Chapter 13 — Management issues

Management decisions are rarely straightforward or clear-cut because of the range of factors and complexity of interactions that contribute to salinity and determine management priorities:

- The expression of salinity in landscapes results from complex interactions between land use and management, landscape hydrology, geomorphology, historic salt loads, and socio-economic and environmental factors.
- Because of the slow hydrologic response in many landscapes, there is often a long lead time between the expense and effort of implementing a management strategy and the subsequent enjoyment of the results.
- In some situations, the cost of implementing management strategies or controls can be greater than the value of on-site benefits or cost of off-site effects (although there is difficulty in assessing the full 'cost' of off-site effects).
- Property boundaries rarely encompass whole catchments, and additional problems can occur when areas where the salinity problem is 'caused' and 'expressed' are controlled by different landholders.

The first step in developing an integrated, sustainable management strategy is to thoroughly investigate the processes and local factors contributing to salinity. Causal factors which have not been investigated and identified can not be addressed comprehensively and effectively. (The section ***Investigating salinity*** page 27 guides the reader through the options and activities of investigating salinity and establishing an understanding of local salinity processes.)

After investigating salinity on-site and considering the available options in the light of the landholder's priorities, in the end the landholder must select a 'best bet' approach.

The best approach to watertable salting management is to view the water raising the watertable as a potential resource rather than as a problem, so that the situation can be managed to the landholder's net advantage. Depending on local circumstances and water quality, this water can possibly be diverted for productive use elsewhere on a property or in a catchment, to increase the productivity of existing resource uses or develop new uses, increasing revenue to the property and diversifying resource use.

Of the water inputs, only the water entering the recharge area is available to be managed. The salt concentration of this water is not readily amenable to management, but the quantity of the water can be managed by implementing strategies to reduce the proportion of water (rainwater and irrigation water) passing through the root zone. Reducing water inputs, wherever feasible, to maintain the watertable below the critical depth in the discharge area will have major benefits for the productivity of any vegetative management strategy for salt-affected lands, providing the salt concentration is still within the salt tolerance range of the vegetation. Other site parameters, such as the volume of groundwater flow and the sodicity of the groundwater, will influence final management options.

To effectively manage for productivity in the medium- to long-term in discharge areas affected by shallow watertables, evaporation needs to be reduced, particularly where there is very limited seasonal flushing of salts from the soil surface or the root zone by rainfall. If the water in this area can be reduced (by transpiration or pumping, or by interception before reaching the discharge area) to lower the watertable, salt can be stored in the unsaturated area at the bottom of the root zone where its effect is less significant. Salt in the root zone will be flushed by seasonal rainfall.

The only other viable option is to physically remove salt from the system. The option of discharging saline water into streams is generally not an acceptable practice. Another option, often not adequately addressed, is to remove water and salts by intercepting water moving in the transmission zone. This interception option is only viable where geologic features, soil conditions and water quality are favourable.

Management options

A number of options for managing salt-affected catchments are available. Not all options are expensive to implement; one of the most common and useful is 'fence and forget'—fencing the area from stock and spelling it while natural or introduced salt-tolerant vegetation becomes established, after which time the area may be suitable for limited or controlled grazing.

Options for managing salted catchments, which can be used individually or in combination with other options, include:

- continuing with existing management—managing the land in its current state
- altering current management practices—considering alternative land uses (such as changing from cropping to pasture or trees), changing the grazing regime (such as resting areas by fencing them off from stock, or utilising an affected area as a gap feed rather than for continuous grazing), and modifying existing irrigation practices
- selecting suitable vegetation species for planting in specific areas—establishing salt-tolerant pasture grass species and fodder shrubs in salt-affected areas, growing deep-rooted perennials such as lucerne or leucaena for fodder crops, considering alternative crops, and planting trees to intercept water in transmission areas or to use water in recharge areas
- retaining native vegetation—allowing native forest or perennial vegetation to revegetate naturally in recharge or discharge areas, and limiting future clearing of native vegetation on recharge areas
- implementing engineering options—installing drains or pumps to dewater areas with high watertables, using drainage systems to disperse water flow away from discharge areas, intercepting water in the transmission area by draining or pumping, and using intercepted water of suitable quality to irrigate crops or water stock.

Selecting an appropriate overall management strategy will depend on:

- the extent and nature of the salting problem
- the characteristics of the area—climate, soils, geomorphology, water quality, and so on
- access to unaffected areas that are contributing to the salinity problem (recharge and transmission areas)
- economic issues, such as the comparative value of the land and cost of implementing various management practices
- the landholder's own particular desires and needs.

Some strategies may be straightforward to implement while others may necessitate a complete reorganisation of farming operations. Catchment boundaries frequently cross property boundaries, with the result that neighbours may have to work cooperatively to effectively address the problem. Intensive engineering works or extensive tree planting programs may have to be staged over a number of years to suit available labour or financial resources.

Integrated management strategies

Broadly speaking, there are four potential management approaches for salt-affected lands. Each of these approaches aims to achieve a hydrologic balance between recharge and discharge areas:

- manage the existing situation
- reduce recharge
- intercept water in the transmission area
- increase water use in the discharge area.

Each of these approaches is listed in Table 41, along with features of situations most suited to each management approach and desirable management practices. This table is intended only to provide an indication of the most viable management options for a situation at hand when management is initially being considered. In addition to the table, more information on determining whether a particular management approach is appropriate for local conditions is provided in this section.

In many situations, a combination of the four approaches may be needed to formulate the best salinity management strategy for local conditions and the available resources. Decision support tools such as property management models and benefit-cost analyses (mentioned in Decision support resources page 96) will assist in developing a balance between different levels of control in each of the recharge, transmission and discharge areas.

The relative size of recharge and discharge areas will determine, to some extent, which strategies may be appropriate. In any catchment, there has to be a minimum rate of drainage below the root zone to achieve a significant excess resulting in watertable rise. At minimum rates of drainage, vegetation can often cope with any additional water in the landscape. This can be approximated to around 0.001%. A maximum theoretical salt-affected area is around 10% of a catchment on the basis that the rate of evaporation from a discharge area can accommodate around 10 or more times the annual recharge rate. Surface seepage can also remove water from a catchment. In practice, this 10% is exceeded in southern Australia where there are widespread regional shallow watertables.

The guidelines in Figure 52 are based on the significance of the problem in the catchment. In Queensland, there are two nominal boundaries to the relative sizes beyond which salting is unlikely to occur.

Table 41. Suitable situations and desirable management practices for each of the major salinity management approaches. Desirable management practices for implementing each strategy are listed approximately in order of likely effect.

Management approach	Situations most suitable for the management approach	Desirable management practices
Manage existing situation	• landform features: basalt, catena, alluvial valley, stratigraphic, dykes, confluence of streams • affected land not of high value or productivity • controlling recharge areas too costly, or recharge areas much more productive than affected discharge areas • vegetation currently surviving on most of the affected area • existing vegetation can be enhanced and/or fenced to control grazing • seepage on the affected area is fair quality water • erosion not a problem, or erosion can be stabilised with vegetation • downstream water quality not significantly affected by salting in the affected area • salt load in the discharge area is moderately high • watertable intercepts the soil surface seasonally or periodically	• set a high priority on maintaining vegetative cover • fence off affected areas and manage grazing pressures • enhance amount of salt-tolerant vegetation in the worst affected areas • stabilise area against erosion, but do not prevent seasonal flooding where this would normally occur • improve surface drainage • plant trees or other perennial deep-rooted vegetation that can handle salt and waterlogging
Reduce recharge	• the catena landform feature • recharge area clearly identifiable and available for treatment • area experiences a winter rainfall pattern • shallow-rooted pastures are main vegetative cover in the recharge area • current cropping practices could be made more water use efficient • rainfall periods not aligned with periods of high water use by crops • recharge rates high • land value or productive value of the discharge area greater than that of the recharge areas • soil in the discharge area likely to be productive after the area is reclaimed—that is, groundwater in the discharge area not particularly sodic and soil structure not severely affected	• avoid summer fallow in summer rainfall areas, and use double or opportunity cropping if possible • introduce deeper rooted or perennial species into the pasture mix • incorporate agroforestry into management • revegetate stock routes and along fence lines and geomorphic boundaries • if leakage from ponded areas is significant, reduce size of these areas
Intercept water in the transmission area	• landform features: basalt, catena, colluvia of former land surfaces, valley restrictions, dykes, confluence of streams • transmission area relatively well defined • recharge area large and not well defined • groundwater is of acceptable quality • good aquifers identifiable in the transmission area • aquifers suitable for pumping or accessible by tree roots • pumped water can be discharged into streams, evaporated or used for irrigation • discharge area is under upward hydraulic pressure resulting from a confining clay layer and is thus much more difficult to manage • both recharge and discharge areas have high land values • large quantities of water involved • major salt loads occur in the discharge area	Depending on water quality and depth to groundwater: • pump with pumps or windmills from single or linked tubewells. (A total minimum flow of around 2 to 3 L/s is needed for this option to be viable.) • if water is good quality, intercept groundwater and use to irrigate adjacent areas or to water stock • plant dense vegetation belts, using high water use species, in areas where these plants can access the groundwater • construct subsurface drainage (for off-site disposal) if water is of acceptable quality
Increase water use in discharge area	• landform features: colluvia of former land surfaces, valley restriction, dykes, geologic faulting • recharge area diffuse and extensive • recharge areas distant from the discharge area, or not under the control of the discharge area landholder • discharge area extensive • high economic value of the recharge areas, regardless of the comparative value of the affected discharge areas • transmission area diffuse • finite salt loads exist in the discharge area • groundwater is of generally acceptable quality, or groundwater is saline and using evaporative basins to evaporate the excess water is cost-effective • waterlogging is an issue	• revegetate the area with perennial, high water use, salt-tolerant vegetation • plant halophytic species in high salinity areas • pump with pumps or windmills from single or linked tubewells. (A total minimum flow of around 2 to 3 L/s is needed for this option to be viable.) • construct subsurface and surface drainage • pump into evaporation basins • if water is good quality, pump to irrigate adjacent areas

Figure 52. Possible watertable salinity control options, based on the relative sizes of recharge and discharge areas. These options need to be considered in conjunction with the text and information in Table 41 (Shaw 1993).

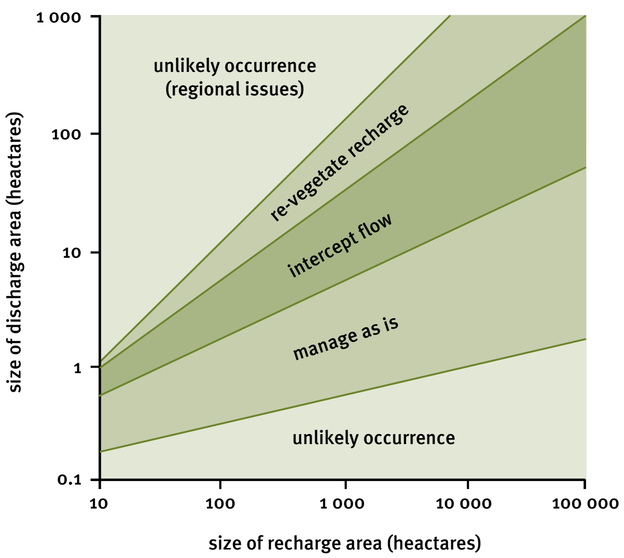
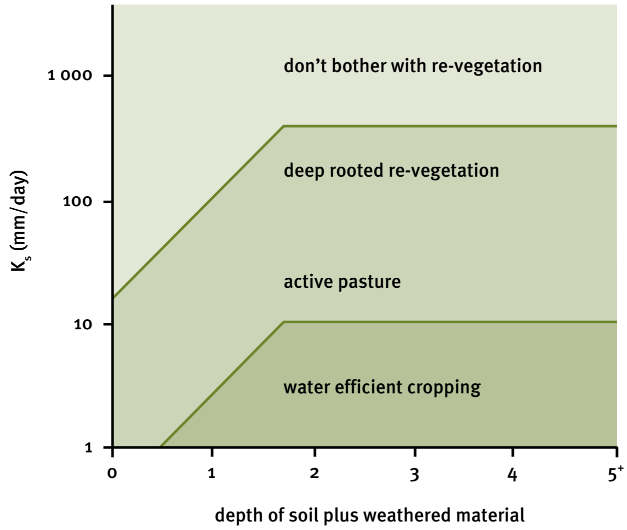


Figure 53. Vegetation management options for recharge areas based on soil depth and saturated hydraulic conductivity (Shaw 1993).



Manage the existing situation

This approach is appropriate where the salted area is of comparatively low-value land and natural processes prevent excessive salt from accumulating at the soil surface. For instance, the soil surface may be flushed on a seasonal basis by runoff or seasonal seepage. The key to this management option is to maintain adequate (and appropriate) vegetative cover at all times. Methods include fencing salt-affected areas and allowing opportunity grazing, and allowing weed or grass growth in cropping areas.

Reduce recharge

To reduce recharge, significant areas of the upper catchment may need to be revegetated with trees or well-managed native pastures, and agronomic practices in cropping areas may need to be substantially modified. Because recharge in many tropical areas is episodic, planting additional vegetation to reduce recharge will only be effective where water use by currently grown crops is low during the high rainfall season.

Selecting appropriate vegetation options for recharge areas—whether or not to revegetate, whether to plant trees, crops or pasture—largely depends on the level of annual recharge. Figure 53 illustrates vegetation management options for recharge areas based on soil depth and saturated hydraulic conductivity (as an indicator of recharge) which determine the length of time during which water moving through the soil profile is available to plants. This needs to be assessed only in areas with high flow ranges, shallow soils over fractured rock, highly permeable soils or very slowly permeable soils.

Intercept water in the transmission area

Water can be intercepted by revegetating key areas or by using engineering methods. If revegetating, groundwater needs to be present at depths that trees can access. Revegetation is more likely to be effective where water use by trees is likely to account for a significant proportion of the flow. If the water is of good quality, it can be reused elsewhere on the property for irrigation or stock watering. If aquifer properties and flow are suitable, water can be pumped from the transmission area using simple, low-technology, low-energy pumps.

Increase water use in the discharge area

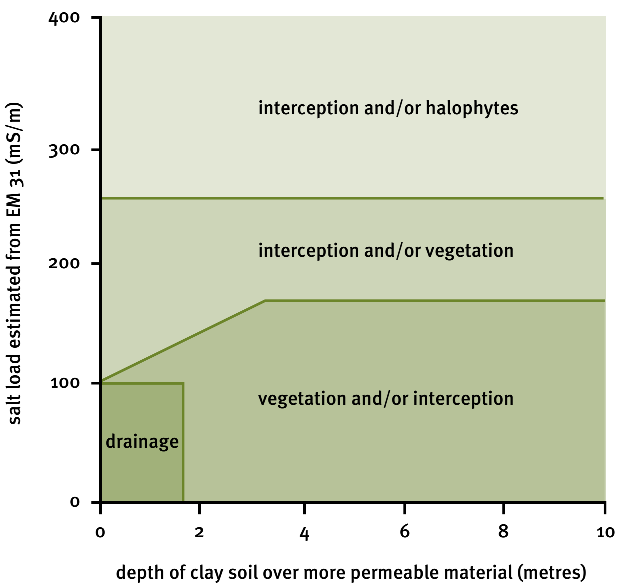
Water use or removal by pumping, drainage and/or vegetation (with halophytes and salt-tolerant plants) is an option on discharge areas depending on the salt load and the depth of clay overlaying more permeable materials. Drainage requires permeable subsurface materials so that flow into the drains is adequate. Clay depth provides a measure of the extent to which water can be removed by vegetation or engineering methods. Salt loads may be at shallow depths in some areas where upward hydraulic pressure operates. Under these conditions, a finite salt load exists that may be controlled by short-term high salt disposal or by managing the watertable level.

Figure 54 indicates the conditions under which interception and vegetation can be considered as management options, depending on clay depth and salt load as measured by an EM-31 instrument (see ***Landscape salinity mapping*** page 43).

It is important that a drainage strategy does not lower the watertable to a critical depth which will actually result in an increase in the bare and salted area. In regions where salts are seasonally flushed from the soil profile by periodic high watertables, lowering the watertable to the critical depth for capillary rise can reduce the effectiveness of seasonal flushing. Surface concentration of salts will increase as a result.

Increased surface water flow from recently-installed drains may enhance gully erosion. The impact of increased salt loads on downstream water users must be considered, as well as environmental protection and water quality legislation.

Figure 54. Incorporating vegetation and interception strategies in discharge areas (Shaw 1993).



Management decision making

Deciding how to manage a particular situation is rarely a case of simply choosing the option with the best prognosis. Many other factors enter into the decision-making process, and these factors will always depend on individual landholder priorities and constraints. Making salinity management decisions can mean deciding between competing objectives, such as economic and environmental objectives.

While technical officers and other advisers provide expertise for assessing how particular areas will respond to different types of management, the final responsibility for deciding what will be done, and carrying out these decisions, lies with the individual landholders.

Broadly speaking, the following need to be considered when contemplating salinity management decisions:

- financial issues, such as set-up costs, comparative 'value' of amenity and aesthetics
- short- and long-term goals
- interest in diversification and alternative land uses
- personal attitudes to environmental responsibility
- potential for impact of a management strategy on properties downslope in the catchment
- activities and attitudes of neighbours and local catchment management groups.

Benefit–cost analyses

Benefit–cost analyses are invaluable when evaluating management strategies. Important considerations are the cost of managing the current degraded situation, costs of management for partial control, and costs of reclamation. For investigations of salinity risk before land is developed, the cost of preventative management for the area predicted to be affected will be required. Other considerations are the value of the productive lands in the recharge areas that may be reduced by some land management options such as revegetation. Management costs need to evaluate on-site versus off-site costs such as increased salinity of water supplies or increased erosion of salted areas, particularly in summer rainfall areas.

Decision support resources

Management decision support services range in scope from catchment-scale to property-scale. Community groups (for instance, landcare and Integrated Catchment Management groups and committees) help focus management strategies for salinity at the appropriate catchment scale. Using the principles of Property Management Planning, management decisions can be comprehensively worked through from initial investigation to implementation, ensuring the problem is thoroughly analysed and addressed and that a solution is determined that addresses the situation needs, is within the scope of available resources, and is consistent with personal and business goals and resource sustainability.

With the increased number of stakeholders involved and more complex assessments of natural processes available, decision making is now a complex process. Decision support system approaches are often necessary to provide a focus for the issues to be resolved. Decision support systems can be defined (after Thompson et al. 1992) as 'the integration of expert knowledge, management models and timely information to assist in making day-to-day operational and long range strategic decisions'. Key concepts are the ability to evaluate 'what if' questions and to predict the effects of decisions. Where there are many stakeholders and multiple solutions, multi-disciplinary approaches are required.

Because the rate of change in groundwater levels with time is often fairly slow, good predictions of the possible long-term consequences need to be made. Models are often necessary to adequately integrate climate variability (particularly rainfall) and spatial variability. However, models are only tools to assist understanding. A scaled approach in model complexity is required. Where the issues can be identified in yes/no terms, simple 'back of the envelope' calculations and expert opinion may suffice. Where the interactions between processes or managements are more complex, more quantitative, broad-scale and complex models with associated greater data requirements need to be considered. In all cases, as the catchment increases in size the accuracy of predictions will decrease sharply.

Catchment scale models, using well-developed groundwater models (for instance, MODFLOW) and incorporating decision theory allowing 'what if' situations to be evaluated, are currently being developed by the Department of Environment and Resource Management and CSIRO. Detailed modelling is generally time consuming and expensive, and is only justified when other management investigations are inconclusive. (Useful modelling software packages are listed in the ***Useful software packages*** page 141.)

Multi-objective decision support systems specifically addressing natural resource management issues are currently being developed. A wide range of agricultural productivity decision support systems are available. The following three approaches, PRIME, AEAM and MODSS, address aspects of natural resource management issues appropriate for catchment scale salinity issues.

PRIME (Planning, Research, Implementation, Monitoring and Evaluation) is a procedure for developing Integrated Catchment Management plans by stakeholder groups developed by Syme et al. (1994). It is a staged decision framework. In the **planning phase**, the problem is defined, available knowledge collated, priorities formulated, objectives negotiated, gaps identified, the basic plan devised, and resources and criteria for evaluation and monitoring determined. In the **research phase**, feasible solutions from the literature and elsewhere are identified, barriers to adoption identified, and collaborative applied research programs developed. In the **implementation phase**, the implementation strategy is derived and resources determined and allocated for priority activities. Similar activities are carried out in the **monitoring and evaluation phases**. The process is followed by a **planning review phase** in which coordination is a priority issue. This process is currently being used in a series of large catchments in Australia where integrated solutions to catchment-scale dryland and water salinity problems are being sought. PRIME is a decision support process rather than a software-based decision support system.

The original AEAM (Adaptive Environmental Assessment and Management) concepts from Canada as reported by Grayson and Doolan (1995) have been used at a catchment scale in some areas of Australia. The AEAM process aims to provide links between communities with a problem and the available technical resources. During a series of interactive workshops, a computer-based model is developed that can evaluate the outcomes of various resource management options using the best available technical information. The major benefits have been identified as the creation of a common understanding and ownership among stakeholders and the development of a computer simulation model using the best available information (Grayson & Doolan 1995). Disadvantages are the need for skilled modellers in structured workshops and limited validation of the model except as a qualitative comparison with informed technical opinion. AEAM is suitable for some (but not all) situations and issues. Its usefulness depends on the time periods of the processes and the extent to which catchment scale averaging of biophysical responses provides acceptable data.

A multi-objective decision support system (MODSS) is available (prototype currently) that allows individuals and groups to identify the issues, the stakeholders, the criteria and the importance ranking in order to select the most appropriate option. The system will produce a number of options together with a matrix of options against criteria to be rated from a range of sources, data, technical experts and simulation models. Following decision optimisation techniques, the preferred options can be considered, discussed and resolved. Further information on MODSS can be obtained from the Department of Environment and Resource Management.