Australian Government

National Land & Water Resources Audit

*An initiative of the Australian Government*

# LAND SALINITY

INDICATOR HEADING

## Areas threatened by shallow or rising water tables

INDICATOR PROTOCOL

## Location, size and intensity of salt affected areas

Location, size and intensity of salt affected areas

**Endorsed**

This protocol has been endorsed by the National Land and Water Resources Audit Advisory Council. Version 1.2 – March 2007 – updated November 2007. The indicators will need to be further developed as identified within the protocol.

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# Status of indicator agreement

The National Land & Water Resources Audit (the Audit) coordinates the collation of data to support reporting on natural resource condition required under the National NRM Monitoring and Evaluation Framework (National M&E Framework).

The National M&E Framework identifies three requirements for monitoring natural resource condition:

- a set of resource condition indicators to measure progress toward the agreed national outcomes on a medium and long term basis
- a set of indicators for monitoring community and social processes relevant to or affected by NRM programs, as well as measures of the adoption of sustainable development and production techniques
- contextual data pertinent to the indicator being considered.

The Audit Advisory Council has agreed to a process for achieving a practical set of indicators under the National Monitoring and Evaluation Framework.

This process is to:

- obtain on-going **recommendations** from the relevant **National Coordination Committees** for each thematic area (including "Matters for Target") on appropriate indicators, protocols and information needs
- seek **endorsement** from the **Audit Advisory Council** that the indicators and protocols can be implemented at the national, state / territory and regional levels
- seek **agreement** from the Natural Resource Policies and Programs Committee (**NRPPC)** (or the Marine and Coastal Committee –**MACC-** for Estuarine, Coastal and Marine) that the indicators will be used and promoted by jurisdictions to underpin evaluations of NRM initiatives.

The NRPPC and MACC report to the Natural Resource Management Ministerial Council (NRMMC).

# Indicator Protocol: Location, size and intensity of salt affected areas

## Version:

1.2 – Updated 8th November 2007

It should be noted that this protocol is subject to change due to the evolving needs of users.

## Matter for target:

Land Salinity

## Indicator heading:

Areas threatened by shallow or rising water tables

Indicators addressed under this heading are:

i) Depth to groundwater

ii) Groundwater salinity

iii) Baseflow salinity

iv) Location, size and intensity of salt affected areas

## Indicator name:

Location, size and intensity of salt affected areas

## 1. Definition

A salt affected area refers to any part of the landscape salinised by shallow or rising watertables, and is further described by the severity of any effects.

## 2. Rationale

Salinisation occurs where soils and vegetation are degraded by the discharge and evaporative concentration of saline groundwater. This commences when the watertable either reaches the root zone or where it can be evaporatively concentrated (commonly within two metres of the ground surface). Monitoring the expansion or contraction and intensity of salt-affected areas provides an effective tool for assessing changes in salinity status over time. It can also aid in determining risk and hazard assessment.

# 3. Monitoring Methodology

## 3.1 Monitoring location selection (i.e. scale)

Within the monitoring region, the boundaries of the salt-affected area and their intensities should be accurately described to allow for monitoring through time.

Where practical, the area of the salt-affected land should be measured in hectares and estimated by using one of the measurement techniques listed under the data measurement section.

Where salt-affected areas are small (<1ha), recording the geographic location of the centre of the areas may be more practical, otherwise record the area.

Intensity should be assessed using the following criteria:

1. **Non-saline**: (land not currently affected by shallow or rising watertables) (<2.0dS/m ECe & <0.5 dS/m ECa)
2. **Slightly Saline**: ground surface seasonally damp after extended periods of rain; gradual change in pasture composition with reduced vegetation diversity; dieback in some trees; intermittent streams flow for longer periods. (2.0-4.0 dS/m Ece and 0.5-1.0 dS/m Eca)
3. **Moderately Saline**: ground surface damp for very long periods after extended periods of rain; change in pasture composition to dominance by salt-tolerant species including salt tolerant grasses; dieback in most trees; stock may be observed congregating in the area and licking the ground; intermittent streams evolve to permanent streams; rising damp in buildings; some deterioration of road conditions. (4.0 – 8.0 dS/m ECe and 1.0 – 1.5 dS/m Eca)
4. **Severely Saline**: ground surface waterlogged or permanently moist; only salt-tolerant vegetation, such as samphires present; all trees dead; areas of bare soil with salt crusts; degradation of soil structure with subsequent soil erosion; rising damp and salt efflorescences in buildings; major deterioration and crumbling of roads. (>8.0 dS/m Ece and >1.5 dS/m Eca)

## 3.2 Monitoring frequency required

The location, size and intensity of salt affected areas should be benchmarked and then reassessed every five to ten years. This will be dependent on, for example, the size of the system, land management, land use change and rainfall.

The frequency of monitoring will be dependent on the variability at the sites and the technology used to map and monitor.

Specific sites may require more frequent monitoring.

## 3.3 Data measurement method

There are various methods to determine areas of salt affected land depending on scale (including air photo interpretation, on-ground resource assessment etc.). These need to be interpreted in accordance with nationally agreed classification of intensity classes.

A number of methods may be employed. The most appropriate method will depend on the individual circumstances, in particular, the scale of the outbreak, capacity of the individuals involved and technology available. A combination of methods generally provides the most confidence in results. In general, airborne surveys may be the most cost effective over larger areas, but all methods will require adequate ground truthing.

Each state or territory should select surface salinity intensity monitoring areas. These areas should be broadly representative of the groundwater flow systems, landforms, geology and land-uses in the various regions where secondary salinity is significant.

The following methods may be employed (Spies and Woodgate 2005):

- Electromagnetic surveys

Bulk conductivity is measured in the field with hand-held or vehicle mounted electromagnetic induction instruments (EM31, EM34, EM38). Surveys are conducted along surveyed traverses or a surveyed grid. An airborne electromagnetic survey offers rapid, accurate coverage of large areas with locations of salt stores and conduits for possible transport of salt, to depths greater than 100 metres below ground surface.

Both ground-based and airborne EM surveys need to be calibrated against down-hole EM39 induction conductivity logs. This requires drilling of dedicated boreholes which could be converted to monitoring bores.

EM maps bulk conductivity, not salinity; therefore all EM surveys need to be calibrated to the actual measure of soil salinity.

- Aerial photographs and satellite imagery

The expansion or contraction of salt-affected areas in the landscape can be recorded by plotting visibly affected land and vegetation on successive air photos (Coram et al. 2001).

Satellite imagery using several bandwidths and wavelengths can be combined with other spatial information to map salinity outbreaks but the satellite record is much shorter than that for air photos.

- On-ground resource assessment

On-ground resource assessment could involve a visual assessment or more detailed analysis involving soil sampling and/or vegetation analysis. Salinity analysis of soil samples should be reported as $EC_{1-5}$ in dS/m.

On-ground resource assessment would also be required to calibrate and/or ground truth remote sensing methods.

Nationally agreed descriptions of soil characteristics need to be utilised (http://www.clw.csiro.au/aclep/)

## 3.4 Data collation/calculation method

The following information on the location, size and intensity of salt affected areas should be recorded according to national standards:

Protocol data collations should include:

- boundaries (or location and size) of salt affected areas;
- intensity of the salt affected areas;
- survey technique and metadata.

## 3.5 Data storage and management

Data storage and management for this indicator should be in accordance with the Australian Soil Resource Information System (ASRIS) and the Australian Collaborative Land Evaluation Program (ACLEP).

Each jurisdiction needs to have a database containing the location, size and intensity of salt affected land.

## 3.6 Data analysis and interpretation

Analysis:

- Total area of salinity (ha)
- Measurable change in area over time (change in ha/time period)
- Area by intensity class (ha/severity class)
- Comparison to other contextual data

Interpretation:

- Risk assessment, to determine the impact of salinity and the likelihood of salinity occurring at a specific time which should be based on the Australian and New Zealand Risk Management Standard AS/NZS 4360:2004 (Spies and Woodgate 2005)
- Conceptual models can be derived from the comparison of relevant contextual datasets (for example climatic and hydrogeologic data)

Where short-term information is considered, it should be viewed in the context of longer-term regional trends. Care should be taken to separate short- to medium-term changes in area in response to intervention activities from changes resulting from short- to medium-term fluctuations in climate.

Useful contextual data to support analysis and interpretation:

- Climatic (rainfall and evaporation);
- Land use and management (historical and current);
- Vegetation type and extent;
- Geomorphic position of outbreak (landform pattern and element/morphological type);
- Topographic and drainage patterns;
- Geologic and geophysical (basement rock and regolith characteristics);
- Soils;
- Hydrogeologic (groundwater flow system present, groundwater depth, trends and quality).

**Product:**
Ground-based EM (electromagnetic) mapping is repeated (~ ten years apart) within a saline sub-catchment to quantify the change in extent and severity of land salinity. Done in conjunction with air photo interpretation, soil sampling and analysis of piezometer data (if available). As a general guide, apparent EC values (ECa, as used in the legends of Figures 13 and 14 from SA Indicator Trials Report) up to 0.5 dS/m indicate soils with very little salt content. Where ECa values exceed 1.0 dS/m, there is substantial salt storage in the soil profile and salt will impact on plant growth and yield. Other composite time-series products may include EM maps superimposed on air photos (Figure 20 from SA Indicator Trials Report). Appropriate use of colours allows visual comparison of any obvious spread or contraction of land salinity, and gives an indication of the intensity of land salinity at the site.

- Choose saline sub-catchment areas (ranges from 100 ha to 400 ha in SA) representative of state GFS. Ideally, piezometer network is also present. Can then cautiously upscale to regional and state level if trends are apparent.

**EM mapping**

- Geonics EM 31& 38 meters used, mounted on or towed behind ground vehicle. Commercial surveys are carried out using a grid spacing of 10m or more at an average speed of 10 – 15 km/hr.
- For repeat surveys, seasonal variables need to be measured during each survey to correct for conductivity changes due to differences in soil moisture and temperature. Repeat surveys should follow the same path.
- Geographic coordinates of EM readings can be recorded with a differential GPS (record in GDA 94, current map grid of Australia).
- Maps of both surveys are produced in ArcGIS or similar. Ha change for different ranges (severity) are calculated for the two time periods, and % change in extent (for a particular severity) is calculated.

**Soil sampling**

- EM readings are "apparent conductivity" (ECa recorded in dS/m), must be ground-truthed by using soil samples from pits, cores or augered holes.
- Number of sample points for ground-truthing (soil testing) depends on the desired accuracy and the variability of the soil as shown by the EM survey. One sample point per 2 ha may be necessary, and sample to depth according to the type of EM meter used, and the mode in which it is employed.

**Air photo interpretation**

- Air photos covering the same time period/same season are sourced, high resolution at 800 dpi where possible. Area of salt-affected land in each is compared using either manual or digital methods. Change in area is compared to EM results.

**Piezometer data**

- Time series data from piezometer networks, along with residual rainfall information, is assessed (HARTT) to determine any depth to groundwater trends. These results are consulted when interpreting the EM maps.

## 3.7 Reliability, validity and quality assurance

A statement of methodology and reliability needs to accompany all data and products. For example:

- Provide a statement of confidence between modeled and measured data
- Identify level of confidence for derived products
- Caveats will be required to identify the limitations to data extrapolation, interpretations or use of methods, and
- The scale and resolution of any mapping should be identified

### 3.8 Metadata

The metadata statement should be consistent with AS/NZS ISO 19105 standards (http://www.saiglobal.com/shop/Script/Details.asp?DocN=AS788380765825).

# 4. Reporting / Information Products

## 4.1 Audiences

Natural resource managers at all levels are demanding consistency between related datasets and seamless datasets providing uniform and standardised descriptions of similar features in order that the feature is defined or classified the same way across Australia.

The audience for information products derived from the use of this indicator include:

- National and state policy makers
- Natural resource managers
- Industry
- General public

National/state policy makers and regional natural resource managers are the primary audience for Information products derived from the use of this indicator. The specific information needs and the scale of data required will vary depending on context; national scale data may or may not be useful for targeting on-ground management action. Smaller scale data may be needed to be used effectively in the NRM regions.

## 4.2 Products

Spatial data and information products such as maps need to comply with the Natural Resources Information Management Toolkit guidelines, particularly the map production guidelines (http://www.nlwra.gov.au/toolkit/index.html)

### 4.2a Example information products for this indicator include:

- Maps showing location and size of salt affected areas
- Maps showing classes of intensity
- Maps/graphs/pie charts identifying trends

Examples under development.

### 4.2b With contextual information, other products could include:

- Trend analysis
- AEM maps
- Description of conceptual models for salinity processes
- Statement of variability in salinity processes causing land salinisation
- Reports of current impact of salinity

Examples under development.

## 4.3 Confidentiality

Maintaining confidentiality of data will be the responsibility of the custodian of the data e.g. the relevant management authority at State/territory level responsible for monitoring and reporting salinity information.

## 4.4 Data collation/calculation method

Refer section 3.6.

### 4.5 Data analysis, integration and interpretation information

For interpreted products specify methodology, assumptions and additional data.

### 4.6 Data access and storage

Data access arrangements need to be developed with various stakeholders and may influence data confidentiality (refer section 4.3).

### 4.7 Product definition statement

A statement should accompany all products derived from the use of this indicator, and should contain the following:

- Type of product, including product description
- Why and when the product was produced
- Product contents

## 5. Implications of proposed indicators and data collection/reporting with respect to existing activities

To be advised.

## 6. Future development

It is unlikely that the indicator will need to be reviewed in the future. It is highly likely the protocol will need revision as new mapping technologies and understanding of salinity processes are developed.

## 7. Links to other indicators

This indicator is related to:

- Depth to groundwater
- Groundwater salinity

## 8. Further information

Allan M J 1996. *Method of assessing dryland salinity in Victoria*. Centre for Land Protection Research, Technical Report No. 34. Department of Natural Resources and Environment, Victoria.

Commonwealth of Australia 2003. *Natural Resource Information Management Toolkit: building capacity to implement natural resource information management solutions*. Canberra.

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*Systems Contributing to Dryland Salinity*. A Bureau of Rural Sciences Project for the National Land and Water Resources Audit's Dryland Salinity Theme.

Coram J.E. (ed.) 1998, *National Classification of Catchments for land and river salinity control*, RIRDC Publication No. 98/78, Rural Industries Research and Development Corporation, Canberra.

Department of Natural Resources and Energy (DNRE) ,2001, *Victorian Catchment Indicators 2001 Our commitment to reporting on catchment condition*, DNRE, Victoria.

Hocking, M., Bastick, C., Dyson, P. and Lynch, S. 2005*. Understanding Groundwater Flow Systems and processes causing salinity in the Northern Midlands* National Action Plan for Salinity and Water Quality Report published by NRM North and NRM South, Tasmania.

National Land and Water Resources Audit (NLWRA) 2000, *Australian Water Resources Assessment 2000,* NLWRA, Canberra.

Robins L. 2004, *Dryland Salinity and catchment management – a resource directory and action manual for catchment managers*. National Dryland Salinity Program, Land and Water Australia, Canberra. ISBN 1 920 860 22 3

Speight, J.G. (1974) A parametric approach to landform regions. Inst. Brit. Geography Special Publication. No. 7. Pp. 213-230

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# 9. Glossary

| | |
|---|---|
| DEM | Digital Elevation Model (DEM). A digital file consisting of terrain elevations for ground positions at regularly spaced intervals. |
| Differential GPS | A technique to improve the accuracy of GPS elevation measurements. Differential GPS requires at least two GPS receivers within the same general geographic area. |
| ECa | Apparent electrical conductivity of bulk soil |
| ECe | Electrical conductivity of an extract of saturated soil paste |
| $EC_{1.5}$ | Electrical conductivity of a mixture of 1 part by weight (g) dried soil to 5 parts by volume (ml) distilled water |
| EM | (31, 34 and 38) Electromagnetic induction equipment used to measure the soils electrical conductivity |
| GPS | Global Positioning System (GPS) is a worldwide satellite navigation system. GPS satellites transmit specially coded signals which are processed by a GPS receiver that computes accurate measurements of position on the Earth's surface. |
| Hydrograph | A graph that shows the elevation of groundwater as a function of time |
| Landform pattern/elements | Morphological types – landscape classifications and descriptions from the Australian Soil and Land Survey Field Handbook based on the formal definitions by Speight (1974) |
| Photogrammetry | The science of mensuration and geometric adjustment of an aerial photograph or satellite image to derive elevations or contours by imagery correction. |