY OF RCLS FOR ENVIRONMENTAL VALUES, LIKELIHOODS OF EXCEEDANCE AND PROPOSED TARGETS

Valley	Valley Reporting Site	AWRC Site Number	Most sensitive environmental value	Most Sensitive RCL (mg/L)	Currently levels of development 95 percentile salinity[2]					Proposed Target (mg/L)	Likelihood of Proposed Target being exceeded[3]
					(EC)			(mg/L)			
					Lower Bound	Upper Bound	Sensitivity[4]	Lower Bound	Upper Bound		
MURRAY RIVER/SOUTH AUSTRALIA											
SA Border	Flow to SA	426200	Irrigated agriculture	410	289	509	NC	173	305	310	High
Lock 6 to Berri	Murray River at Lock 4 (Flow)	426514	Irrigated agriculture	410	426	641	NC	256	385	390	High
	Berri Pumping Station (Salinity)	426537									
Murray–Darling Basin	Murray River at Morgan (Salinity)	426554	Irrigated agriculture	410	615	870	NC	369	522	410	Very High
Below Morgan	Murray River at Murray Bridge	426522	Irrigated agriculture	410	717	948	NC	430	569	410	Very High
NEW SOUTH WALES											
Murrumbidgee	Murrumbidgee River d/s Berembed Weir	410023	Raw drinking water	500	NA	252	NC	NA	151	160	High
Lachlan	Lachlan River at Forbes (Cottons Weir)	412004	Raw drinking water	500	741	915	NC	445	549	500	High
Macquarie	Macquarie River at Dubbo	421001	Raw drinking water & Marshes	500	512	529	NC	307	317	320	High
Namoi	Namoi River at Narrabri	419002	Raw drinking water	500	NA	NA	NC	NA	NA	500	NA[5]
Gwydir	Gwydir River at Pallamallawa	418001	Raw drinking water & Gwydir Wetlands	500	553	585	NC	332	351	360	High
Barwon-Darling	Darling River at Wilcannia Main Channel	425008	Raw drinking water & Menindee Lakes	500	NA	1,543	NC	NA	926	500	Very High
Barwon-Darling	Darling River downstream of Menindee lakes at Burtundy	425007	Irrigated agriculture	410	473	1,746	NC	284	1048	410	Very High
Wimmera	Wimmera River at Horsham Weir	415200	Lake Albucutya	500	NA	2,650	NC	NA	1,590	500	Very High
Avoca	Avoca River at Quambatook	408203	Avoca marshes	500	2,778	10,039	NC	1,667	6,023	500	Very High
Loddon	Loddon River at Serpentine Weir*	407229	Irrigated agriculture	410	1,763	2,449	1,688–3,950	1,058	1,469	410	Very High
Campaspe	Campaspe River at Campaspe Weir	406218	Irrigated agriculture	480	605	1,360	638–1,360	363	816	480	Very High
Goulburn	Goulburn River at Goulburn Weir	405259	Irrigated agriculture	300	133	334	133–301	80	200	200	High
Mallee	Murray River at Redcliffs	414204	Irrigated agriculture	410	185	572	NC	111	343	350	High
Mallee	Murray River at Swan Hill	409204	Irrigated agriculture	420	153	441	NC	92	265	270	High
Riverine Plains	Murray River at Torrumbarry	409207 [6]	Irrigated agriculture	420	106	199	NC	64	119	120	High
Riverine Plains	Murray River at Yarrawonga Weir	409216 [7]	Irrigated agriculture	420	77	85	NC	46	51	60	High
Condamine-Balonne	Ballandool River at Hebel-Bollon Rd	422207A	Raw drinking water	500	252	706	NC	186	522	500	High
Condamine-Balonne	Narran River at New Angeldool#	422012 #	Raw drinking water	500	525	807	NC	389	597	500	High

Notes to table:

\# — These sites are operated by New South Wales on behalf of Queensland.
R — Site appears elsewhere on table.
* — Additional operational site
NA — data not available either because no continuous monitoring at the site, or because simulated data not available for that site.
NC — not completed (as sensitivity assessment only requested for Victorian data)
TBA — To be advised — advice subject to approval for further data analysis.

2 Statistics based upon a five year rolling average of average daily salinity data (as described in MDBA 2010a). It should be noted that a different set of statistics would be generated if the analysis was conducted as a 12 monthly rolling average, which would in turn impact upon the right hand column — the qualitative assessment of the likelihood of the proposed target being exceeded.

3 The low, medium and high categories are based on the likelihood that the proposed target exceeds the upper bound. The likelihood groupings are: **Low** Upper bound is more than 300EC below Proposed Target, **Medium** Upper bound is 100EC-300EC below Proposed Target, **High** Upper bound is 100EC either side of Proposed Target, **Very high** Upper bound is more than 100EC above Proposed Target

4 A sensitivity analysis was conducted on three Victorian valleys, as documented in MDBA (2010a). The results presented are the likely salinities of the lower and upper bounds at the 95th percentile after considering changes in flow sharing rules which have occurred since the salinity model was calibrated.

5 Uncertain given lack of data at Narrabri, but based on salinities downstream, expected to be high or very high.

6 Statistics use monitoring data from gauge 409207 (from 2000 onwards) but modelled data (pre 2000) from 409219.

7 Statistics limited to modelled data from gauge 409025 as no continuous monitoring data was available from 2000 to 2010.

APPENDIX B ASSIGNMENT OF SALINITY MANAGEMENT ACTIVITIES TO THE BASIN PLANNING FRAMEWORK

Table 12-1 Salinity management activities and issues.

Application of elements of salinity management	Basin scale planning & accountability	River operating regime	Issues
Stream monitoring	✓	✓✓✓	Monitoring is required to aid the refinement of knowledge and, thus, assessment of likely long term trends. It is also critical to inform river operation decisions and evaluate performance against operational targets
Outcomes assessed over simulated/ modelled period	✓✓✓	✖	Basin scale planning and accountability is largely focused on long term outcomes requiring a constant 'benchmark period' to evaluate outcomes over both wet and dry periods.
Catchment Actions (Salt Interception)	✓✓	✓✓✓	*BSMS* annual reporting provides evidence of day-to-day tangible outcomes on the river, as well as long term benefits over the benchmark period.
Catchment Actions (irrigated agriculture)	✓✓✓	✓	The magnitude of in-river impacts of changes in system efficiencies, on-farm water use irrigation systems, and on-farm management are a function of the prevailing wet or dry climatic conditions and the time lag between an action and when salt is subsequently mobilised to drains or the river. Notwithstanding some modelling uncertainty, the current arrangements whereby impacts are recorded in the salinity registers should be maintained.
Catchment Actions (rain-fed agriculture or forestry)	✖	✓✓	The impact of changes to rain-fed agricultural/forestry systems on stream salinity is generally diffuse and remote from catchment or basin scale accountabilities (possibly by decades), thus in most cases difficult to quantify with any degree of certainty. Also, actions in dryland landscapes are largely voluntary, with land use determined more by annual rainfall patterns and markets (i.e. landholder priorities) than by catchment management priorities (Cooke 2008). Application of this functionality to the framework therefore fits more closely to operational targets, ensuring that investment towards salinity outcomes are appropriately prioritised and constrained to works that will deliver tangible outcomes.
River operations (dilution management)	✓✓✓	✓✓✓	Changed flow management arrangements are an accountable action under Schedule B.

Application of elements of salinity management	Basin scale planning & accountability	River operating regime	Issues
Salinity Registers	✓✓✓	✗	The BSMS *Mid-Term Review* proposed building a linkage between the salinity registers and real time salinity outcomes. However, as the existing registers are a proven and effective (albeit not perfect) basis for managing accountability, and the concept of operational targets is relatively new, it is considered that at this stage, the Basin planning framework for salinity management should maintain relative independence between registers and targets until understanding of the effectiveness of operational targets reaches a higher level of maturity.
Salinity Planning resource condition indicator	✓✓✓	✗	Implementation of the existing *BSMS*/Schedule B water salinity targets have provided a highly useful framework for assessing changes in the cumulative impact of all significant land and water management actions across the basin. This accountability framework should be preserved, but with existing targets re-termed as indicators of long term outcomes, reflecting a reference point to aid long term planning.
Salinity Targets	✗	✓✓✓	Targets should be SMART (specific, measurable, achievable, relevant and time bound). The SMART attributes fit within a river operation regime but are unsuited to the assessment of long term salinity trends, as simulated outcomes over a benchmark period for rain-fed agricultural systems are, by and large, not measurable, achievable or relevant to communities responsible for the actions.
Prioritisation of sub-catchments or landscape units (e.g. floodplain)	✓	✓✓✓	The 50 year and 100 year forecasts on the register deal with long term risks. This activity is more about ensuring that short term threats are identified (i.e. floodplain and high salinity sub-catchments) so that investment can be targeted towards short term outcomes.

Guide to table:

✓✓✓ — strong applicability

✓✓ — moderate applicability

✓ — low applicability

✗ — no relevant application

APPENDIX C IMPLICATIONS FOR SCHEDULE B AND THE OPERATIONAL PROTOCOLS

C.1 Introduction

This appendix assumes acceptance of the recommended approach to basin salinity targets as set out in this report. It considers the implications upon the existing *BSMS* protocols and on any new protocols and guidelines that may have to be developed to support the *WQSMP*.

Pertinent to the recommendations in this report is the following:

- The proposed new Basin Salinity Management Framework consists of two elements:
  - A Basin scale planning component (BSP) that broadly corresponds with the existing *BSMS* and its protocols.
  - A Basin salinity operations (BSO) component that does not presently exist. It focuses on the real time measurement of salinity at selected sites within catchments, i.e. water supply, to the environmental values covered in this report, namely aquatic ecosystems, raw drinking water and irrigation supplies. Targets would be based on resource condition limits (RCL).
- The proposed approach recognises areas for improvement in the *BSMS,* as documented in the 2007 *Mid-Term Review*, and is consistent with the recommendations of Shepherd (2010), 'Evaluating Salinity Accountability for the *WQSMP*' January 2010'.
- It is anticipated that the substance and intent of the *BSMS* and its protocols should continue, but amendments will have to be made to reflect the findings of the *Mid-Term Review* and to comply with the provisions of the *Water Act*, of which the *BSMS* is now a part.
  - The BSO component of the proposed framework will be documented for inclusion in the *WQSMP* and the Basin plan. This documentation will have to be in a form suitable for registration as a legal instrument.
- New protocols or other user-friendly guidance material will be required to support the BSO.

C.2 The existing *BSMS* protocols

The existing protocols were devised 'to give practical form to the principles and accountabilities set out in the Schedule'. The Schedule referred to is now Schedule B to Schedule 1 of the *Water Act 2007*, entitled 'Basin Salinity Management', and the current position of documents subordinate to the *Water Act* is illustrated in Figure 12-1. Some relevant points about the present protocols follow:

- They gain their authority from, and are envisaged by, the schedule. The schedule provides for the authority to make or change protocols, and gives examples of what they might cover.
- The schedule and the resultant protocols focus on accountability, reporting and review arrangements, and are hence only a partial expression of the *BSMS*. The full scope and objectives of the *BSMS* are described in '*Basin Salinity Management Strategy* 2001–2015' published by the MDBC in 2001. This description of the *BSMS* carried the authority of the ministerial council, but it is not part of the *Murray–Darling Basin Agreement* or its schedules.
- The schedule is written in legal language and is a legal instrument. The original protocols were not written in a form suitable for a legal instrument.

- The protocols are designed for a specialised audience with some technical understanding of the content. They are written in plain English and do not have the rigour of a legal document (the protocols contain, for example, words like 'should' and 'as agreed').
- Although the preparation of protocols is not mandatory under the schedule, it would be extraordinarily difficult to implement the provisions of the schedule and the core components of the *BSMS* without them. The protocols provide the additional technical and procedural detail that is needed to fully comprehend the intent and necessary operational practices.
- The protocols cannot and do not prescribe anything that is not within the scope of the Schedule.

C.3 Proposed changes to the *BSMS* protocols

The *BSMS* protocols were first published in 2003. An amended version, 2.0, was published in 2005 and was made accessible online. The intent was that no further hard copy versions would be produced and any further changes would be promulgated online. A further protocol (*Reconciliation of Salinity Credits*) was approved by the commission in 2006.

A number of proposals have since been made for further amendments. They may be summarised as:

- A revised draft protocol was developed in 2007 that more explicitly articulated the process leading to the reconciliation of salinity credits. It has not yet been approved by the authority.
- The 2007 *Mid-Term Review*. The review noted that Schedule C (now Schedule B) was robust and did not require modification. A number of revisions and extensions were proposed for the protocols relating to the targets, the benchmark period, the registers, the joint works and measures program, and annual reporting.
- Most of these recommendations required further technical work to be done before any specific amendments could be framed, and it is likely that some of the changes arising would require amendments to Schedule B. No amendments of this kind have been made.
- Leaving aside the requirements of the *WQSMP*, the present review of end-of-valley targets for the *BSMS* may result in a redefinition of the Basin salinity target and/or the end-of-valley targets. Should this occur, amendments to the protocols will have to be made, and possibly changes to Schedule B as well.
- Some of the provisions of the protocols have not been met, are not likely to be met, or are now known to be unrealistic. Examples are the date by which jurisdictions were to submit valley programs of actions to the commission (31 March 2004) and the completion of the 61 EC works program (31 December 2007). Some are also not practical, such as 'Administrative Principles for SIMRAT' (Appendix 3.11).
- While these matters may not be grounds for a complete amendment in themselves, they should be corrected when the opportunity arises. If it is apparent that some provisions can be disregarded, it diminishes respect for others that may be more important. From an accountability perspective, objectives need to be respected and achievable, as Shepherd (2010) points out.
- The authority has been advised that as a consequence of embedding the *Murray–Darling Basin Agreement* and its schedules and protocols into the *Water Act*, the protocols are (or will become, as soon as they are amended) legal instruments. Since amendments are inevitable, and the protocols will then need to be written in legal language, a substantial rewrite will become necessary even if the technical content remains largely unaltered.

The approach proposed by Hyder Consulting (2009) is to split the content of the present protocols into a new protocol and a guideline (which could be written in plain English and would not be a legal instrument). If this course was adopted, any changes resulting from the other points mentioned above could be incorporated at the same time.

C.4 Protocols — their audience and use

The *BSMS* protocols, as they now exist, fulfil several purposes:

- They provide a compendium of useful technical information as a convenient reference for those concerned with operating or administering the scheme on a day to day basis, including those involved in research, audits and reviews.
- The process of preparing them involved extensive discussion and negotiation within the former BSMSIWG, with all participating jurisdictions represented. This had the effect of improved communication and the forging of an agreed common approach to some difficult issues.
- They interpret and extend the formally expressed prescriptions of the schedule into practical operational detail. Each protocol summarises the intent of the part of the schedule to which it relates, allowing the protocol to be consulted as a standalone document using plain English terminology. For most users, backward reference to the schedule is not necessary.

These are qualities that should be preserved in any revision or restructuring of subsequent documentation. In particular, there is a risk that partitioning the existing protocols into protocols and guidelines as proposed by Hyder Consulting (2009) could lose some of the coherence that is important (Point 3 above).

C.5 Protocols and the *WQSMP*

The *WQSMP* is one of the mandated components of the Basin plan which is required to be produced by the *Water Act 2007*. The *WQSMP* has some similarities to the *BSMS* in that both of them call for the establishment of salinity targets and monitoring, but there are some distinct differences:

- The ultimate focus of the *BSMS* is the continuing level of salinity in the Murray, as determined primarily by modelling the long term average salinity at Morgan and cost effects in the lower Murray. The proposed salinity objectives and targets proposed for the *WQSMP* in this report are primarily concerned with the immediate impacts of salinity on environmental values, specifically aquatic ecosystems, raw drinking water and irrigated agriculture, including at specific sites and within sub-catchments that are known to be generators of salt.
- The *BSMS* brings accountability through its assessment of accountable actions and the maintenance of salinity credit and debit registers, all relating to the basin salinity target. The approach to salinity objectives and targets proposed in this report relies upon the real-time monitoring of operational targets at nominated sites.

Arguably, the new aspects of the *WQSMP* give expression to the underlying intent of the initial *BSMS* document (of which Schedule B implements only a part) and deal more effectively with some parts of the *BSMS* (e.g. within valleys) that have not been implemented to full effect.

C.6 Protocols as legal instruments

With the exception of the 2006 one-off adjustment protocol, the existing *BSMS* protocols are not written as legal instruments, but will become so as soon as they are amended by the suthority. If challenged in a legal environment, they would not provide an adequate basis for a clear and non-ambiguous legal decision. Any new protocols prepared to support the *WQSMP* (and/or the Basin plan) become legal instruments immediately. Promulgation in this form requires transformation into legal language and registration as a legal instrument.

A question to be considered is whether the existing or similar protocols as they stand would suffer in terms of utility if they were transformed into legal instruments (with the necessary rephrasing and structuring into legal language). In this regard the 'General Principles of Accountability' as articulated by Shepherd (2010). are relevant and supported. In summary, they are:

- There must be objectives, and entities charged with their achievement
- Objectives must be agreed, achievable, justified, respected, and measurable.
- Incentives — success in achieving an objective should attract a reward, and failure should bring a penalty. Rewards and penalties may be intangible, such as prestige, embarrassment or loss of face.
- There must be transparency and trust of process, and trust between participants.

None of these depend upon or require legal sanctions or enforcement. They are the qualities that have contributed to the level of success that has been accomplished by the *BSMS*, which should be a reasonable basis for their continuation. Therefore, much of the content of what are currently published as protocols need not be written in legal language or be a legal instrument in order to be effective in providing guidance on operational practices.

In order to meet the requirements above, protocols (or their future replacement) need to be coherent, user-friendly, and useable as a standalone document. They must also limit their content to the scope of a source document (such as Schedule B to the *Murray–Darling Basin Agreement*) and cannot be developed without such a source. While they may elaborate the technical requirements of a statement, definition or process in the source document, they cannot expand or extend the intent of the source.

C.7 How to proceed — the start point for protocols and guidelines

At the time of writing this report, the structure of the Basin plan and the *WQSMP* had not been finally determined. What follows here assumes that their scope and content will require elaboration both in further legal prescription and in technical guidance material. Two possible approaches can be considered for the preparation of protocols and guidelines.

Option 1 — Integration

It would be consistent with the philosophy expressed in this report (i.e. the roles of the BSO [new] and the BSP [based on the *BSMS*]) if the two components were merged into one integrated document to then constitute the *WQSMP*. In that event, the old *BSMS* would be removed from Schedule 1 of the *Water Act* and incorporated in the *WQSMP* and, thus, the Basin plan.

The new aspects of the *WQSMP* and the *BSMS* have different origins and objectives, and they utilise different technical approaches (broadly defined as strategic planning for the *BSMS*, and operational

management for the remainder of the *WQSMP*). However, there is commonality in their ultimate purpose and opportunities to share information and monitoring sites and to build linkages between monitoring based evaluation of progress against targets and modelled results. There is advantage in treating them together, potentially in a single coordinated document, as shown in Figure 12-2.

If this course is followed, then a comprehensive document would be prepared to describe the *WQSMP* as a whole, possibly including any other influences on salinity management flowing from other parts of the Basin plan. The *Environmental Watering Plan* and the *Water Trading and Transfer Rules* also potentially affect the operation of the salinity registers and the potential to achieve targets, and so should be reviewed from this perspective.

It is possible that the integrated *WQSMP* document could be structured as a schedule to the Basin plan in a style and format similar to the present Schedule B to Schedule 1 that describes the *BSMS*. In any event, it would provide the basis on which protocols and guidelines could be developed and would be written in a form suitable for registration as a legal instrument.

Option 2 — A phased approach

Incorporating the *BSMS* into the *WQSMP* is a major task, and resource and time constraints may prevent its immediate application. In the short term, the *BSMS* could remain structurally separate and continue in operation, bearing in mind that when any amendments become necessary, the existing *BSMS* protocols immediately become a legal instrument and would have to be rewritten.

The *WQSMP* document would then be limited to the new provisions referred to in this report as the BSO and any other elements required by the act (such as identification of the key causes of water quality degradation and non-salinity water quality targets and objectives). It would provide the platform upon which a separate set of protocols and guidelines would be prepared to provide guidance on the operation of that part of the *WQSMP*. This approach is shown in Figure 12-3.

The process of complete integration could then follow over time.

C.8 Protocols and guidelines

The preparation of guidelines to supplement the protocols was advocated by Hyder Consulting (2009) and entitled *Operational Protocols Review — Directions Paper*. Given that, in the *Water Act* structure, the existing and any new protocols would become legal instruments, a user-friendly guidance document or manual could only be produced as a separate guideline. This would produce a three tier hierarchy of documents. Given this, it is clear that a prime consideration should be the coherence, clarity and comprehensiveness of the document that users will use — that is, the guidelines. It is therefore proposed that:

- The general form, content and style of the guidelines should be modelled on the present *BSMS* Operational Protocols.
- The content of the new protocols (the second tier) should be limited to that information that is not included in the source document (i.e. the *WQSMP*) and that is necessary to prescribe in legal form. It should be an objective to keep these to a minimum (i.e., protocols should be kept as short as possible and prescribe only what needs to be prescribed).
- The source document (in this case the *WQSMP*, be it a schedule or not) should make explicit provision for the preparation of protocols and guidelines, in much the same way as Schedule B (Part IX).

- the guidelines should, where necessary, duplicate or provide easy access to information in the protocols to the extent required to provide a logical structure and guideline ease of use.

A solution that meets the above requirements is shown in Figure 12-4. A consolidated document which includes both the protocols and the guidelines has advantages, and the document could be structured as a sequence of individual protocols, followed immediately by the relevant technical and procedural guidance. This approach is recommended.

Figure 12-1 *Basin Salinity Management Strategy* — current context of the protocols

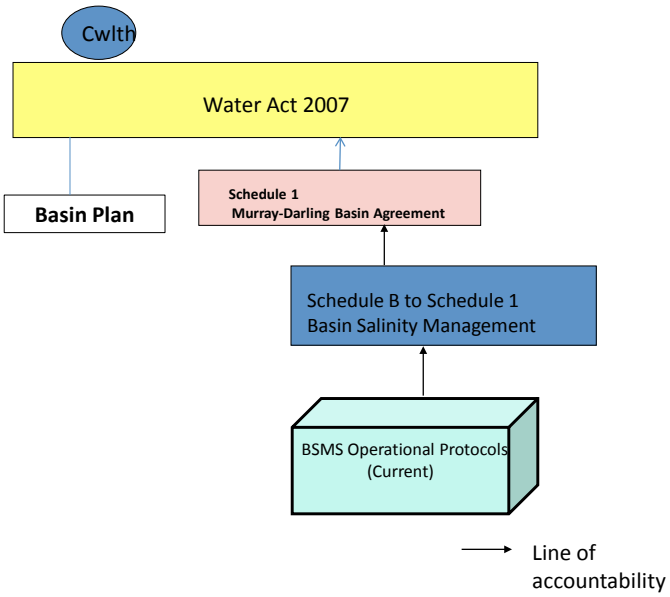


Figure 12-2 *Water Quality and Salinity Management Plan* — context of the protocols (option 1)

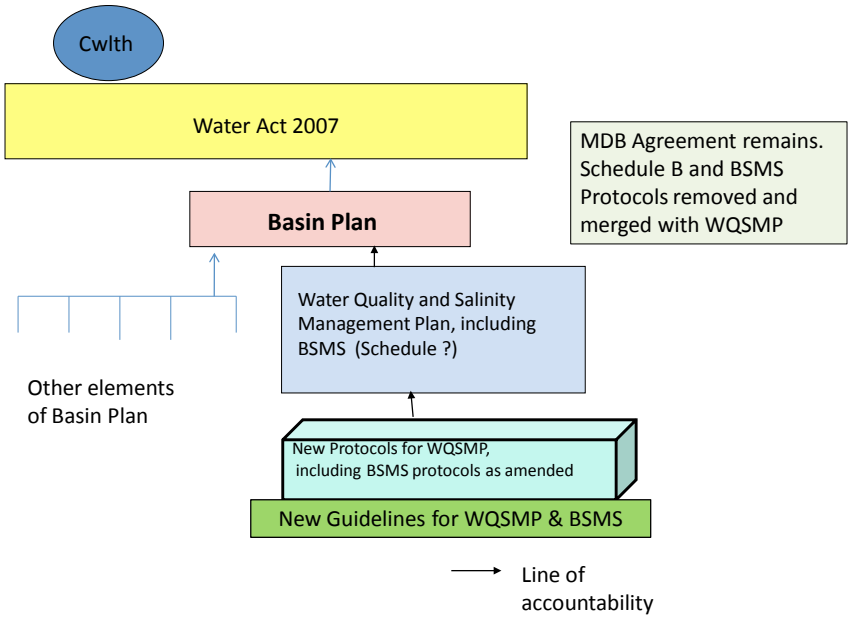


Figure 12-3 *Water Quality and Salinity Management Plan* — context of the protocols (option 2)

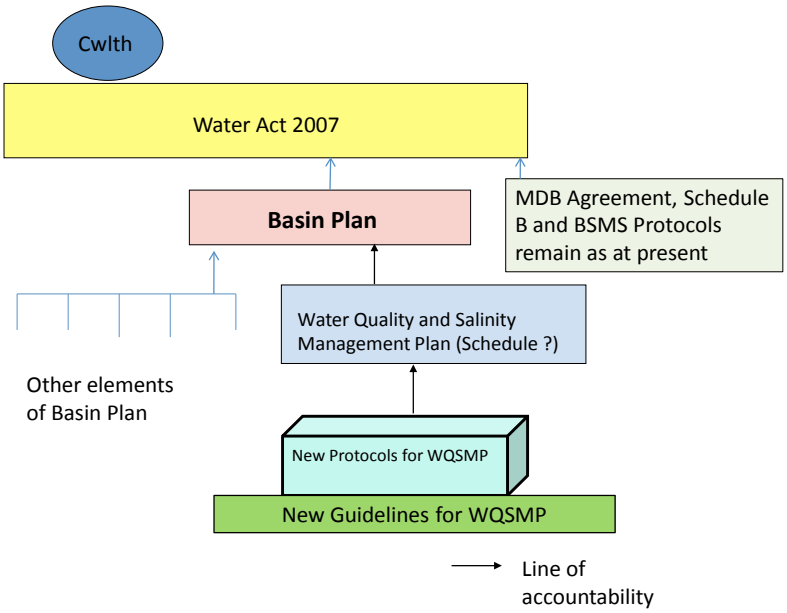
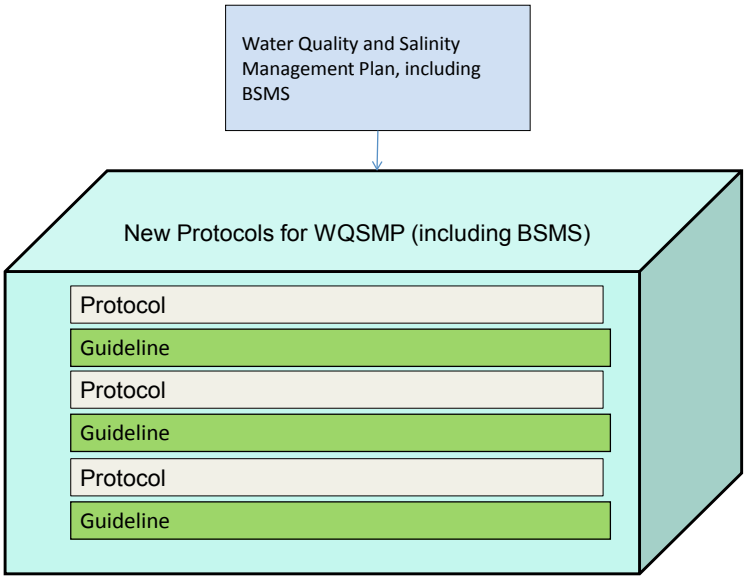


Figure 12-4 *Water Quality and Salinity Management Plan* — proposed structure of protocols and guidelines



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