ASSESSMENT OF SALINITY RISK IN THE WEST WIMMERA

NOVEMBER 1998

CENTRE FOR LAND PROTECTION RESEARCH

Technical Report No. 46

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ISBN 0 7311 4241 1

ISSN 1038-216X

Department of Natural Resources & Environment

Hocking, Mark, 1973 -.
Assessment of salinity risk in the West Wimmera.

Bibliograph.

ISBN 0 7311 4241 1.

Hydrogeology - Victoria - Wimmera River Watershed. 2. Salinization - Victoria - Wimmera river Watershed. 3. Wimmera River Watershed (Vic). I. Victoria. Dept. of Natural Resources and Environment. II. Centre for Land Protection Research (Vic). III. Title. (Series: Technical report (Centre for Land Protection Research (Vic)) ; no. 46).

551.483099459

Centre for Land Protection Research

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November 1998

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ABSTRACT

The West Wimmera region is characterised by terminal freshwater and saline wetland lakes and poor surface water drainage. Three main aquifers occupy the West Wimmera. The uppermost is highly saline (Parilla Sand Aquifer) and is underlain by a fresh water aquifer (Murray Group Limestone Aquifer), which in turn, underlain by a poorer quality aquifer (Renmark Group Aquifer).

Land salinisation is more common in the south-west of the region, particularly where the Parilla Sand Aquifer intersects the ground surface. Salt scalds are becoming increasingly apparent in drainage depressions where salt accumulates due to poor drainage characteristics. Localised salinity occurs at the base of stranded beach ridges and is attributed to saline water discharging at the break of slope in the landscape.

1 INTRODUCTION

There has to date been little salinity related hydrogeological research undertaken in the West Wimmera. The aim of this report is to provide a preliminary insight into the complex salinity processes of the region and is a follow-on report from Hocking (1997). The Centre for Land Protection Research (CLPR), has undertaken this work as part of project R219: Hydrogeological research and investigation in support of the Wimmera Salinity Management Plan (WSMP).

The West Wimmera region falls mainly into the Millicent Coast Basin drainage division in Victoria. The location of the West Wimmera region is presented in Figure 1.

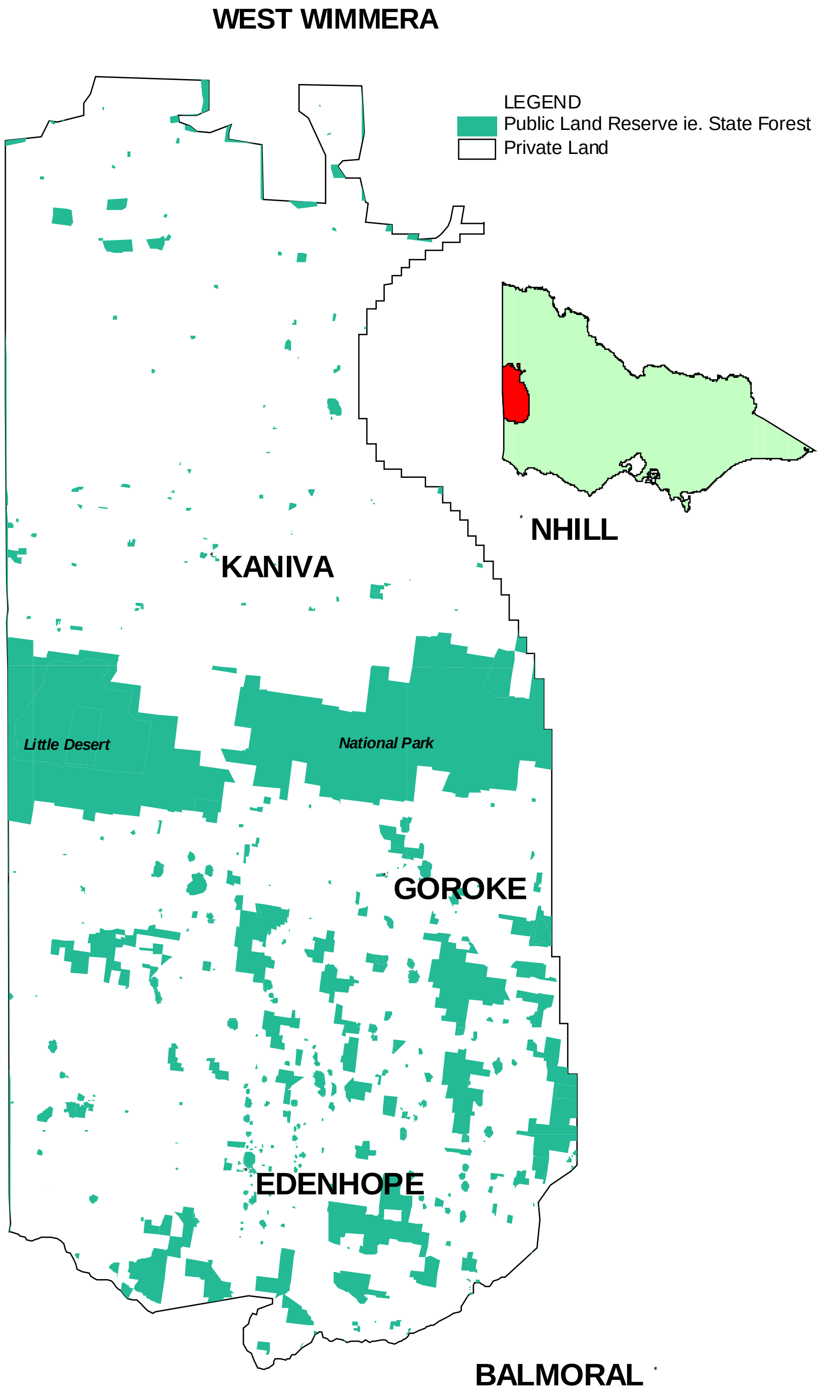

Figure 1 Location of the West Wimmera Region.

2 SALINITY CAUSING MECHANISMS - GENERAL

Salinity mechanisms in the West Wimmera are varied. Salinity occurrence is influenced by regional and local groundwater processes as well as long periods of waterlogging or inundation.

2.1 Regional Groundwater Discharge

The Parilla Sand Aquifer is one of the most well known saline aquifer in Victoria. This aquifer is generally the uppermost saturated geological unit in the West Wimmera (refer to section 6) and contributes significant salt loads to the southern waterways of the region (Figure 2).

Figure 2 Waterway affected by salinity in the southern region.

2.2 Local Groundwater Discharge

Land affected by salt at the base of stranded beach ridges is associated with local groundwater processes. This is a common occurrence both north and south of the Little Desert National Park where the soils are relatively porous, allowing significant volumes of rainfall to infiltrate. Following the infiltration of water into the soil, water flow can occur in two general directions: laterally and/or vertically. Infiltration water usually travels vertically, unless an impermeable layer restricts this movement, thus causing it to flow laterally. This is the case with stranded beach ridges, where the layered sediments restrict the vertical movement of water, hence causing most water to ultimately move laterally and discharge at the base of the slope.

2.3 Waterlogging

Waterlogging is a salinity process that previously has not been considered a significant process in land salinisation in the West Wimmera. Areas that are affected by waterlogging generally occur in the southern region of the West Wimmera, which is characterised by high rainfall and heavy clays (Figure 3).

Figure 3 Heavy clays combined with low water usage has led to the establishment of spiny rush.

Waterlogging by definition is a seasonally perched watertable that is at ground surface level. Waterlogged areas in the West Wimmera have become more apparent over the past fifteen years. Many of these waterlogged sites may have once been perennial swamps or lakes before drainage and clearing of these sites occurred.

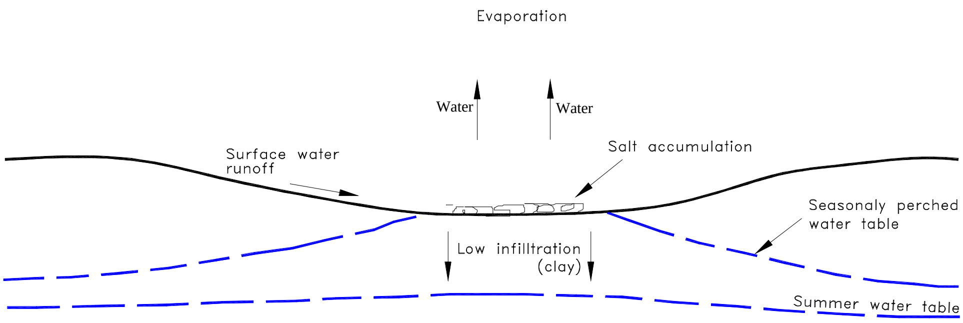

Figure 4 The process of salt accumulation in waterlogged areas.

Waterlogging induced salinisation occurs by the gradual accumulation of salt in low lying areas with poor surface and subsurface drainage (Figure 4).

3 CLIMATE

The climate of the West Wimmera varies markedly from north to south. Annual rainfall ranges from 576 mm at Edenhope to 364 mm at Telopea Downs in the north (Table 1). The occurrence of rainfall is greatest around the winter/spring period. For a more detailed description of climatic characteristics in the West Wimmera, refer to Baxter et al. (1997).

Table 1 Average annual rainfall for areas in the West Wimmera (source; Bureau of Meteorology, 1997).

Location	**Average annual rainfall (mm)**
Edenhope	576
Goroke	525
Kaniva	462
Serviceton	497
Telopea	364

4 GEOMORPHOLOGY

The Millicent Coast Basin falls into the geomorphic division known as the Murray Basin Plain. The Kanawinka Fault divides the Murray Basin Plain and the Otway Basin Plain. The depositional environment of the sedimentary sequence of the region has determined many landforms that can be observed. A detailed review of the geology in the area is provided in Ludbrook (1971) and Brown (1989).

Tertiary and Quaternary age (65 million years ago - present) features of the Murray Basin comprise the relatively low relief undulating landscape that can be observed today.

The majority of the current landscape geology has been influenced by aeolian and marine processes with some surficial geomorphic features evident. Remnant strandline Parilla Sand ridges (10 - 30 metres) high form the most prominent relief in the basin. Overlying the Parilla Sand, the east - west trending surfical Lowan Sand has been derived by the aeolian reworking of the Parilla Sand, forming sand dunes and plains. Distributed irregularly within the inter-dune corridors, the fluvio - lacustrine clays of the Shepparton Formation can be up to 20 metres thick (Stadter & Stewart, 1990) where swamps occur.

5 HYDROLOGY

The varying sea levels of the Tertiary period have influenced the surface hydrology of the study area. The southern region of the Millicent Basin contains the majority of hydrologic features. This is attributed to high regional groundwater levels and high rainfall relative to those experienced in the north of the West Wimmera.

The majority of terminal waterways in the area trend from south east to north west. They form many swamps, sink holes and permanent and intermittent lakes. Water in these depressions either infiltrates into the underlying aquifer or is removed by evaporation, depending on the recharge characteristics of the soil (Stadter & Stewart, 1990).

Poor surface drainage combined with low recharge and high evaporation rates, leads to salt accumulating in topographically low areas. This process is not the same as groundwater discharge. Hocking (1995) studied stream salinities of the Mosquito Creek, south of Edenhope and concluded that the majority of saline surface water originated from groundwater discharge occurring from the Parilla Sand Aquifer.

The relatively ill-defined drainage networks of the West Wimmera result in considerable ponding of water on what may have once been swamp land. Management of surface water drainage is an issue throughout the region as the water generally terminates in poorly drained low lying areas (Figure 5).

Figure 5 Ill-defined surface drainage causing water ponding.

A number of wetlands in the West Wimmera have high nutrient loads, which sometimes results in algae blooms. This issue is, however, outside the scope of this report.

6 HYDROGEOLOGY

6.1 Background

The Victorian - South Australian border has a buffer of land 20 km wide in both states known as the Border Zone (Figure 6). The Border Zone has been established to avoid any deleterious effects occasioned by present and future large-scale groundwater withdrawals along the state borders of South Australia and Victoria (Stadter & Stewart, 1990). A number of different hydrogeological investigations have been undertaken within this zone, for example Stadter & Stewart (1990), Bradley, et al. (1995), Sibenaler & Stadter (1989), Dudding (1990). Some specific hydrogeological assumptions of this section rely on information deduced from these Border Zone projects.

In descending order, from shallow to deep, the three main aquifers that comprise the Millicent Basin are; (i) the Pliocene Sands Aquifer (Parilla Sand of the Murray Basin), (ii) the mid to late Tertiary Limestone Aquifer (Murray Group Limestone Aquifer of the Murray Basin) and (iii) the lower Tertiary Sand Aquifer (Renmark Group of the Murray Basin). The regional groundwater flow direction in these aquifers is generally to the north north west.

6.2 Renmark Group

6.2.1 Groundwater Depth, Quality and Quantity

Currently, the Renmark Group is not regarded as an important groundwater resource because good quantities of generally better quality water is available in the overlying Murray Group Limestone Aquifer (Bradley, et. al., 1995). It is also less developed as a groundwater resource because of the high drilling and pumping costs associated with the greater depth. As a consequence hydraulic data for this aquifer is sparse.

Bradley et al (1995) suggests the Renmark Group Aquifer can provide an alternate groundwater resource to that of the Murray Group Limestone Aquifer as it is of useable water quality and yield.

6.2.2 Recharge and Discharge Processes

Recharge to the Renmark Group Aquifer is believed to occur along a wide strip from east Kaniva across to the Wimmera Trench. Downward leakage of groundwater to the Renmark Group is restricted by the Ettrick Formation and Geera Clay. Together, the Ettrick Formation, Geera Clay and a low hydraulic gradient limit the amount of recharge into the Renmark Group Aquifer. There have been no investigations into inter-aquifer leakage into the Renmark Group. Assessments of inter-aquifer leakage are likely to be provided in the next five year technical work plan of the Victorian-South Australian Border Zone Agreement.

An almost continuous layer of Ettrick Marl acts as an aquitard between the Renmark Group and Murray Group Limestone Aquifers in the West Wimmera.

6.2.3 Groundwater Trends

The South Australian Border Agreement Zone Review Committee have recognised the potential of this aquifer for irrigation and initiated some water chemistry monitoring programs to enable the assessment of the Renmark Group Aquifer (Bradley, et al. 1995). Currently, little groundwater information has been presented in relation to salinity or water level trends in the Renmark Group Aquifer.

6.3 Murray Group Limestone

6.3.1 Groundwater Depth, Quality and Quantity

Without doubt the Murray Group Limestone is the most valuable groundwater resource within the West Wimmera. The relatively shallow depth of this aquifer allows economical groundwater extraction. Yields are relatively high and salinity is low. The potentiometric surface of the Murray Group Limestone ranges between approximately 60 and 90 metres above sea level throughout the area and decreases in a north westerly direction.

Excessive groundwater pumping can induce lateral and/or vertical migration of higher salinity water into the pumped aquifer (Bradley et al. 1995). Dudding (1990) suggests that the most sensitive parameter controlling groundwater salinity changes is the volume of groundwater extraction. A permissible annual volume increase of five times would increase groundwater salinity by one or two fold over 100 years, with a linear rise after the first ten years of pumping (Dudding, 1990). Zones 4B, 5B and 6B (refer to Figure 6) already show an increase in groundwater salinity ranging from 3 to 150 ppm/annum (Bradley et al. 1995). However, this is associated with rising groundwater levels and/or the recent clearance of native vegetation.

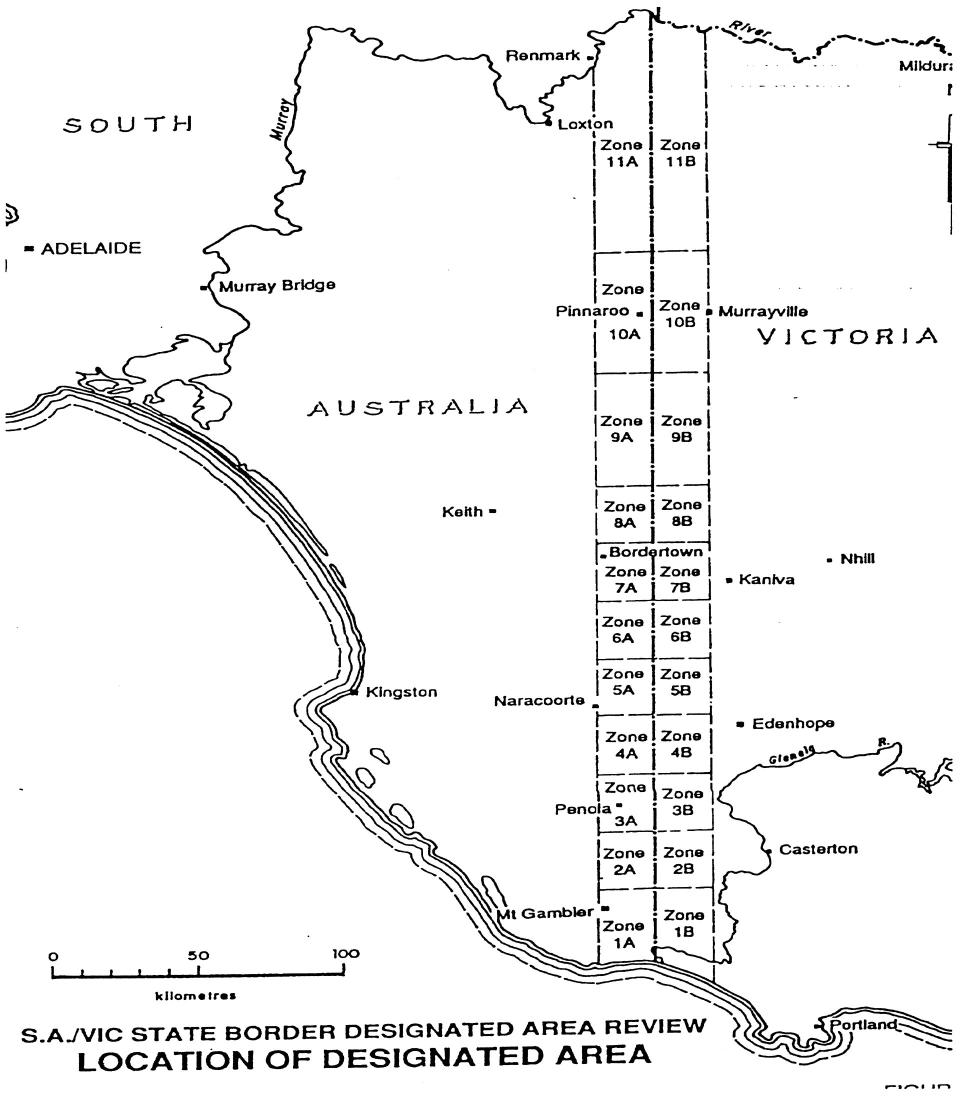

Figure 6 Location of South Australian/Victoria border zones (Source; Bradley et al. 1995).

6.3.2 Recharge and Discharge Processes

Recharge to the Murray Group Limestone occurs by two general processes: point source and diffuse recharge. Point source recharge in the West Wimmera occurs in few areas and is more common to the west. Where the aquifer is unconfined to semi-unconfined, the diffuse recharge is derived from rainfall. Where the aquifer is confined, the recharge occurs via downward leakage through the overlying Parilla Sand Aquifer.

Overlying the Murray Group Limestone Aquifer, the Bookpurnong Beds fossiliferous clays act as an aquitard between it and the overlying Parilla Sand Aquifer. The distribution and thickness of the Bookpurnong Beds varies in the Millicent Basin (Bradley et at. 1995), allowing potential for some downward leakage from the Parilla Sand Aquifer into the Murray Group Limestone Aquifer.

6.3.3 Groundwater Trends

Within the South Australian - Victorian Border Groundwater Zone, the permissible average annual rate of decline of the potentiometric surface has been determined to be no greater than 0.05 metres for all zones (Bradley et al. 1995). Currently, water level data suggests the potentiometric surface is relatively stable.

6.4 Parilla Sand Aquifer

6.4.1 Groundwater Quality and Quantity

The Parilla Sand Aquifer is the uppermost saturated layer within the majority of the West Wimmera. Groundwater quality is the greatest restraint to utilising this aquifer. Aquifer salinities increase, moving east to west, from approximately 700 µS/cm to 18 000 µS/cm. The Parilla Sand Aquifer is believed to be the most significant contributor to land salinisation in the Millicent Basin, particularly in the south-west. Consequently, this aquifer should be targeted as a high priority in the control of salinity in the Millicent Basin

6.4.2 Recharge and Discharge Processes

Recharge to the Pliocene Sand Aquifer is mostly a regional process, with some local or point sources. Point sources of recharge include perched lake systems (Figure 7) and the seasonal recharge of groundwater discharge lakes. In general, the watertable is relatively flat and discharge occurs where the ground surface intersects the watertable.

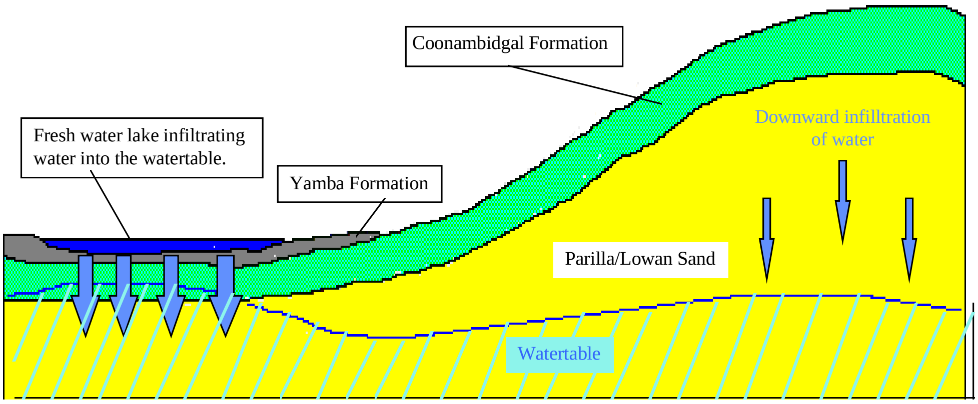

Figure 7 Conceptual model of a fresh water lake recharging and perching the regional watertable.

The Quaternary aged Woorinen and Shepparton Formations act as aquitards between the Parilla Sand Aquifer and the more recent overlying sediments.

The depth to the Parilla Sands Aquifer is greatest in the east and decreases to the west, where the shallowest watertables occur, south of Edenhope.

The Parilla Sand Aquifer is only saturated in the eastern and central parts of the Millicent Basin. and gradually decreases in water level initial unsaturation to the western side of the Victorian component of the basin.

The aquifer is also saturated in the Otway - Murray Basin divide, where the depth to watertable is shallowest in the basin. Ferruginisation of the Parilla and Lowan Sands has led to some localised watertable perching.

6.4.3 Groundwater Trends

Water level information within the study area, particularly in the Edenhope region of the basin, suggests a rising watertable. Hocking (1996) analysed a 'representative' piezometer in the area which averaged a rise of 4 cm/year for the past fifteen years. Basin wide data reveals a slight rise in groundwater levels in the Parilla Sand Aquifer.

6.5 Stranded Beach Ridge Aquifers

6.5.1 Groundwater Quality and Quantity

The localised nature and interbedded calcareous stratifications of these shallow aquifers are consistent with the observed extremely low aquifer yields and relatively high groundwater salinities (about 16 000 μS/cm). Consequently, the aquifers are of little use for groundwater extraction purposes. They are however, a significant contributor to land salinisation and should be targeted as a high priority for salinity control.

6.5.2 Recharge and Discharge Processes

The stranded beach ridges aquifers are local groundwater systems. Recharge occurs by infiltration of rain water on the ridge tops and slopes, and discharge occurs at the base of the ridges.

6.5.3 Groundwater Trends

There are no known piezometers monitoring groundwater water levels in this aquifer due to it being saturated seasonally rather than perennially. Anecdotal evidence suggests aquifer saturation frequency has increased, as areas of discharge have increased over the past ten to fifteen years. The increase in salinity is more than likely associated with the clearing of native vegetation and the establishment of annual pastures and crop systems.

7 CONCLUSIONS

The regional Parilla Sand Aquifer, the localised Stranded Beach Ridge Aquifers and surface water processes influence salinisation in the West Wimmera. The current mapping of salt affected vegetation by the Department of Natural Resources and Environment should assist in understanding the localised salinity causing mechanisms, and in determining areas of the landscape most likely to be affected by salinity.

Monitoring of bores in the Parilla Sand Aquifer indicates a slightly rising regional watertable trend, which jeopardises a significant area of land in the south-west of the West Wimmera. The extent of the area at risk is not yet certain due to the complex interaction of wetlands with the regional watertable. In addition to causing further land salinisation, continued increases in water level in the Parilla Sand Aquifer will ultimately increase the amount of saline groundwater recharging the Murray Group Limestone Aquifer.

8 RECOMMENDATIONS

The following recommendations have been made on the basis of the information presented in this report.

The West Wimmera Region community develop its own salinity management plan, separate to that of the Wimmera Salinity Management Plan.

Further groundwater drilling be carried out, with an emphasis on monitoring the Parilla Sand Aquifer water levels and groundwater interactions with swamps and saline lakes.

Groundwater monitoring be conducted at a minimum of quarterly intervals. This monitoring can be used to monitor the effectiveness of salinity control in the West Wimmera.

Alternative farming practices be investigated, with a view to maximising water use for salinity control purposes.

Representative swamps in the region be monitored to detect any water quality or ecological change.

9 ACKNOWLEDGEMENTS

The author would like to thank the following people for assistance in the production of this report.

Bernie Dunn (formerly NRE, Edenhope), Julie Gequillana (CLPR, Bendigo) and Rob Clark (CLPR, Bendigo). A special thanks to Mark Reid (CLPR, Bendigo) for editing this report.

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