‘Living with Salt Lands in SEQ’ - Management Options

Workshop Booklet

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1 Background to this workbook

Your land, perhaps it's your chance to live your desired lifestyle, earn an income, get away and be closer to nature or a place to raise some livestock, grow your own veggies or simply enjoy the fresh air. Whatever the reason for owning land, we know it's one of your most important assets. Realising your dream for your property, however may seem like a constant challenge. This is made even harder when salinity is an issue on your property. This 'living with salt lands' workshop will provide you with assistance in planning how to manage salted areas of your property.

This workbook provides background to how salt occurs in the landscape and gives you an overview of management options you can take to manage your salt lands. These topics will be discussed during the workshop where we will have some practical activities and field visits to get you thinking how to apply the information to your property and gives you important links to some of useful further information.

How do you currently manage salt on your property?

Think about how you currently manage salinity issues on your property. Do you have a management plan? Is it written down and do you refer to it? Or is it in your head? There are many options for managing salt on your property and before you look at making any future changes it is a good idea to assess your management plan. Using the questions outlined in the table below rate your understanding of salt lands and management practices options, don't worry if you are unsure about any. This self-assessment tool will help to guide you in developing goals for managing salt on your property and provide you with a basic management plan in order to achieve those goals.

Table 1 – Your Current Management Practises for salt lands

Rating Scores : 1 – no knowledge or understanding of this practice; **2** – you recognise this practice but have no plans to implement it at this stage; **3** – you have plans to implement this practice but have not done so as yet; **4** – you have commenced to implement this practice; **5** – you have fully implemented this practice; **NA** – this practice not applicable to your property or business			
No.	CURRENT RECOMMENDED MANAGEMENT PRACTICE	RATING	ACTION (Y/N)
1.	We understand the underlying cause of the salinity expression on our property		
2.	We identified key agricultural productive areas and areas affected by salinity.		
3.	We have considered diversification of activities (farm forestry, biodiversity) for salt lands on the property.		
4.	We implement grazing management practices which maintain good land condition and manage our salt lands appropriately		
5.	We understand what vegetation types will be suitable for our property and their role in reducing bare salted areas.		
6.	We have identified the top three salt affected areas that we would like to make more productive or stabilise.		
7.	We have assessed soil erosion and instability and practices are in place to manage areas at risk.		
8.	We have mapped and identified any significant eroded areas on the property or near salted areas.		
9.	We understand groundwater, salinity and water balance processes, and their relationship to saline or sodic soils on our property.		
10.	We understand general soil health processes in relation to biological and nutrient interactions and practices which maintain or improve soil health.		
11.	We have identified different soil characteristics (depth of surface and subsoil, structure, pH, organic matter, limitations in relation to sodicity and salinity, etc) to assist in their management.		
12.	We understand physical soil processes including erosion, landslip, dispersive soils, hard setting soils, soil compaction, water infiltration, slope limitations and structural degradation.		
13.	We know what kind of impact salt is having on land and water use and our enterprise profitability		
14.	We know the salt content (electrical conductivity) of any bores, wells, dams, creeks and seeps on the property		
15	We have Identified, and regularly monitor, areas that are consistently wet or have seepage areas and noted when we first noticed them being wetter than other areas		

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2 Introduction

Salinity problems are a landscape scale issue and generally extend over areas larger than individual properties. Often the expression of salinity is a result of land management options taken over 100 years ago, on hydrologically sensitive landscapes and thus have a history that can't be changed easily or quickly. Where the expression of salinity may have taken 100 years since clearing to become evident, it will take a long time to stabilise. Downstream impacts mean that transferring the problem downstream is rarely a viable option.

Salt lands at Roadvale – the shallow watertable means that as water evaporates from the surface of the soil, salt is left behind and means no plants can grow. It also makes the soil highly prone to erosion.

Thus living with salt will be the only option in some situations where conditions indicate that on-farm reclamation solutions will not be viable. A range of management options are possible for living with salt which can often improve land stability and reduce degradation of salt affected areas. A do-nothing option is not really an option since salt affected land is in an unstable state. It will transition to either a larger area of affected land or finally, over many decades, reach an equilibrium through soil erosion and gully incision in an attempt to lower the watertable. Where this transition is not possible due to geological features or other factors, salinity will become a natural part of the landscape. However, some management practices can reduce the impacts of salinity on the landscape and, to some extent, improve land productivity.

This workbook looks at options to consider when salinity reclamation options are not viable, too expensive or require sub-catchment scale operations. It gives some definitions of salinity, an overview of the processes that result in landscape salinity and some landscape features to identify the particular processes in a given locality, salt tolerance of vegetation and steps in decision making to consider the most effective land management approach.

Key steps are:

- Identify the cause(s) of salinity in the particular location to allow an informed choice on the most appropriate management options that will make a difference and not waste effort and cost for a limited impact.
- Work out the preferred and viable management options for the enterprise and expectations for the future. Work through the benefits and trade-offs for the preferred options.
- Develop an action plan with key decision points.

3 What is salinity and sodicity, where are they coming from and is it getting worse?

Some definitions are useful to make sure we are talking about the same things.

Salinity is the presence of soluble salts in or on soils or in waters that result in reduced plant growth. Common measurements are;

- EC Electrical conductivity (dS/m) for water
    - 1 dS/m = 1 000 µS/cm
- $EC_{1:5}$ EC of soil suspension 1 part soil to 5 parts water
- EC_{se} EC of a saturated soil extract
- ppm EC (dS/m) * 1.5 * 1000 - an alternative unit in common use

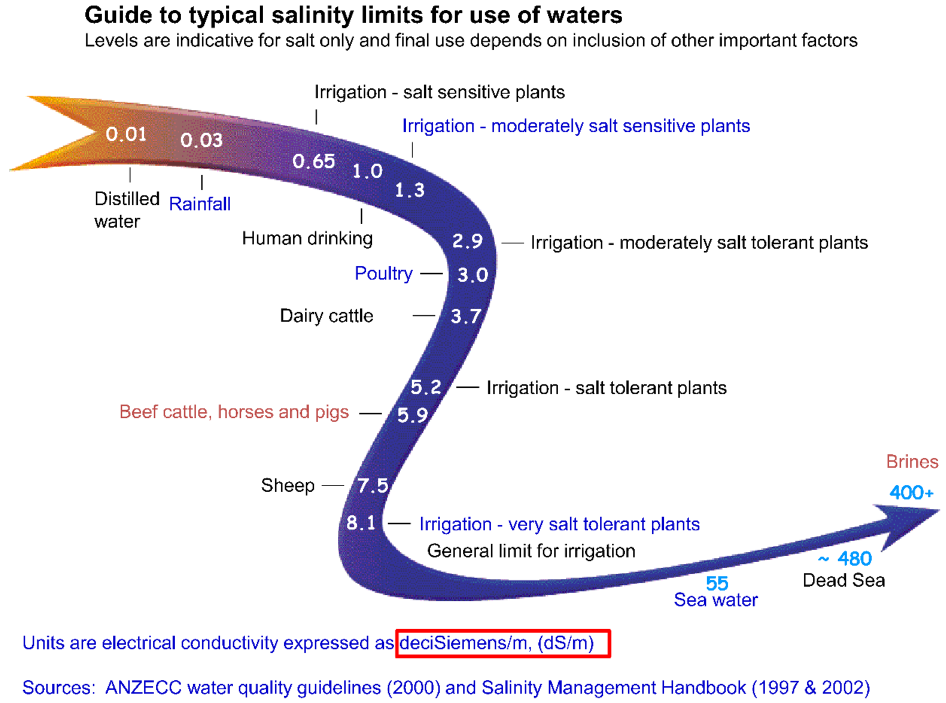

Figure 1 - gives agricultural suitability of a range of salinity values, as EC, and Table 1 gives the inter-relationships of soil measures and plant salt tolerance groupings. Guide to the use of waters for agricultural use are based on salt content. Other factors including the composition of the salts can modify the suitability and need to be considered for local use.

Values for l EC measurements differ between soil and water because of how water is concentrated in soils. Table 1 relates the plant salt tolerance groupings for irrigation in Figure 1 to soil EC measurement values for different soil textures represented as clay content.

Table 1. Soil salinity criteria EC_{se} and $EC_{1:5}$ for four ranges of soil clay content related to plant salt tolerance groupings from Salinity Management Handbook (2002).

Plant salt-tolerance grouping[1]	Corresponding ECse range[2] (dS/m)	Equivalent EC1:5 reading, based on clay content of soil (dS/m)				Soil salinity rating
		10–20% clay	20–40% clay	40–60% clay	60–80% clay	
Sensitive	< 0.95	< 0.07	< 0.1	< 0.12	< 0.15	very low
Moderately sensitive	0.95–1.9	0.07–0.15	0.1–0.2	0.12–0.25	0.15–0.3	low
Moderately tolerant	1.9–4.5	0.15–0.35	0.2–0.45	0.25–0.55	0.3–0.7	medium
Tolerant	4.5–7.7	0.35–0.65	0.45–0.75	0.55–0.95	0.7–1.2	high
Very tolerant	7.7–12.2	0.65–0.95	0.75–1.2	0.95–1.55	1.2–1.9	very high
Generally too saline	> 12.2	> 0.95	> 1.2	> 1.55	> 1.9	extreme

1. These groupings are statistically derived divisions based on families of linear curves representing the salt-tolerance ratings of the majority of crops reported by Maas and Hoffman (1977). The terminology of Maas and Hoffman has been modified and an additional group of sensitive incorporated.

2. ECse is the boundary EC_{se} at which 10% yield reduction occurs for these plant salt tolerance groups. The $EC_{1:5}$ ranges have been determined from these EC_{se} ranges using the equations provided in *the Salinity Management Handbook (2002)*

Sodicity is the presence of a high proportion of sodium ions to calcium and magnesium in a water or a soil.

Common measurements are:

- ESP: exchangeable sodium percentage 0 -100% - the sodium adsorbed onto clay minerals
- SAR: sodium adsorption ratio 0.1 to >100 – the ratio of sodium to calcium + magnesium in waters or soil solutions
- RA: residual alkali in water - the excess of sodium bicarbonate and carbonate relative to calcium and magnesium carbonates

The normal values for soils and waters are for an ESP or SAR value to be less than around 6 to minimise soil surface structural degradation including soil dispersion, crusting and hard-setting. When waters evaporate, the less soluble salts of calcium and magnesium precipitate first leaving dominantly sodium chloride in solution which increases soil and water sodicity.

Soil dispersion is the process where clay particles are repelled from each other and the particles separate, forming a suspension of clay particles in water. This process is enhanced by high ESP and low salinity.

High salinity can flocculate dispersed soils. A soil may be flocculated and stable if the salt content is high due to evaporative concentration. However, under rainfall, the salt is washed away and soil dispersion will occur. An example of dispersion is shown in Figure 2.

Figure 2. An example of surface soil dispersion on a ploughed field with high soil sodicity following a rainfall event. The relationship between EC and SAR, or ESP, and soil stability is shown in Figure 3 on page 11.

Groundwater is water occurring below the surface of the landscape occupying spaces in the underlying strata. The upper surface of this saturated zone is called the **watertable** which is at atmospheric pressure. The watertable depth is usually measured as the standing water level relative to the soil surface.

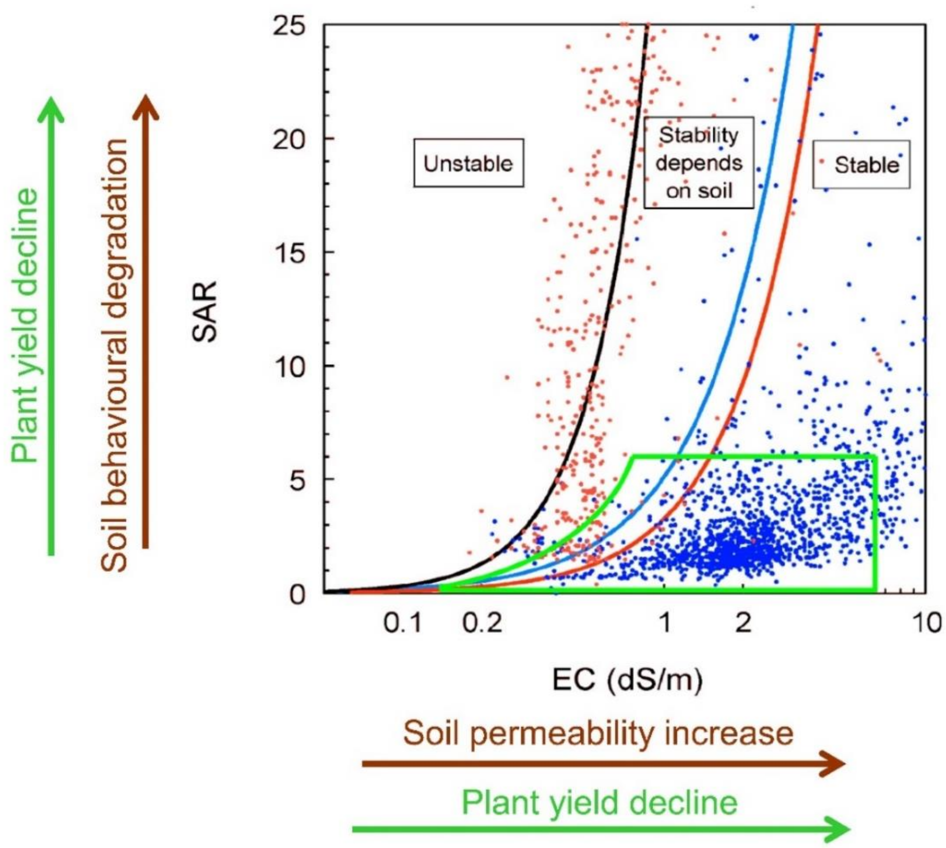

Figure 3. Relationship between EC of an irrigation water and the sodium adsorption ratio (SAR) of the water and the effect on soil structural stability at different EC and SAR levels. The black and red lines indicate the range in response for different soils with the intermediate area depending on soil properties. Waters that fall within the green outline are preferred for soil stability on most soils. Rainfall will dilute the EC and move the stability response of the soil to the left, making the soil structure unstable. The blue dots are waters from the Lockyer Valley and the red dots are waters from the Great Artesian Basin (but not in upper Purga Creek area).

Further Links

Title	Link
Salinity Management Handbook (2nd edition)	https://publications.qld.gov.au/dataset/salinity-management-handbook
Aerial imagery of Queensland including historical imagery	https://data.qld.gov.au/dataset/aerial-imagery-queensland-series

4 Where does salinity come from?

Salts come from rainfall and weathering of rocks and soils over long periods of time. Salts are concentrated by evaporation of water and by transpiration through vegetation leaving salt behind in the soil. Salt accumulation depends on how much leaching occurs through the soil to the groundwater and the quantity of annual rainfall. Clay soils have lower permeability and hence generally more salt than sandy soils because the vegetation can use more of the available water. Longer residence times of groundwater in sediments and aquifers will generally increase the salt content of groundwater due to weathering and dissolving of soluble and partially soluble salts in sediment and aquifers. Rainfall contains dissolved carbon dioxide which forms a weak acid and promotes weathering.

Salt accumulates in the landscape where there is an imbalance between water inputs to a sub-catchment and water outputs through stream flow and groundwater flow. This is usually associated with a restriction to lateral movement of groundwater which causes a consequent rise in the watertable and evaporation. This can be likened to a bathtub, when the inflow rate exceeds the outflow rate through the drain hole, the bathtub fills and overflows and/or evaporation occurs.

Landscapes with higher slopes tend to have lower groundwater salinity due to the higher gradient of water flow which increases the flow rate out of a catchment. Vegetation is the natural buffer in the landscape and vegetation increases in density where there is more water and the vegetation is more salt tolerant. In SEQ, Black tea tree is found in higher salinity and wet areas, and Brigalow in drier more salty areas. When changes to landscape hydrology occur, the natural balance is disturbed through land clearing, dams, irrigation, groundwater use, rural residential developments (particularly non-sewered subdivisions), disposal of mine waters etc, then a rise in groundwater level occurs and when the watertable is close to the soil surface < 1 m below ground level, capillary rise of water in the soil occurs with evaporation of water leaving salt behind at the soil surface.

5 Is landscape salinity getting worse?

For many areas, landscape salinity is now relatively stable but with the affected area fluctuating with periods of wetter years where it gets worse and reducing in affected area in drier periods. This quasi stability is a new equilibrium between inputs and outputs from general land clearing more than 100 years ago on hydrologically sensitive landscapes. For areas in fairly flat alluvial areas, the extent of salinity may still increase because of the very slow lateral groundwater movement. However, as land use changes on a landscape that has already been changed historically by clearing, then further salinity hotspots occur. Often expansion will occur following unusually wet periods and because it has changed into a salted state, it tends to remain salt affected, see Figure 4 below. Thus anything that increases effective rainfall will increase the inputs and may cause an expansion of salinity. The SEQ regional plan which indicates increased residential development along the Brisbane to Toowoomba corridor would suggest an increase in salinity will occur due to reticulated water to residential blocks and if the development is not sewered in that region.

Increased recharge of soils from historic clearing or additional inputs, moves the historic salt in the soil profile to the groundwater and increases the salinity of the groundwater. This may take decades to appear.

Once a landscape has become salt affected, it has moved into another state and it is quite difficult to reverse to a non-saline condition unless two variables, soil salt content and watertable level are reduced concurrently. This is illustrated in Figure 4 and described below.

With the change in land use and increased recharge to groundwater, the watertable rises slowly with time as a result of the imbalance between inputs and outputs. Once the watertable levels get close to the soil surface in the more hydrologically sensitive parts of the landscape, capillary rise of water to the soil surface increases and evaporative concentration of salt on the soil surface kills vegetation. Vegetation had been using groundwater, while the salt content was reasonable, and also reducing surface soil evaporation through shading. Once the vegetation has gone, evaporation increases the soil salinity at the surface quite quickly. Salt tolerant vegetation may survive if the salt content is not extreme however, this is usually at a physiological cost to the plant to exclude the salt. For reclamation to occur, the rate of evaporative concentration of salt on the soil surface has to be reduced. This can occur through lowering the watertable level so capillary rise is reduced and hence salt content in the soil becomes reasonable and vegetation can be established or reducing evaporation through mulches etc.

Thus, for reclamation to occur, both the soil salinity level and the level of the watertable have to be reduced to a relatively safe watertable level greater than 1 to 1.5 metres below ground for > 90% of the year.

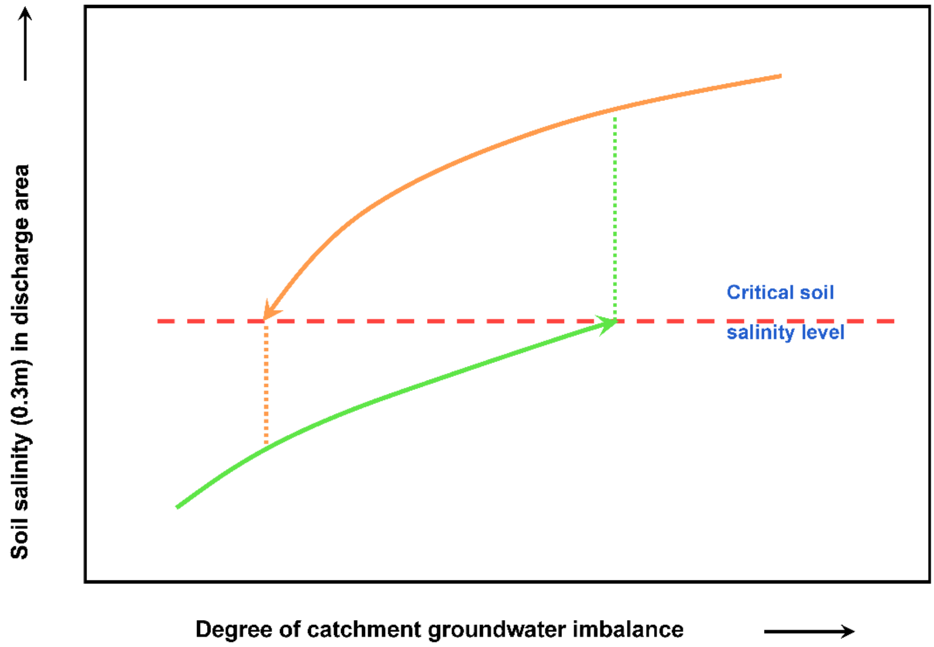

Figure 4. The processes of developing salinity and reclaiming salt affected areas. Once a critical soil salinity level is reached, vegetation is killed by salt and evaporative concentration continues. To reduce salinity and re-establish vegetation, the watertable has to be lowered with a corresponding reduction in soil salt content until vegetation can re-establish.

6 Identifying landscape features and causes of salinity

The common landscape features associated with the occurrence of salinity in Queensland are shown in Figure 5. Each form has an identifiable restriction to groundwater flow out of the catchment. They are described in more detail in the Salinity Management Handbook (2002). The common forms are generally regionally determined by geology but with roads and dams additional factors that influence occurrence of salinity.

South East Queensland has several regions of salinity of variable impact. The main areas with multiple occurrences are in the Lockyer and Bremer catchments and eastern Darling Downs. In the Lockyer valley, the hydrology of the southern tributaries tends to be dominated by the highly weathering resistant Winwill conglomerate formation which has controlled the flow of water and hence salt accumulation in the groundwater upstream of the Winwill formation. The Lockyer is dominated by the catchment restriction form and alluvial valley form but with dams and roads resulting in a higher incidence of salinity. Some of the new non-sewered rural residential areas also show salinity from the additional water inputs and the geology. Figure 6 shows the occurrence of salinity in the Lockyer Valley from Shaw (2008).

For the Bremer, the long alluvial valleys show salinity where groundwater flow is restricted as well as the catena form where high watertable levels in alluvial valleys slow the water movement out of adjacent uplands. Purga Creek ends in a wetland area with evaporative and transpiration concentration so salt. Periodic flushing with floods can manage the salinity levels mostly. The upper Purga Creek area has an uncommon source of water for SEQ from the Great Artesian Basin. The alluvial valley and catena forms occur and also roads and dams are causing local salinity. The artesian water under upward pressure is causing salting and also causing seepages where the water flows across the soil surface. Generally seepages don't always result in soil salinity because of flushing by the upward flowing water.

Figure 7, on page 18, shows the extent of salinity in upper Purga Creek from Shaw and Eyre (2015).

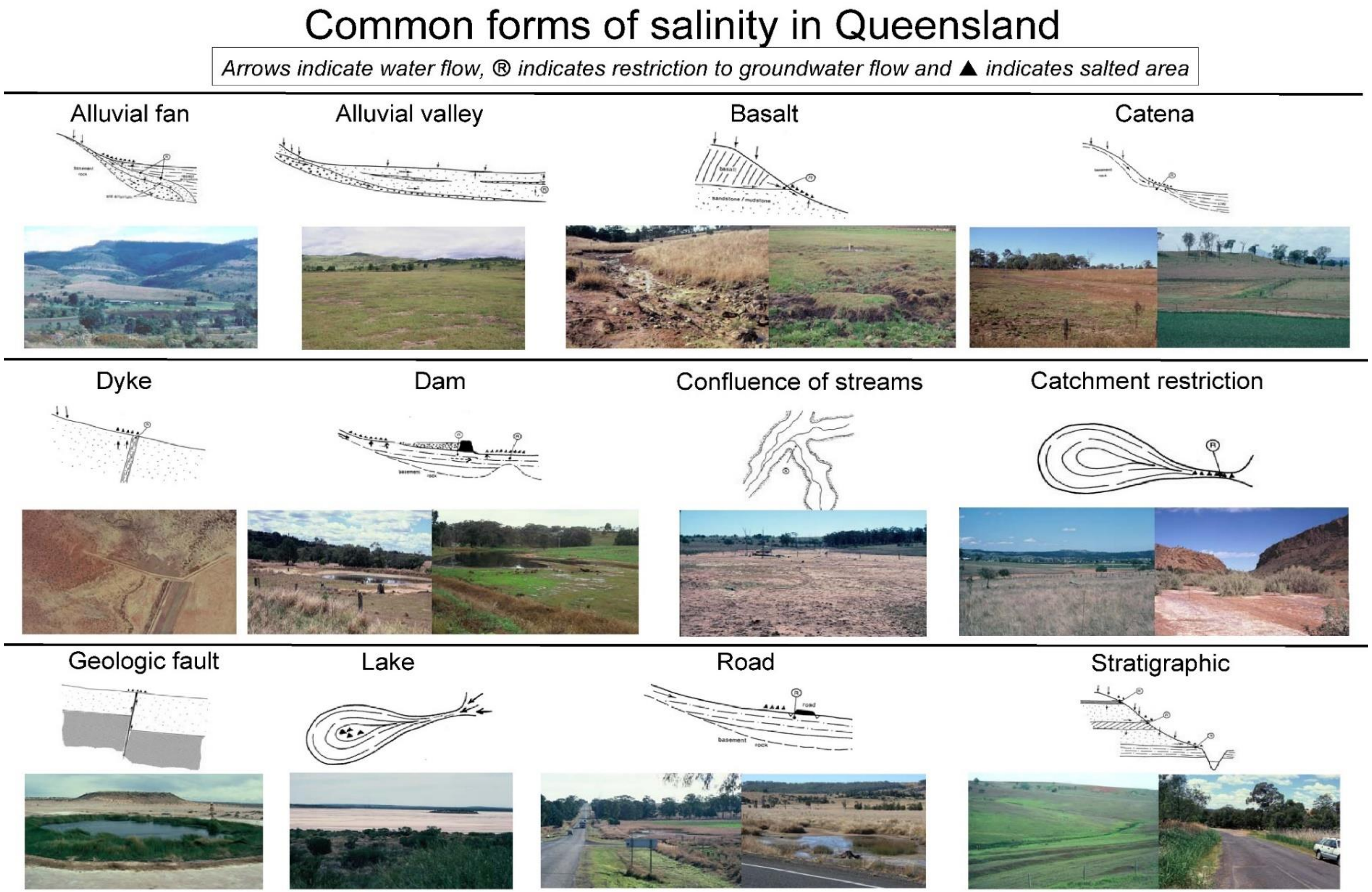

Figure 5. Common forms of salinity in QLD identifying restrictions to groundwater flow and processes operating from Shaw et al. (1987).

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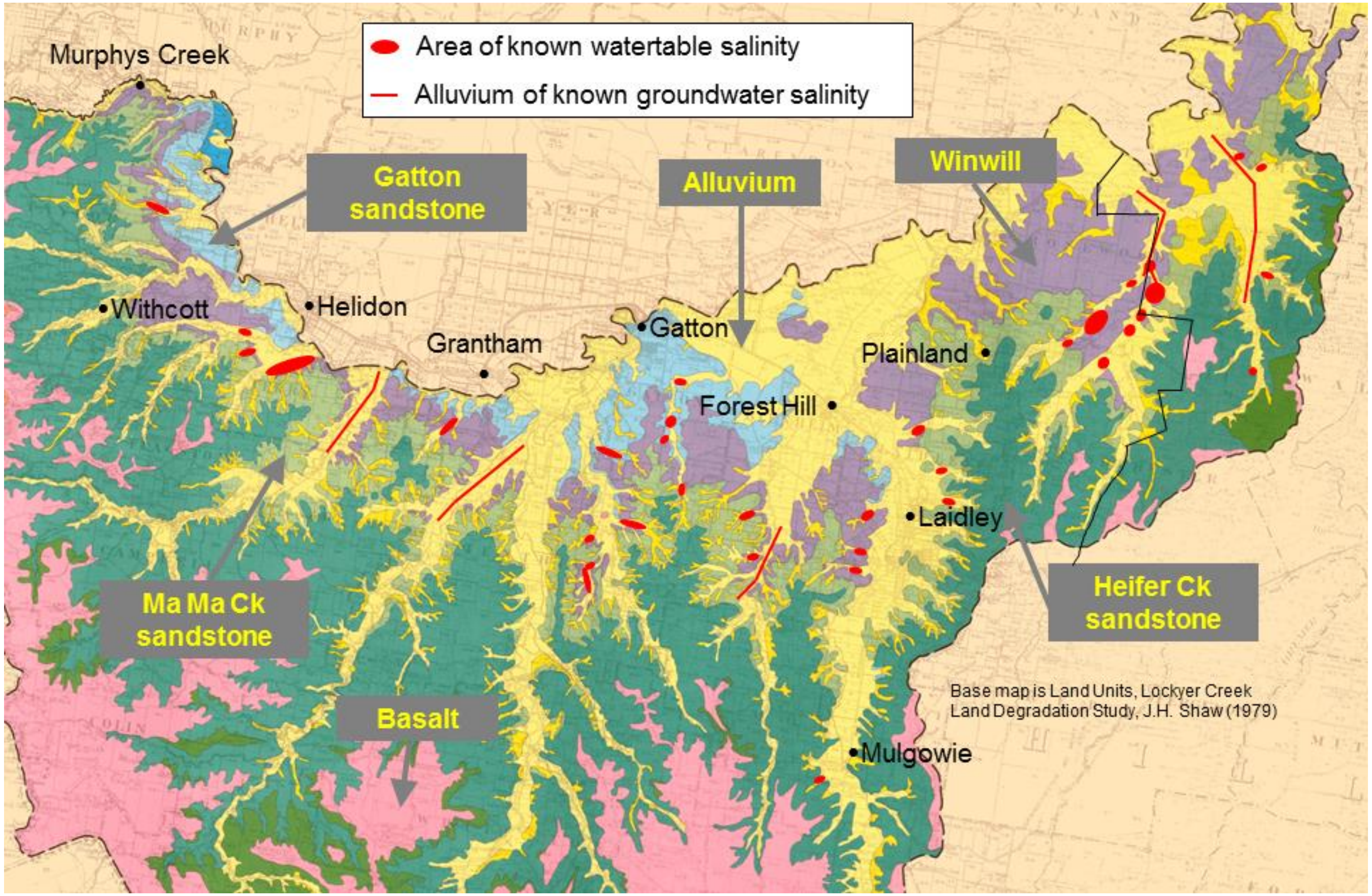


Figure 6. Dryland salinity in the Lockyer Valley shown as red areas. The line segments indicate high salinity in the southern tributaries to Lockyer Creek based on work by several people. The very strong association with Winwill geology is evident. The elliptical areas of red are indicative of where watertable salinity occurs and not an indication of the areal extent of salinity at each location. Small and intermittent salted areas are not shown. Figure modified from Shaw (2008).

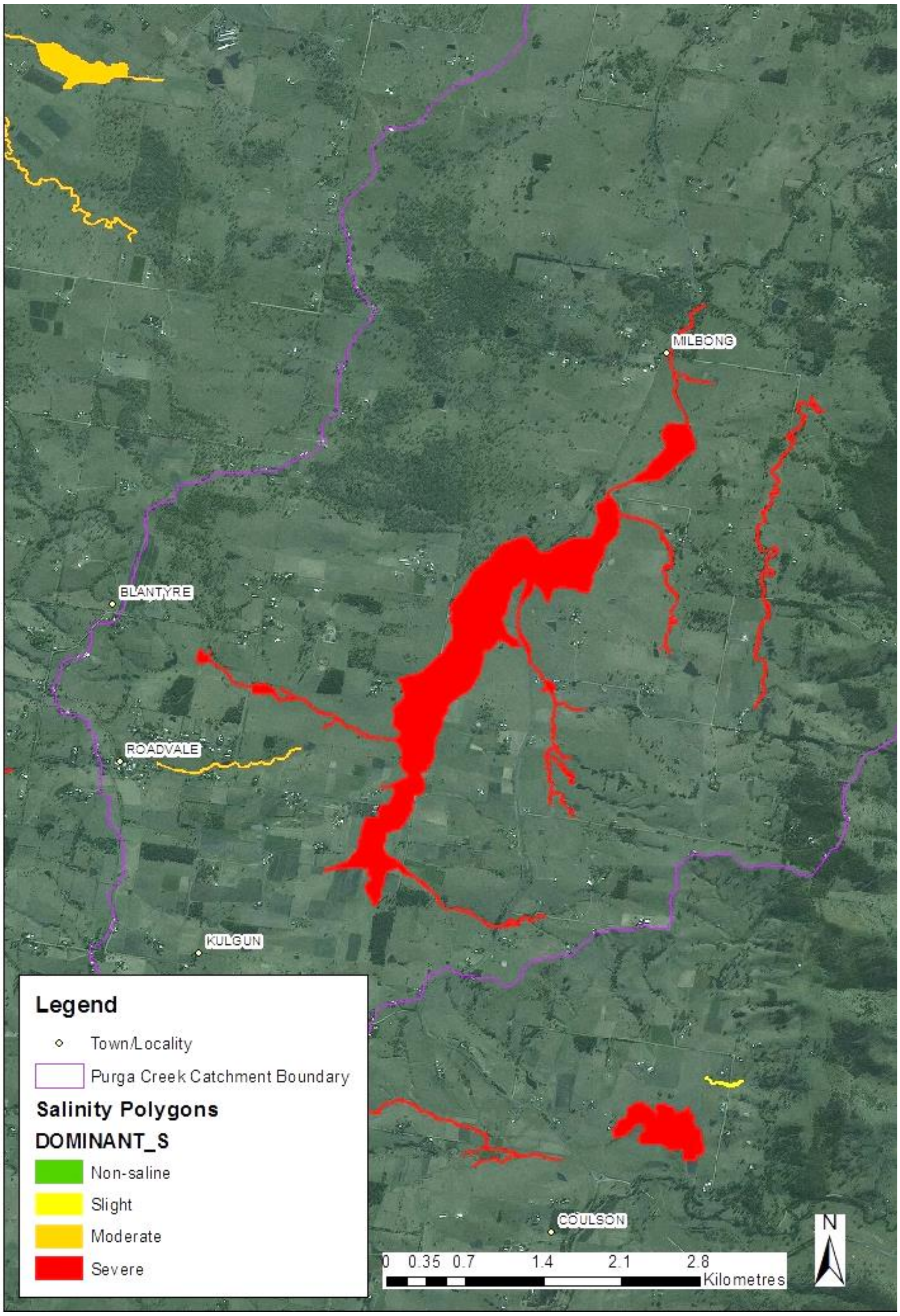


Figure 7. Extent and severity of surface soil salinity in upper Purga Creek. Red areas are severely affected and orange areas (north of Roadvale) are moderately affected, from Eyre and Goulding (in press). Figure from Shaw & Eyre (2013).

Further Links

Title	Link
Shaw, Roger & Eyre Lauren 2013, Roadvale salinity project: Salinity processes, management options and planning considerations for upper Purga Creek catchment. Final report for Scenic Rim Regional Council, SEQ Catchments, the Roadvale-Milbong community including Roadvale State School, Queensland Department of Natural Resources and Mines and Bremer Catchment Association. SEQ Catchments, Brisbane.	www.seqcatchments.com.au/resources-general-reports.html
Shaw, Roger 2008, Bio-physical options to prevent, minimise or manage salinity issues in the Lockyer Catchment. Technical Report for Lockyer Valley Regional Council, Gatton.	http://www.seqcatchments.com.au/ Default.aspx?A=Search&ID=/results.html
Shaw, Roger 2007, Strategic approach to determining salinity mitigation investment for Woolshed and Plain creek catchments, 2007 – 2012. Technical Report, SEQ Catchments Ltd, Brisbane.	http://www.seqcatchments.com.au/ Default.aspx?A=Search&ID=/results.html

7 Living with salt – management options

Options to manage salinity

Before considering the specific options for living with salinity, the following is an overview of the management options for landscape salinity to provide the context. Often a single option is not sufficient of itself and combinations of options are required. These are each described in broad detail. There may well be other options possible. The options are:

1) Do nothing
2) Reduce groundwater inputs (recharge area)
3) Intercept groundwater (transmission zone)
4) Increase groundwater outputs (discharge area)
5) Store the salt
6) Remove the salt
7) Live with salt and stabilise the affected area

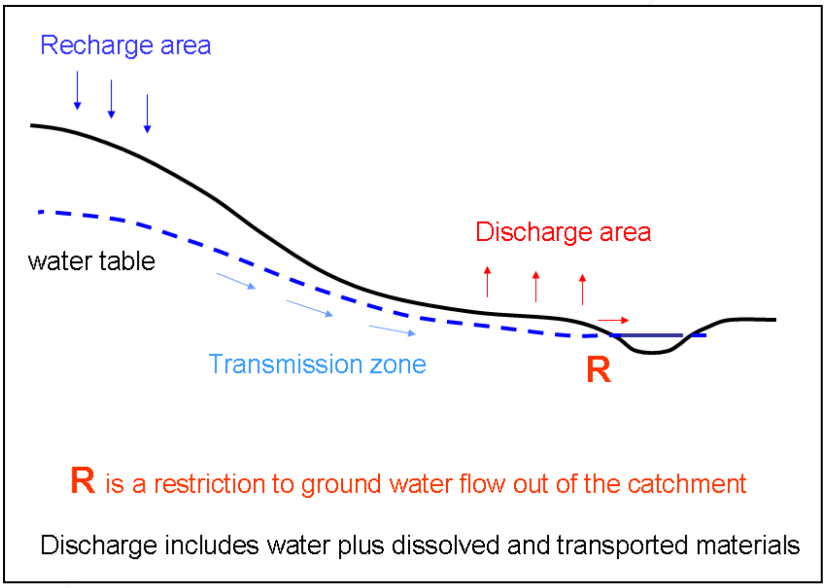


Figure 8. A simple model of groundwater processes resulting in watertable salinity in a catchment illustrating recharge, transmission and discharge zones. Evaporation occurs in the discharge area from a shallow watertable.

1) Do nothing

This approach is most applicable to situations where:

- The salinity situation is relatively stable
- Bare salted areas are intermittent or small
- The stream saline base flow from the salinity affected area is relatively small in quantity with minimal salt load impact on downstream resources.

The preferred approach is:

- 'Fence and forget', though control weeds if required
- Revegetate where cost effective and viable

If it is an area of Black Tea tree or Brigalow or other indicators of wetness or salinity as past or present vegetation, these areas need to be substantially protected and vegetation increased in association with other methods to achieve a buffer depth to the water table to moderate water table levels in wetter periods to prevent spread of salinity.

2) Reduce groundwater inputs (recharge area)

This option is most appropriate if a recharge area with a higher rate of recharge is identifiable and can be managed. However,

Recharge areas are usually large and diffuse.

There are usually very long lead times for change. If it takes 70 to 100 years for salinity to come to a new equilibrium then it will take at least that long by revegetation of much of the area for it to reduce to a reasonable level given normal rainfall. In cases where additional water is stored and or used in a catchment, there may not be adequate change in hydrology from revegetation alone to make any impact. Also, if a catchment is sensitive to hydrology and salinity under natural conditions, partial revegetation of recharge areas with deep rooted vegetation will still be insufficient.

The option may be useful in combination with other strategies such as using all available groundwater in the upper part of the catchment above any major salinity area. Evidence suggests that around 80% of the recharge area would need to be revegetated with deep rooted vegetation to make a significant difference and require a long period of time.

There are many good reasons for revegetating a catchment, but salinity is not a sufficient reason of itself and it is most unlikely that revegetation alone will make a major impact on salinity.

3) Intercept groundwater (transmission zone)

This option works best where:

There is an identifiable transmission zone between the recharge area and the discharge area (Figure 8) and has reasonable groundwater flow rates, often alluvial channels, or side slopes of more permeable materials before they reach the less permeable alluvial areas. Groundwater flow rates in wells or bores intercepting the area need to be in the order of 3 to 5 L/second to be practical for pumping groundwater.

The quality of intercepted water needs to be suitable for the intended use. Irrigation is most effective since it can use large quantities of water and the area and vegetation to be irrigated can be matched to the available supply and water quality.

The process is effective if water can be extracted a reasonable distance upstream of a restriction where it is likely to be of better quality and can very effectively lower the water table in the affected area. Given that the porosity of soils with shallow water tables is in the order of 5 to 10% (maximum), removal of water can have a large effect on lowering high water tables if the transmission area is fairly well defined. Thus pumping and using groundwater can be effective in lowering watertables.

4) *Increase groundwater outputs (discharge area)*

In general:

Vegetation is not very successful unless the soil salinity is below the critical soil salinity threshold and accumulated salt from transpiration and evaporation can be flushed or leached from the soil surface. A buffer depth to the water table of at least 0.5 m and preferably greater than1 m is needed for say > 90% of the year.

Pumping is possible but generally the flow rates are low and linked tube wells may be required. Mostly flow rates are so low that this is not effective.

Drainage is effective if there is some more permeable material at depth and it can break through the restriction to groundwater flow. The salt content and flow rates need to be acceptable to downstream users to minimise impacts.

Pumping and disposal in an evaporation basin is possible if the salinity level is too high for other productive uses if land is available, see option 6 below.

One option is to allow salt flushing out of the catchment in periods of high flows since there is such a dilution effect as salt leaves the catchment.

5) *Store the salt*

The most realistic place to store the salt is where it was before the salt affected areas appeared. This is in the soil profile below the root zone. More than 90% of the currently salted areas in SEQ show strong evidence of salting historically probably in higher rainfall periods and earlier geologic periods. This approach means lowering the watertable or raising the soil surface to reduce both salt concentration and watertable effects. This approach is unlikely to work unless the watertable level can be controlled adequately.

6) *Remove the salt*

Where the salinity of the groundwater is high the only viable option is to remove the salt by release of stored salt in flood flows, transport of evaporated salt, reverse osmosis techniques or solar distillation processes. Harvesting some of the salt from an evaporation basin and removing it from the catchment is the more cost effective option. This may mean an evaporation basin Evaporation basins are most effective when rainfall is low since the amount of water that can be evaporated is the difference between annual evaporation and annual rainfall. For SEQ with 1500 mm evaporation and say 800 mm rainfall per year, this is 700 mm which is 7 ML per hectare of evaporation basin assuming there is some sacrificial area available and the groundwater can be accessed to put into the evaporation basin. It does work in the Murray-Darling basin but at fairly high cost.

7) **Living with salt**

To have any chance of long term stabilisation of salinity, the soil salt levels in the upper root zone need to be reduced to below the critical soil salinity threshold level (Figure 3) where they have exceeded it, and prevent an increase in soil salinity where salinity is not yet present.

This means changing the groundwater imbalance to reduce recharge. While revegetation of recharge areas is possible and will contribute, it will not be sufficient of itself. Strategies that use available groundwater where the quality is acceptable and reduce salts in the upper soil profile to below the critical soil salinity level at the same time will be required. It will be important to:

- Enhance vegetation on areas surrounding the bare salted areas

- Maintain all grass cover at a minimum height of 200 mm to reduce evaporation.
- Fence from stock and use limited controlled grazing
- Increase the depth to the water table by land fill (mulch or soil) on top of the salted area where appropriate i.e. (surface flows and erosion control are feasible).

Mulch on the areas surrounding the salt scald should be progressively extended to the worst affect areas. This reduces evaporation and some plant establishment can occur. The mulch needs to be regenerated with time and may require some flushing of accumulated salt of the soil under the mulch if the groundwater salinity is high. Laying mulch can also cause expansion of salted area, since by restricting evaporative salt concentration, water tables will rise and spread in area to come to a hydrologic equilibrium.

Surrounding salted areas can be irrigated with water from a dam, bore or well or creek if EC < 8 dS/m and SAR <9 (and planted with salt tolerant vegetation) to flush evaporated salt and have a root zone more conducive to vegetation growth. If water is too salty for normal agricultural growth it may still be considerably better than the salt content of the salted area shallow groundwater. An area showing 50% plant productivity will be better than a bare salted area.

One option is to mound the salted area and irrigate the mounds planted with salt tolerant grasses initially then plant trees if water is available to maintain irrigation. The area between the mounds will be saline but the root zone in the mounds will be useable for vegetation due to flushing with irrigation water, if it is available. Can mulch the inter-mound areas but is likely to wash away in flow events until vegetation is established. Erosion control will be required.

An example of mounds is shown in Figure 9. Mounds about 0.5 m high and 1 to 2 m wide in longitudinal rows in an upstream/downstream direction on the salted area beginning nearest to the salted margins and vegetate with salt tolerant grasses and trees and irrigate with any available source of water with an EC < salt tolerance of the vegetation or at around 50% of the salt tolerance threshold to move salt downwards in the soil profile. Water EC should be less than 8 dS/m. Once creeping or stoloniferous grasses establish, the stability of side banks would increase.

Sprinkler or micro-sprinkler irrigation is much preferred to dripper systems as they provide a wider area for downward flushing of salts and do not generate the surface and lateral salinity concentrations at the edge of the wetted area that drippers do. Irrigation is preferred to control salt accumulation in the mounds with frequency determined by salt accumulation and rainfall.

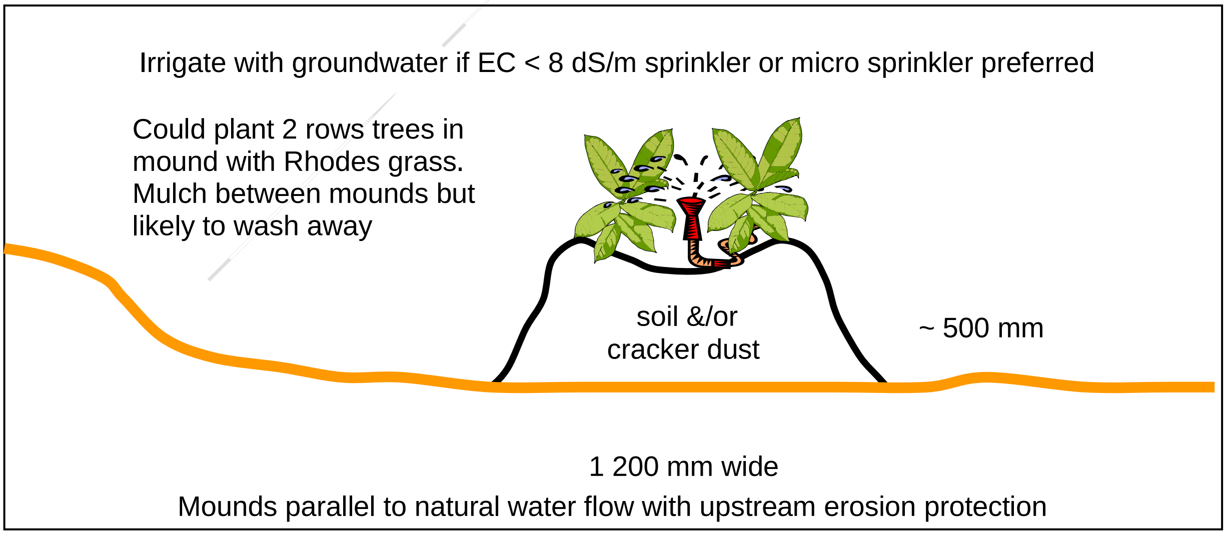


Figure 9. Example structure of mounds to place near edges of salted and bare areas to allow reclamation to occur. Irrigation is desirable to control salt level in the mounds.

8 Vegetation recommendations for salt lands

At the outset it is important to appreciate that most, if not all, of our local saline land was before European settlement vegetated by at least some woody vegetation. Many of these areas now have at least some grasses and maybe some saltbushes. It is common knowledge that the original plants have been cleared initially by human efforts of some kind and later the impacts of various factors including livestock, drought, increasing salinity or a combination thereof.

Why revegetate?

Because most woody plants take a relatively long time to reach a 'productive stage' it is important to take a bit of time to reflect on and carefully plan your project.

Revegetation and Restoration are two different practices. In saline areas it would be, at least, virtually impossible to return the original species as the soil composition and structure together with the water quality and water table have been greatly altered. The reasons for restoring woody vegetation varies from property to property and may include the following:-

- to improve the appearance and value of the property.
- to increase the biodiversity, and thus the ecological health of the land.
- to improve the grazing capacity by better grass cover with some shade from trees which will also give winter protection for livestock.
- to produce some timber or ecologically sustainably wood fuel.

Figure 10. Reclaimed salt lands which now are shallow wetlands, which have increased the bird life and biodiversity value of Barry Jahnke's Property at Kalbar.

What vegetation to use?

After deciding why you want to revegetate it will then be important to study the site and prepare a strategy plan. If the property is stocked with livestock it will be necessary to restrict their access as stock have been referred to as "tree destroyers". It will also encourage the landholder to restrict him or her to work on a smaller area which will prove to be more manageable and satisfying. The ideal practice is to use only local species but in reality this is not possible as there are few suitable for these degraded sites and they may not suit the owner's plans for the land utilization.

The local *Dichanthium* and *Bothriochloa* grasses may not grow in these salty soil and Rhodes and Kikuyu grasses may have to be used instead. Fortunately, the local *Melaleuca bracteata* (Black Teatree) is fairly salt tolerant, moderately fast growing, frost tolerant and provides good shade. It is not possible to provide an extensive suggested plant list here so speaking with experienced people or go here (salinity management handbook) is the best source for help. Several Australian trees, which are not locals, but are worth considering are:-

Eucalyptus argophloia (Queensland or Chinchilla White-gum) can be grown near saline areas and is noted for its beauty, fast growth, frost resistance and useful timber.

Casuarina glauca (Coastal She-oak) is very salt tolerant, fast growing and an excellent wood-fuel which should be grown locally to provide a local sustainable firewood industry, thus saving some of the currently used habitat trees.

Figure 11. Reclaimed salt lands which now grows a woodlot on Barry Jahnke's property at Kalbar. The wood lot consists of *Casuarina glauca*, *Callitris columellaris, Eucalyptus argopholia* and *Araucaria bidwillii.*

It is useable in about twelve years and does not need replanting as it suckers which is useful if the trees are to be commercially harvested but on the other-hand that could be seen as a liability. However, if cattle are part of the enterprise they would probably browse on suckers outside of the wood enclosure.

Cautions

- When using non-local species there is always the danger of them becoming another weed so do your planning and selection with great care.
- One of the trade-offs with woody plants is that they will often have weeds under their canopies from wind and animal dispersed seeds.
- Don't let the potential problems stop you from making vegetation improvements on your saline land!

Figure 12. Forest plot on higher ground at Barry Jahnke's property, the trees include: *Casuarina glauca, Araucaria cunninghamii* and *acacia harpophylla.*

9 Mapping my salt lands

Before you can set goals and think of activities to start managing your salt lands you need a basic understanding of why and how salinity occurs and the possible capabilities and limitations. Mapping your property, with particular care given to these areas helps you to start breaking the salt problem down into manageable sized chunks and is also a low cost way to explore options before investing your time and energy (and money) to live better with the salt on your property.

A map of your property will allow you to locate the position of your infrastructure, natural assets and features and where they are in relationship to your salt lands. Some things to keep in mind when mapping is having an accurate scale making the transfer from paper to paddock easier.

Current property Mapping (Mark in colours matching the symbols below) /

a. **Soils**
b. **Land types**
c. **The location of buildings** - homes, sheds, chemical storage
d. **Location of salt lands**
e. **Water Sources** – bores, dams, tanks, creeks, wetlands and seepages
f. **Vegetation areas** (remnant vegetation, vegetation corridors)
g. **Fencing** – Existing fences, gates, paddocks, stockyards

Future property mapping (in the context of managing salt lands on your property map)

a. **Revegetation areas** (note type and sequence of planting)
b. **Water sources that might support salt land management**
c. **Areas for mounding with soil or mulch**
d. **Fencing**

There is a range of mapping services and software available. Google Earth and Google Earth Pro are two programs, both of which can be downloaded and used free of charge. The Queensland Globe is an additional add in from the Queensland Government that contains a range of data layers including soil and land types, vegetation layers and groundwater that can be used by you when developing your property map. Remember these layers should be used as a guide only and further advice should be sort prior to undertaking any activity. Mapping can be broken down into three areas - some things to consider including are (remember all might not be applicable to your property or situation);

Further Links

Google Earth/ Google Earth Pro free downloadable mapping software	https://www.google.com/earth/
Google Earth Pro Training Manual	Available from Healthy Waterways and Catchments
Queensland Globe is a Queensland Government product providing a range of free mapping data layers	https://www.business.qld.gov.au/business/support-tools-grants/services/mapping-data-imagery/queensland-globe/install-mac-pc

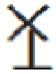
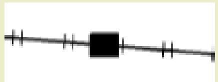
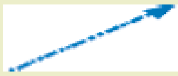
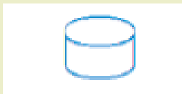
Feature	Symbol	Feature	Symbol
Access track		**Fence- Existing**	
Bore	•B	**Windmill**	
Building		**Gate**	
Chemical Shed	CS	**Power line**	
Constructed Waterway/ Pipeline		**Pump**	P
Dam	D	**Stockyard**	
Tank		**Watering point (trough)**	W
Fire lines		**Excess nutrient in-put (i.e. sewerage,**	N
Contour bank		**Planted vegetation**	PV
Improved pastures	PI	**Farm forestry**	FF

Figure 13. Symbology for property mapping. Extracted from Healthy Waterways and Catchments Rural Essentials – a guide to managing your property. Healthy Waterways and Catchments Ltd.