MALLEE CATCHMENT
TECHNICAL BULLETIN

Technical Bulletin #33

Dryland Salinity Drivers and Processes

Above: Primary salinity at Cowangie. Photo: Vincent Grinter.

Dryland salinity is a significant land management issue in the Mallee region. This technical bulletin outlines the drivers and processes behind dryland salinity in the Mallee Catchment Management Authority (CMA) region.

Groundwater recharge is a natural process where water moves downward from the surface to the groundwater table. Also known as root zone drainage, the movement of water beyond the plant root zone means that it can no longer be lost to the atmosphere by evapotranspiration (the combination of evaporation of water to the air and transpiration of water by plants). Land use is the primary factor that influences groundwater recharge. Native Mallee vegetation is very efficient at maximising the use of the available water in the root zone, such that there is little root zone drainage. As a consequence, groundwater recharge under native Mallee vegetation is very low and estimated to be around 0.1-0.3 mm per year (Cook *et al* 2001).

Changes in land use can lead to increased root zone drainage. For example, under

At a glance

- Dryland salinity is a significant land management issue in the Mallee region. The basic drivers and processes that cause dryland salinity in the Mallee are well known;
- Clearing native Mallee vegetation to establish dryland agriculture has resulted in additional groundwater recharge;
- Rising groundwater, which is naturally saline, has led to additional areas of land being affected by saline groundwater discharging at the surface. This has also led to an increased salt load to the Murray River.

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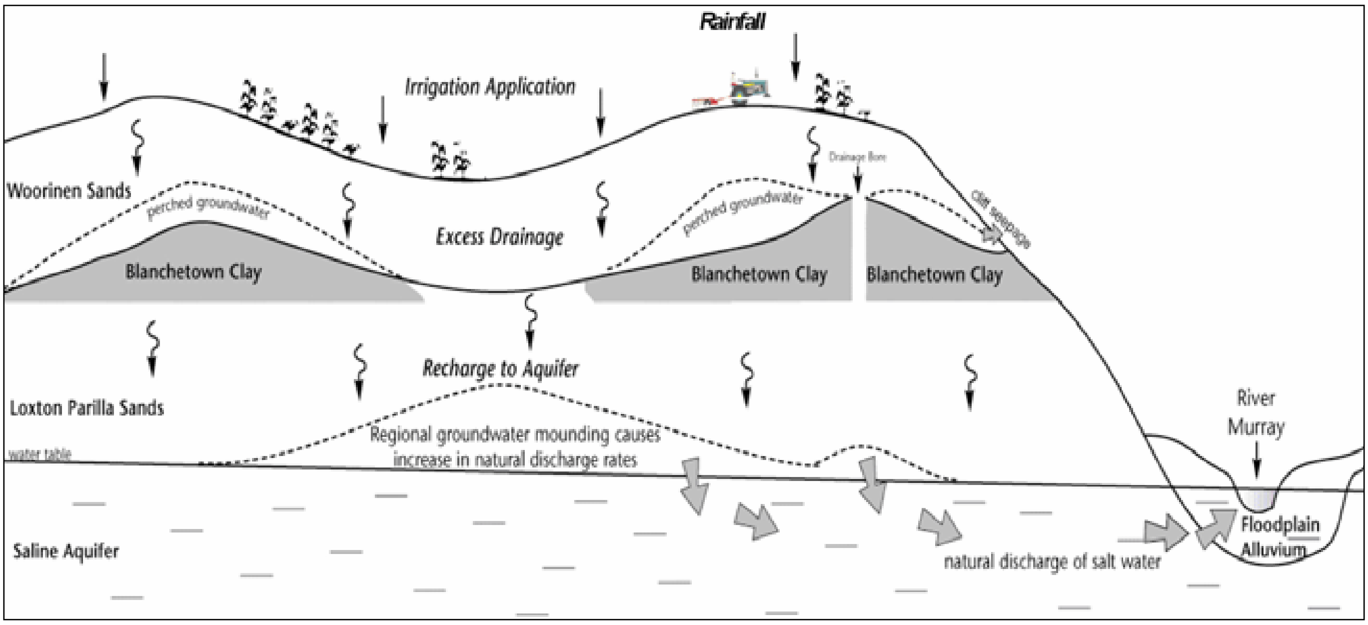

Figure 1. Model of salinisation processes in the Mallee (Miles et al., 2001)

dryland agriculture, deep-rooted perennial native vegetation is replaced with shallow-rooted annual crops which use considerably less soil water. The water that crops do not use drains from the root zone and contributes to increased recharge (Wang *et al* 2005).

The area between the root zone and the groundwater table/aquifer is the unsaturated zone. Water must percolate across the unsaturated zone before it enters the watertable and becomes groundwater recharge. How long water takes to cross the unsaturated zone depends on the depth of the water table (i.e. the thickness of the unsaturated zone) and the hydraulic properties of the unsaturated zone. For example, clay layers impede the movement of water. The Blanchetown Clay (Figure 1) in the Mallee acts as a regional aquitard (a confining or impermeable layer) (SKM and AWE, 2003). This results in a perched aquifer occurring in the sandy soils of the Woorinen formation, overlying the Blanchetown clay (Figure 1).

Within the Victorian Mallee, the Parilla Sands aquifer, being the upper-most aquifer, is most relevant to land management. This aquifer is highly saline and is the shallowest of the regional aquifers. Groundwater recharge is the key process that affects salt mobilisation and salt accumulation in the dryland farming area (Macumber 1991).

Water that drains past the root zone can later discharge at the surface through a rising watertable, or water may move laterally and discharge at the surface before it enters the water table (e.g. as cliff seepage) (see Figure 1). Groundwater discharge in the Mallee is manifested in several ways, including:

- More extensive areas of waterlogged and salinised land in low lying areas or dune swales;
- Groundwater seepage onto floodplains or salinas that concentrate through the processes of capillary rise and evapotranspiration;
- Additional flow to inland surface water features such as saline wetlands;
- Additional flow to the Murray River (Macumber 1991).

These discharge processes occur over a long timeframe and may occur some distance from the source of recharge. There are many examples of natural discharge basins throughout the Mallee, including Raak Plains, Lake Tyrrell and Pink Lakes (Macumber 1991). However, the largest discharge feature in the Mallee region is the Murray River, which eventually receives most of the salt moving down-basin via the regional groundwater systems (Macumber 1990).

Why is the Mallee susceptible to land salinisation?

Saline groundwater discharge sites and saline wetlands are a natural feature of the Mallee landscape. The Mallee CMA region contains around 142,200 ha of saline land (about 3.8 percent of the Mallee region) (Figure 2). Most of this land (86,278ha) is classified as primary salinity or naturally occurring groundwater discharge zones (Grinter and Mock 2009). The expression of salinity in the Mallee landscape is associated with the geomorphologic evolution of the lower Murray Darling Basin (Bowler et al 2006). The many saline wetlands that occur in the region formed during the final drying phases of the ancient Lake Bungunnia about two million years ago (Stephenson 1986). These wetlands or salt lakes mostly exist in low lying parts of the landscape. Figure 2 shows the current distribution of saline wetlands overlayed on the prehistoric location of Lake Bungunnia. These systems act as regional discharge zones and expand and shrink as groundwater levels fluctuate (Macumber 1980).

Changes in land use have caused an estimated additional 55,928 ha to become saline, as highlighted in red (induced) in Figure 2 (Grinter and Mock 2009). Secondary salinity, or induced salinity, is generally associated with primary saline discharge zones expanding and salt pans forming in low lying landscapes such as dune swales. Examples of secondary salinity can be observed in many places in the Mallee (Figure 3) (Grinter and Mock 2009).

What are the key drivers and processes of dryland salinity in the Mallee?

The basic drivers and processes that cause dryland salinity in the Mallee are well known. Clearing native Mallee vegetation to establish dryland agriculture has resulted in additional groundwater recharge. The subsequent rise in the levels of groundwater, which is naturally saline, has led to additional areas of land being affected by saline groundwater discharge and waterlogging. This has also led to an increased salt load to the Murray River. These processes occur over long timeframes, such that the impacts of clearing native vegetation pre-1988 will likely not fully manifest for at least another 100 years (Wang et al 2005).

The water balance in the Mallee landscape is very sensitive to change. There are large areas in the Mallee region where the water table is generally shallow and less than 10 metres below the ground (Figure 4). The water table is also very flat with a fall in head of less than 80 metres from Wycheproof to Renmark, a distance of approximately 350 kilometres (SKM 2010). Therefore, minor increases in groundwater recharge can have large effects on the regional water balance and result in increased saline discharge at multiple locations throughout the Mallee.

Widespread clearance of the native Mallee vegetation began in the 1880s and continued for a century. Most intensive clearing occurred in the 1910s and 1920s. There has been minimal clearance since the 1980s when regulations were introduced in Victoria to support the retention and preservation of native vegetation. Figure 5 shows the extent of dryland agriculture in the Mallee, which roughly corresponds to the area of land where native vegetation has been cleared (REM 2005).

While post-clearing recharge rates are reported to be 45 times greater than pre-clearing, this translates to only minor changes in groundwater depths, measured in millimetres and centimetres (Wang et al 2005). Low rainfall in the Mallee and a subsequent low recharge rate (even with clearing), mean that the high salinities are not flushed from the landscape and are maintained within the regional water table aquifer, the Parilla Sands.

The timing, intensity and duration of rainfall are crucial in determining recharge rates in the Mallee. There is considerable variability in rainfall on yearly and decadal scales. Prolonged droughts, as evident in the early 2000s, or wet periods which occurred in the 1950s and 1970s, can lead to substantial changes in recharge rates and groundwater levels. This variability can mask the effectiveness of management strategies aimed at combating salinity through better utilisation of water within the root zone. For instance, a decline in groundwater levels may largely be the result of a period of below average rainfall, rather than serving as proof of the success of a particular salinity management strategy. Conversely, practices to improve water use efficiency may have limited ability to reduce salinity in years following high rainfall (Fawcett 2012).

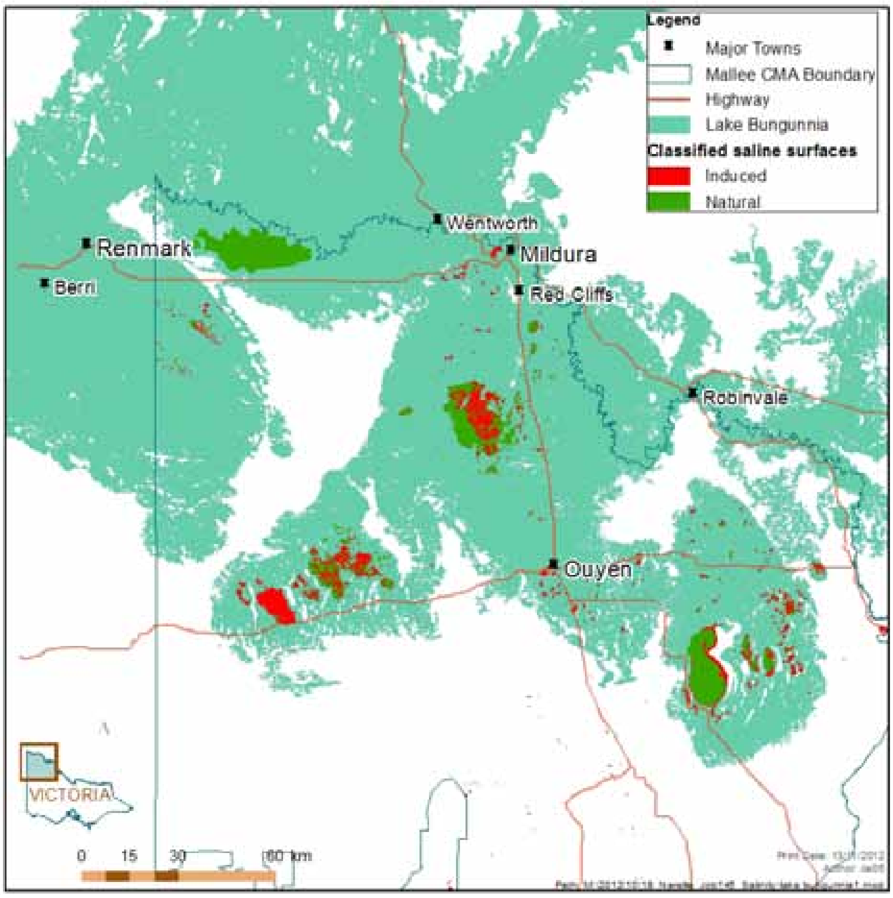

Figure 2. Distribution of salt lakes in relation to the ancient lake Bungunnia - (after Bowler et al., 2006)

Figure 3. Example of secondary salinity at Nowingi. Photo: Vincent Grinter.

The effects of climate change on groundwater recharge may only become apparent in the longer term. It is unclear exactly what impact climate change will have on the amount and timing of rainfall in the Mallee region, but in general more infrequent and intense rainfall events are predicted. A greater degree of accuracy in climatic modelling and monitoring of the groundwater and salinity response is needed to better predict and quantify the impact on dryland salinity in the Mallee. The Mallee CMA undertakes annual groundwater monitoring, a summary of the most recent monitoring is available from the Mallee CMA website **www.malleecma.vic.gov.au**

What management strategies are used to reduce root zone drainage and manage dryland salinity?

Once the land becomes saline, it greatly limits the productivity potential; many commercial crops are sensitive to saline soils and cannot grow profitably in these areas. Although Mallee vegetation has evolved to cope with naturally saline areas, few species can cope with the high salinities observed at many discharge sites. The main challenge for dryland Mallee farmers is to minimise areas of secondary salinity from expanding to ensure agricultural profitability and protect native vegetation.

Land management practices aimed at making the most efficient use of rainfall can minimise root zone drainage and accession to underlying groundwater. However, while management practices can reduce the amount of root zone drainage and in turn groundwater discharge, in many instances the legacy of native vegetation clearance is so great that management practices are limited in their ability to reduce the discharge effect.

Strategies to reduce root zone drainage and maximising on farm water use include: revegetation; strategic tree planting; use of deep-rooted perennial crops; and use of break crops rather than fallow crops.

While the improved management of agricultural land offers several opportunities to reduce root zone drainage and dryland salinity, some barriers remain in place when adopting these practices, for example, finding suitable break crops for use in the Mallee. The Mallee CMA and regional partners undertake various research and demonstrations of potential break crops options for the Mallee. For further information, visit the Mallee CMA website: **www.malleecma.vic.gov.au**

Revegetation is an effective strategy, but it is expensive as it reduces the area of land available to agricultural production. This strategy is best applied strategically, focussing on zones of higher than average recharge rates, for instance, on coarse textured sandy soils that can be linked to localised recharge.

The improved management of dryland agriculture can only partly mitigate recharge as the impacts of past native vegetation clearance are still to be fully expressed in the landscape.

The modern era of dryland salinity management now focuses on management of discharge areas as it is recognised that recharge areas within the Mallee are broad scale and mitigation activities such as revegetation, are likely to have minimal impact in the naturally saline landscape. Recognising that dryland salinity is here to stay, increased focus has been directed towards the revegetation of waterlogged verges with salt tolerant species, including research of alternative options such as salt tolerant native fodder species.

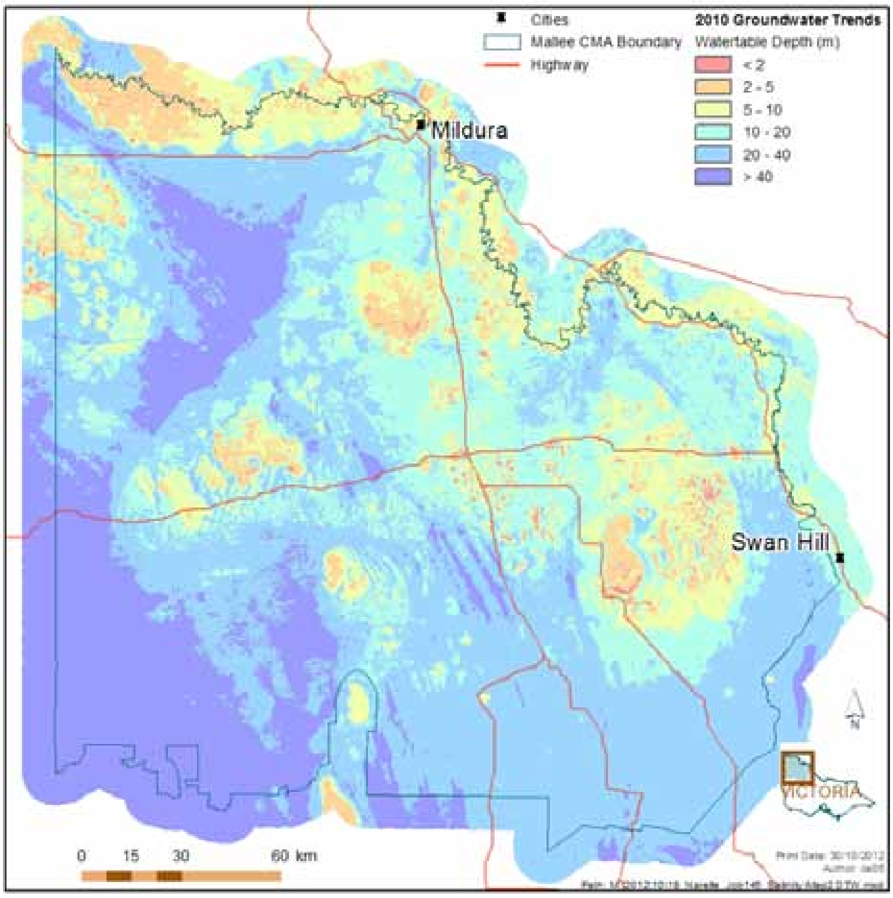

Figure 4. Depth to water table for the Mallee region, SKM 2010.

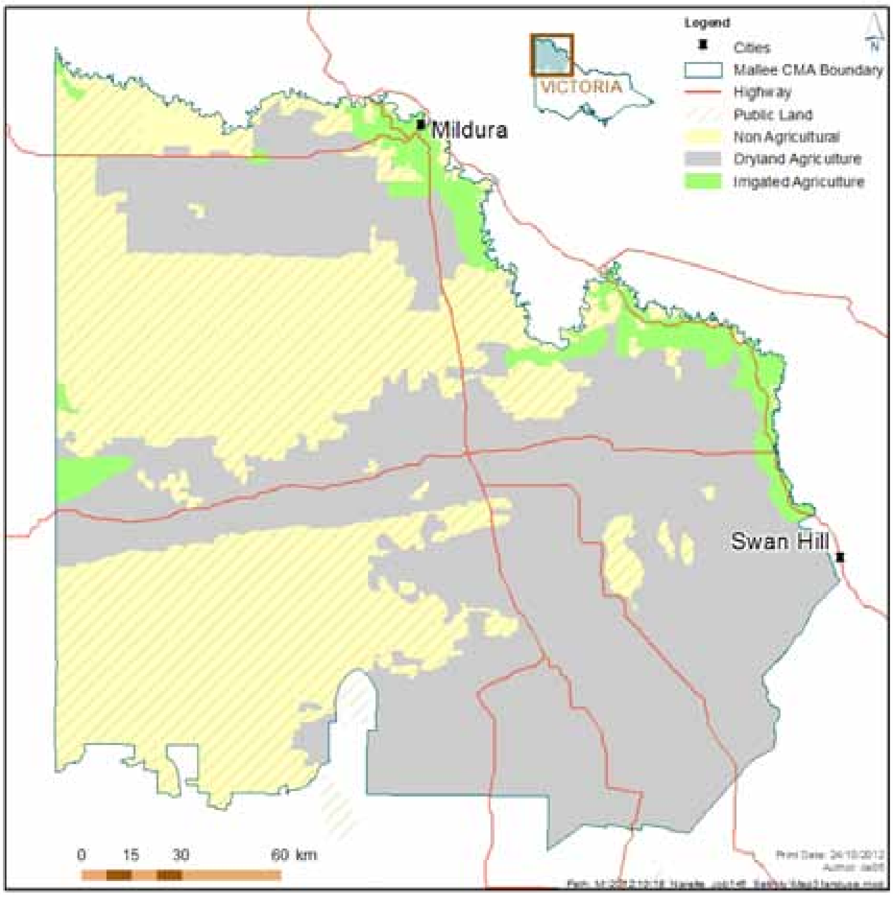

Figure 5. Area of dryland and irrigated agricultural land in the Mallee region.

Above: Induced saline surface soil in former fresh water depression. Photo: Vincent Grinter.

Summary

The four most important points about salinity in the Mallee dryland:

1. Saline wetlands are a natural feature of Mallee landscapes. The geological formations of the Mallee region are such that small changes in the water balance can cause an increase in groundwater levels and land salinisation.
2. Under wet conditions (e.g. large rainfall events), increased recharge may not be preventable because high rainfall events can outweigh the efforts of land management practices in reducing root zone drainage.
3. Greater focus is on management practices that target the discharge sites to mitigate the spread of secondary salinity.
4. The impact of past vegetation clearing is yet to be fully observed in the Mallee landscape.

Acknowledgments

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Above: Natural saline basin. Photo: Vincent Grinter.

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Project Partners

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