Book 2 Dryland Salinity: Identifying Saline Sites

Introduction

Learning to identify and assess the extent of dryland salinity is important for the management of affected areas.

The appearance of areas of salinised or waterlogged land indicates that the water balance of a catchment has changed. These areas, called discharge sites, are usually the first visible clue to an emerging salinity problem.

Early detection of saline sites is important. It helps prevent further land degradation and maximises the time available to treat the problem. Understanding the level of salinity is important for selecting appropriate land use and management practices for saline areas.

Saline sites are commonly identified and assessed by recognising the visual signs of salinity in the landscape and measuring salinity in soil and water.

Visual assessment of land provides a quick and easy way to identify and estimate the severity of salinity. Changes in the health and composition of plant communities, soil and water characteristics, or stock behaviour can all be indicators of salinity.

Testing soil and water offers an accurate method of measuring salt levels and can determine if factors other than salinity are affecting an area.

This booklet provides an overview of how to undertake a visual assessment of a site for the presence of salinity and the choice and use of appropriate tests to confirm and quantify the severity of salinity in the area. Information collected through this process may be used to classify land according to the level of salinity present, providing a guide and framework for the prioritisation of areas for intervention and the choice and implementation of salinity management options.

Visual identification of saline sites

Location of saline discharge sites

Saline discharge occurs as a result of complex interactions between several factors including climate, groundwater, geology, soil, terrain and land use.

Discharge sites usually develop in the lower parts of the landscape, for example, on footslopes and in broad drainage depressions. However, they can also occur higher in the catchment as a result of catchment shape or geological complexity.

Discharge sites often develop where geological features such as rock bars, converging ridgelines and fault lines restrict groundwater flow. Discharge sites can also occur where heavier clay soils down slope restrict water movement and where roads or stock routes compact soil, thereby impeding water drainage.

Water, soil and plant indicators

Salinity affects water quality, soil properties and plant growth and many signs can be useful indicators of salinity problems. While individual indicators are not conclusive proof that salinity exists at a site, the more indicators that are present, the more likely it is that an area is saline.

Saline water is often clear in appearance. Other indicators of saline water include salt crusting and/or foaming around the water's edge and the presence of salt tolerant plants such as Cumbungi.

Saline soils are often bare or sparsely vegetated. Salt crystals may be visible on the surface and sheet or gully erosion is often present. Saline soils may be puffy when dry or slippery when wet. The soil may be continuously or seasonally wet or waterlogged. If the level of salinity is high, affected areas may also have a ‘seaside’ smell. Stock often camp on saline areas to lick salt from the ground.

Changes in plant health or the mix of plant species indicate that growing conditions have changed. Saline areas generally have a ‘halo’ of reduced growth, where salt is generally concentrated on the perimeter of the ring, in crop or pasture paddocks and salt tolerant species dominate affected areas. Discharge sites may also support lush pasture growth in summer due to excess soil moisture.

Some common salt tolerant plants are shown below, however, their presence is not conclusive proof of salinity. The presence of other symptoms such as tree death, canopy thinning, stunted growth and bare soils may indicate the land is saline but this should be confirmed by testing the soil salinity.

Figure 1: Common salt tolerant plants.

Sea Barley Grass (Critesion marinum)

Couch (Cynodon dactylon)

Creeping Saltbush (Atriplex semibaccata)

Windmill Grass (Chloris truncata)

Salt Sandspurrey (Spergularia marina)

Cumbungi / Bull rush (Typha spp)

Other plants that can indicate salinity include:

Muellers salt bush	*Atriplex muelleri*
Creeping saltbush	*Atriplex semibaccata*
Ruby saltbush	*Enchylaena tomentosa*
Curly windmill grass	*Enteropogon acicularis*

Pioneer rhodes	*Chloris gayana*
Purpletop rhodes	*Chloris inflata*
Sedges	*Cyperus spp*
Brown beetle grass	*Diplachne fusca*
Samphire	*Haloscarcia and Sarcocornia spp*
Hairy panic	*Panicum effusum*
Marine couch	*Sporobolus virgincus*

Measuring salinity

Electrical conductivity - Salt concentration is the amount of dissolved salts in a given volume of water.

A convenient method of estimating the amount of salt in a soil or water sample is to measure the electrical conductivity (EC) of a solution. This is because dissolved salts conduct an electrical current that is proportionate to the amount of salt in the water.

Units of measurement - Electrical conductivity is measured in Siemens, and is commonly expressed as deci-Siemens per metre (dS/m) or micro-Siemens per centimetre (m S/cm). These are referred to as electrical conductivity units or EC units. However, other units are also commonly used. The relationship between these units is shown in Table 1 below.

Table 1: A guide to commonly used units for recording salinity measurements

Conversion example		
1 =	1000 =	640*
deciSiemen/metre (dS/m) **OR** milliSiemen/cm (mS/cm)	microSiemen/centimetre (µS/cm) **OR** micromhos/centimetre (mhos/cm)	parts per million (ppm) **OR** milligrams/litre (mg/L) **OR** Total Dissolved Salts (TDS)

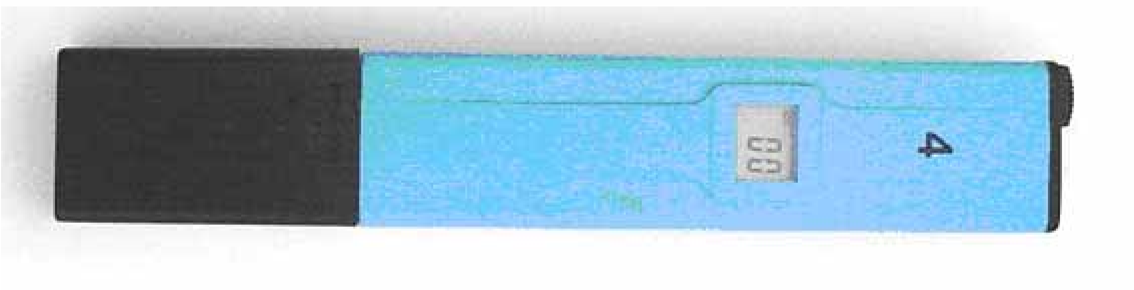
* Note: The conversion factor for ppm varies depending on the salts present. The variation at 1 dS/m can be from 400 – 970ppm. Due to the salts commonly present in soils, especially on saline areas, an accepted average conversion value is 640ppm.

Electrical conductivity (EC) meters - are used to measure the salinity of a water sample. The saltier the water is, the higher the reading will be. Soil salinity can be also be measured by making a soil and water solution and measuring the EC with a meter.

EC meters need to be calibrated prior to use, using a standard solution. If you have a sample you suspect is highly saline, the meter should be calibrated using a higher standard (12.88 dS/m), otherwise errors will be introduced. If samples are quite fresh, try to calibrate at the low end (using a standard of 1.41dS/m).

Several brands of EC meters are available, however, they often vary in the units of measurement used. It is important to know in what units the meter records and how to convert these units into deciSeimens per metre (dS/m).

Two commonly used handheld EC meters are the blue ‘Hanna DiST 4' that reads in milliSiemens per metre and the ‘Eutec ECScan High' which reads in deciSiemens. Both meters are pictured below:



The 'Hanna DiST 4' EC meter

The 'Eutec ECScan High' EC meter

Measurements of soil and water salinity - There are many different ways to measure soil and water salinity. The salinity of water can be measured directly with an EC meter. The salinity of soil can be measured by drawing salts from the soil into a solution and measuring the salinity of the solution. Table 2 identifies the different methods of measuring salinity.

Table 2: Common measurements of soil and water salinity .

Measurement symbol	**Soils or water measurement**	**Definition**
EC_w w = water	Water	A direct measurement of water using an EC meter.
$EC_{1:5}$	Soil:water solution	1 part soil + 5 parts water. A method to determine the salinity of soil. Does not take account of soil texture.
EC_e e = extract	Soil	Takes account of soil texture. Soil salinity is determined by multiplying EC 1:5 by a soil texture factor (see Table 5).

EC_{se} se = saturated extract	Soil	Laboratory method used to determine soil chemistry including EC. Measures water extracted from a soil:water paste. This measurement is *approximately* the same as EC e .

Testing water salinity

There are two types of water moving around catchments, surface water and groundwater. Surface water runs across the land surface and generally drains into creeks, rivers or dams. Groundwater lies below the land surface and can be discharged from springs, seeps or base-flow into creeks and rivers.

The Australian Water Resources Council (1976) has defined classes for water salinity, listed in Table 3. The units for water tests are commonly expressed as deci-Seimens per metre (dS/m) or milligrams per litre (mg/L) or parts per million (ppm).

Table 3: AWRC saline water quality classes

Water Quality Class	Salinity level (dS/m)	Salinity levels (mg/L)
Fresh	less than 0.8 dS/m	less than 500mg/L
Marginal	0.8 – 1.6 dS/m	500 - 1000mg/L
Brackish	1.6 – 4.8 dS/m	1000 - 3000mg/L
Saline	greater than 4.8 dS/m	greater than 3000mg/L

Source: Taylor 1993

Many different salts are found in both surface and groundwater. The EC of a water sample does not identify what salts are present in the water, only the total concentration. Some salts have a stronger effect on plants and soil than others, for example, sodium salts can have a very detrimental effect on plants while calcium salts often have minimal effects.

The only way to find out the type of salts that are present is to have the water tested by a National Association of Testing Authorities (NATA) registered laboratory. The Department of Primary Industries sells water sampling kits.

Interpreting water salinity results - The level of salt in water can determine its suitability for a range of uses (refer to Table 4).

Table 4: Water salinity levels .

Source/Use	EC w (dS/m)
Distilled Water	0.00
River Murray (SA, 1993)	0.79
Desirable potable limit for humans	0.83
Absolute potable limit for humans	2.5
Limit for mixing herbicide sprays	4.69
Limit for poultry	5.8

Limit for pigs	6.6
Limit for dairy cattle	10.00
Limit for horses	11.60
Limit for beef cattle	16.6
Limit for adult sheep on dry feed	23.00
Highest reading of underground water in Forbes*	24.00
Sea water	50.00
The Dead Sea	555.00

*Source: Taylor 1993 and * Nicholson & Wooldridge 2003*

Refer to the booklet in this series entitled *Dryland Salinity - Productive Use of Saline Land and Water* for information on the uses of saline water.

Testing soil salinity

An EC meter can be used to test soil salinity in the field or soil samples can be sent to a laboratory for analysis. Field measurements are convenient and cost effective but will not have the accuracy of laboratory analyses, which must be carried out according to scientific standards.

Normally, soil samples are taken from many sites in a paddock and pooled into an aggregate sample. Thus the test results will not provide an accurate estimate of salinity for a particular area within a paddock. When sampling for soil salinity, it is important to sample several locations in and around the edge of the suspect area.

Bare soils on saline sites often have elevated levels of salinity due to evaporation. Soil samples taken from the surface of a bare area will therefore not give a true indication of the surface soil salinity. In such circumstances, 2 - 5cm of soil should be scraped from the surface before collecting a soil sample.

If you are unsure whether salinity is present, take samples from inside and outside the suspect area and compare the test results. If the area is saline, the EC readings inside the area will be higher than readings from outside the area.

Soils are classified as saline when the EC e is greater than 2 dS/m. Sometimes soil salinity test results from a saturated soil extract are reported as EC sat:ext rather than EC e . If the EC is in units other than dS/m, use Table 1 to convert the reading.

***Field method for testing soil* -** To conduct a salinity test in the field using a 1:5 soil extract you will need a transparent plastic screw top container with straight sides. The lower two-thirds of the container should be graduated into six equal parts, leaving the upper third of the container free. A calibrated EC meter and distilled water or rainwater is also required. Calibration can be organised by your local land management agency. The Department of Primary Industries (DPI) sells 'Salt Bags' that contain equipment and instructions for testing soil and water salinity.

- **Step 1**: Take a soil sample from the top 1 - 30 cm of soil (or 5 - 30 cm for bare areas). Collect as many samples as practical. Between 5 – 10 samples should be collected from areas with a similar surface condition. Mix the samples together so that an average soil salinity result is gained from the test.

- **Step 2**: Fill the sample container with the collected soil sample to the first graduation mark. The soil should be tapped down gently but not compacted. Fill the remaining five graduations with distilled water or pure rainwater. Dam or bore water should not be used because the mixing water needs to be free of salts (test the water first if you are unsure of the quality).
- **Step 3**: Screw the lid on tightly and shake the container for at least one minute to ensure the salts are dissolved. If you have time, more shaking will dissolve more salt into the solution (try 1 minute every 10 minutes and repeat three times).
- **Step 4**: Let the solution stand for at least one minute.
- **Step 5**: Take a reading with the EC meter. Convert the measurement into dS/m if needed.
- Step 6: Determine soil texture and apply appropriate texture conversion factor from Table 5 to convert the $EC_{1:5}$ reading to EC_e as shown in the two examples below. The Department of Primary Industries *Salinity Note No. 8 How to Texture Soils and Test for Salinity* provides detailed instructions on how to perform soil texture tests.

Example using the blue 'Hanna DiST 4' meter to measure the salinity of a loam soil

50	**¸ 100 = 0.5**	**x 10**	**= 5**
Salinity meter reading (milliSiemens/meter)	Convert to dS/m (EC 1:5)	Soil factor for loams (from Table 5)	dS/m saturation extract (ECe)

Example using the round 'Eutec ECScan High' meter to measure the salinity of a loam soil

0.5	**x 10**	**= 5**
salinity meter reading already in dS/m(EC 1:5)	Soil factor for loams (from Table 5)	dS/m saturation extract (ECe)

Table 5: Multiplication factors for converting EC 1:5 to Ece .

Soil Field Texture	**Description**	**Conversion Factor**
Sands	Very little or no coherence. Cannot be rolled into a stable ball. Individual sand grains adhere to the fingers.	17
Loams	Can be rolled into a thick thread but will break before it is 3 - 4 mm thick. Soil ball is easy to manipulate and has a smooth spongy feel with no obvious sandiness.	10
Clay Loams	Can be easily rolled to a thread 3 - 4 mm thick but with a number of fractures along the length. Plastic like soil, capable of being moulded into a stable shape.	9
Light Clays	Can be rolled to a thread 3 - 4 mm thick without fractures. Some resistance to rolling out. Plasticity evident, smooth feel.	8
Medium Clays	Handles like plasticine. Forms rods without fractures. Some resistance to ribboning shear. Ribbons to 7.5 cm or more.	7

Source: Slavich & Petterson, 1993.

Soil texture is important for assessing soil salinity because the same amount of salt will be far more toxic to plants in a sandy soil compared to a clay soil. The EC readings from the salinity meter ($EC_{1:5}$) have to be converted into units (EC_e) to take account of the influence of soil texture. EC_e indicates how salinity will affect plant growth.

Interpreting soil salinity results

Table 6 lists common crops and pastures and the soil salinities at which they begin to decline. Refer to the booklet in this series entitled *Dryland Salinity - Productive use of saline land and water* for information on the establishment and management of plants in saline areas.

Table 6: Salinity levels at which production begins to decline.

Salinity tolerance levels - crop species	**Salinity tolerance levels - pasture species**	**Level of soil salinity (ECe) at which plants begin to decline**	**Soil Salinity Class**
Sensitive crops turnip, strawberry, beans, carrot	**Sensitive pastures**	0 - 1 dS/m	0
Moderately sensitive crops potato, grapes, corn, cowpea, linseed	**Moderately sensitive pastures** most clovers, medics,	1 - 2 dS/m	0
Moderately tolerant crops grain sorghum, rice	**Moderately tolerant pastures** lucerne, 'salt tolerant' lucerne, kikuyu, phalaris	2 - 4 dS/m	1
Tolerant crops oats, sorghum, wheat, canola, safflower, soybean, sunflower	**Tolerant pastures** couch, oats, fescue, phalaris, perennial ryegrass, balansa clover, burmuda grass, Pioneer rhodes grass buffel grass	4 - 8 dS/m	2
Very tolerant crops barley, cotton	**Very tolerant pastures** tall wheat grass, dundas wheat grass, puccinellia, palastine, strawberry clover,	8 - 16 dS/m	3
Generally too saline for crops	**Very tolerant pastures (for extreme conditions)** salt bush, blue bush, distichlis	> 16 dS/m	4

Salinity and sodic soils **-** Saline areas should also be checked to see if they are sodic. Sodic soils have excess sodium attached to clay particles, while saline soils have excess sodium salts dissolved in water in the soil. Many soils can be sodic without being saline, however, most saline soils are sodic.

The problems associated with sodic soils occur because these soils disperse when wetted. The free salts in saline soil help to preserve soil structure in a sodic soil, but if the site is dried out and the salts are washed away, a strongly sodic soil will result.

Signs of sodic soils include:

- erosion, high run-off and low infiltration rates, surface ponding & poor aeration;
- severe surface crusting, slaking or collapsible soils;
- sodium (Na) levels greater than 6% of the total cations in a soil test; and
- soils that show cloudiness when dropped into a dish of rainwater (showing dispersion and therefore sodicity).

To test for sodicity, place a small piece of soil into a dish of pure water. Leave undisturbed and check its appearance at 10 minutes and at 2 hours. If the water is cloudy at 10 minutes the soil is highly sodic. If the water is clear at 10 minutes but cloudy at 2 hours the soil is slightly sodic.

The booklet in this series entitled *Dryland Salinity - Productive Use of Saline Land and Water* contains information on saline and sodic soils.

Classification of saline land

As salts build up in the soil, or the period of waterlogging increases, the composition of plant species changes and vigour is reduced and surface soil conditions deteriorate. For simplicity, these changes can be classified according to severity.

Soil salinity classes take account of the landscape features and are ranked in terms of soil salinity (EC_e), which is measured in deciSiemens per metre (dS/m). The EC_e ranges for the five soil salinity classes are listed in Table 7.

Table 7: EC_e Values of soil salinity classes

Class	**Salinity Class**	**EC_e**
Non-saline	0	<2
Slightly saline	1	2-4
Moderately saline	2	4-8
Very saline	3	8-16
Highly saline	4	>16

Source: Taylor 1993

Class 0: Non-saline (0-2 dS/m EC_e) - All land naturally contains some salt. Class 0 sites do not exhibit any signs of salinity and are referred to as non-saline.

Some non-saline areas exhibit mild to severe waterlogging. Mildly waterlogged areas can exhibit good summer growth of pastures due to the high level of soil moisture. Severe waterlogging can cause bare soil, yellowing of crops and pasture and tree death due to excess soil moisture and poor soil aeration.

Even though the soil and water may be non-saline the area can become saline and should be monitored for any early signs of salinity.

Class 1: Slightly Saline (2-4 dS/m EC_e) - Class 1 sites show earliest visible signs of salting and occur where the watertable has started to move salts into the root zone. They have a surface soil electrical conductivity (EC_e) of 2 - 4 deciSiemens per metre.

Plate 1: Class 1 site south west of Cowra showing yellowing of a cereal crop due to water logging & salinity.

A wide range of salt tolerant grasses and legumes can be sown on these sites. It is important to establish these at an early stage to minimise the amount of salt building up on the surface.

The early signs of salinity to look for are:

- new wet patches or boggy areas in paddocks;
- patches of reduced growth and/or yield of crops and pastures, often associated with a slight yellowing of the leaves; and
- patches of salt tolerant species such as Sea Barley Grass *(Hordeum marinum),* Couch *(Cynodon dactylon),* Wimmera Rye Grass *(Lolium rigidum),* Spiny Rush *(Juncus acutus)* or Strawberry Clover *(Trifolium fragiferum)* .

Class 2: Moderately Saline (4-8 dS/m EC^e) - Class 2 moderately saline discharge areas occur where the watertable is at or near the surface for extended periods. These sites have a surface soil electrical conductivity (EC_e) of 4 - 8 deciSiemens per metre.

Plate 2: Class 2 site showing vegetation zoning (spiny rush, couch then sea barley grass), vegetation death and small bare areas.

Class 2 sites have salts concentrated in the root zone and at the soil surface. These sites are suited to highly salt tolerant grasses and shrubs and there is generally a dramatic change in species composition to highly salt tolerant species and the appearance of small, bare areas.

The signs of moderately saline land are:

- extensive loss of pasture/crop species and replacement with Couch (*Cyndon dactylon*), Sea Barley Grass *(Hordeum marinum)* , Annual Beard Grass *(Polypogon monspeliensis),* Curly Rye Grass *(Parapholis incurva)* and Saltmarsh Grass *(Puccinellia stricta)* and a reduction in the vigour of less tolerant species such as Strawberry Clover;
- reduction in crop yields;
- presence of a salt smell;
- occurrence of scattered bare patches which may remain boggy all year;
- appearance of salt crystals on the soil surface when dry;
- bleached appearance of soil surface and clay seals become hard set when dry;
- stock congregate on the site to lick salt from the ground; and
- watercourses and dams lower in the catchment are very clear due to high levels of salinity causing clay particles to flocculate and drop out of suspension.

Class 3: Very Saline (8-16dS/m ECe) and Class 4: Highly Saline (greater than 16dS/m ECe) - Severely affected sites have extensive scalding and salt loving plants (halophytes) are present. The EC_e of topsoil for very saline sites generally exceeds 8 dS/m and is much higher for highly saline sites (30 dS/m is common).

Plate 3: Class 3 site north of Eugowra showing tree decline, scalding, sheet erosion and salt encrustation.

Regeneration of these sites is more difficult and may require some cultivation of the top few centimetres to dilute the salt at the surface. An application of mulch will also provide a less severe environment for germination.

Signs of Class 3 and Class 4 saline land include:

- reduction in yield of very tolerant crops;
- extensive areas of bare ground with salt crystals;
- agronomic species being replaced by salt loving succulents such as Salt Sandspurrey (*Spergularia marina*);
- sheet and gully erosion;
- clear water in seepages; and
- presence of salt smell.

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