NUFG Kamarooka Project Groundwater Monitoring Report - April 2007

prepared by Phil Dyson

Introduction

The Kamarooka Project involves reclaiming 40 hectares of salt affected land using a mix of saltbush, native grasses and farm forestry species. Changes in the soil/water/vegetation balance, and the productivity and biodiversity benefits, are being measured through a 'community monitoring program'.

Results to date of groundwater monitoring, within the broader monitoring program, challenge the conventional understanding of how both remnants and new plantings interact with the saline environment in which they live. Grassroots research at Kamarooka is capturing the unprecedented change in both water balance and groundwater behaviour. As the watertable drops it provides a window of opportunity to establish new management regimes on land previously subject to salinity. The project is a working example of an effective partnership between science and the community.

History of the Kamarooka Project

Salinity was first observed at Kamarooka in the mid-1950s. The Kamarooka project started in 2004 with the group planting a mix of saltbush, native grasses, farm forestry species and biodiversity trees and shrubs to reclaim saline land. The Hay family, also NUFG members, support the project making available the land and actively participating in project management.

The project has received funding from the Australian Government through the Natural Resources Innovation Program (2004/05) and the National Landcare Program (2005/06). The project also receives in-kind support from NUFG members, scientists and local natural resource management (NRM) agency staff.

During 2004 NUFG members consulted with the scientific community, including hosting a site visit and 'think tank' with Dr Ed Barrett-Lennard (Department of Agriculture, WA) Dr Richard George (Department of Agriculture, WA) and Dr Nico Marcar (CSIRO Division of Forestry). Dr Clive Malcolm (WA) also advised on species selection for the site.

In 2004 the group established 11,000 trees, 10,000 saltbush plugs, six hectares of direct-seeded saltbush and native grasses and five kilometres of direct-seeded trees. Another 5,000 trees were planted in 2005.

In 2006 grazing trials commenced to research the productivity benefits of reclaiming marginal land - again the Hay family contributed large numbers of lambs for the trials.

Monitoring soil/water/vegetation interactions at Kamarooka

Phil Dyson, NUFG member and hydrogeologist, manages a comprehensive groundwater-monitoring program as part of the project. Phil brings important history to the project having been involved in monitoring at Kamarooka since the early 1980s when he worked for the Soil Conservation Authority.

Monitoring has taught us about the groundwater system and the way that if functions to cause salinity. Recent monitoring has clearly shown the impact of more than tens years of altered rainfall regimes on the salinity-groundwater interactions in the Kamarooka catchment.

In 2004 ten groundwater observation bores were installed on site to evaluate the on-going impact of the growing vegetation. Another four bores were installed in 2006. Two bores are located within isolated patches of remnant vegetation immediately adjacent to severely salinised land where the watertable is less than 1.5 metres from the surface. The watertable under the remnant vegetation ranges from 6 to 7 metres deep in the north, whilst in the south it ranges from 2 to 5 metres below the surface.

Figure 1: Phil Dyson holds an electronic datalogger that is located inside the groundwater bore and takes readings of the changes in the watertable every 30 minutes.

The deeper watertable under the remnant vegetation is surprising because the groundwater salinity is almost two-thirds the salinity of seawater. After ten years of prolonged drought the ancient Grey Box trees have to be transpiring at least some saline groundwater.

To better understand the interactions between the remnant vegetation and the watertable two high definition water level loggers and a barometric pressure logger were installed. The loggers permit short interval watertable measurements (ten minutes) over extended time periods (three months). With these instruments we witnessed enormous fluctuations in watertable depth (20 to 30 cm) resulting from barometric pressure changes, and observed daily changes in watertable elevation caused by evaporation and transpiration.

Climate change and groundwater observations at Kamarooka

Since 1996 rainfall has been very different to that of the 1980s and early 1990s. Over the last ten years we have seen reduced annual rainfall and a shift in distribution from winter dominance to enhanced spring and early summer precipitation.

The winter-dominant higher rainfall regimes of the 1980s caused groundwater to rise within the upper Kamarooka catchment. The peak occurred in 1994 when levels in the upper slopes reached approximately 117 metres above sea level - about six metres above the discharge zone. This six-metre head differential drove the salinity on the project site. It provided the hydraulic pressure for groundwater to flow through small fractures in the underlying rock down to the saline land below.

There has been minimal groundwater recharge since 1996. Either there has been insufficient rainfall to saturate the soil and allow water to leak to the groundwater below, or the rainfall has fallen when evaporation/transpiration has been high and there has been insufficient water left to seep beyond the plant root zone.

A decade without appreciable groundwater recharge has allowed groundwater to drain from the catchment. Groundwater levels have fallen on the slopes and crests (Figure 2). At bore 72, in the upper catchment, groundwater has fallen from 116.5 metres above seal level (masl) to about 111.5 masl since 1995/96. This fall has almost eliminated the hydraulic gradient required for groundwater to move from the upper catchment down to the land below. Much of the saline land, including the project site, occurs at an elevation of about 111 masl.

Figure 2: Decline in groundwater elevation in bore 72 (Upper Kamarooka catchment)
Source: Victorian Department of Primary Industries, 2006.

The dynamics of the catchment-groundwater system substantially altered with the onset of the post mid-90s climate change. The processes both causing and maintaining salinity were disrupted. Groundwater is now receding as it moves toward a new equilibrium.

Localised recharge on the saline land

The saline land at Kamarooka arises from the lateral down-slope flow of groundwater from the upper catchment. Our measurements to date, however, demonstrate that this is not the only hydrologic process active in the salinity at Kamarooka.

During 2005 a data logger from a bore in the saline land recorded a rapid response to a relatively modest rainfall event that came after a prolonged dry period. The watertable response occurred within hours of the event and could only be explained by localised recharge.

It now appears that a large accumulation of salt within the surface soil most likely prevents dispersion allowing deep infiltration and drainage to the watertable. Similar observations elsewhere (pers. comm. Mark Reid, DPI, 2006) reveal the same phenomenon has recently been recorded in saline land in the Upper Bet Bet catchment of Central Victoria.

The understanding of these dual processes arising from the Kamarooka work is significant both in a scientific and a management sense. It reinforces the need for a holistic approach that involves both upper catchment management and management of vegetation on saline land.

The impact of vegetation on salinity at Kamarooka

The Kamarooka project is about establishing perennial vegetation on saline land. The main challenge was to revegetate saline land and adjacent areas with productive vegetation that would flourish in saline soils with shallow watertables.

We did not expect that the newly established vegetation would immediately lower watertables and solve a fifty-year salinity problem. However, a valuable opportunity arose to establish monitoring systems that would allow us to learn from our experiences in ways that would benefit NUFG and others throughout eastern Australia struggling with similar salinity issues.

The challenge has been to establish an efficient monitoring regime capable of reporting on the effectiveness of the treatments, and to do this in ways that are both scientifically credible yet relatively inexpensive. Constrained by these guidelines we opted to monitor the groundwater responses to the treatments imposed. The questions asked in this process were, "Can we detect changes in watertables that we can attribute to vegetation-groundwater interactions?" "Can we maintain healthy growing vegetation in areas with high salinity and shallow groundwater?"

Our monitoring has also led us to explore how the ancient native Grey Box vegetation survives under the extremes of salinity. The old trees are not only surviving, in at least one instance they are dramatically suppressing the watertable.

The extent to which our treatments at Kamarooka influence the watertable is still unknown. Our monitoring efforts, by chance, coincided with a change in climate that ultimately produced the most substantive change in landscape-groundwater interactions in the last fifty years. This change in background conditions masks the changes that we might otherwise hope to see resulting from our management systems. At this stage we are not able to separate climatically driven effects from those that we might expect from the treatments.

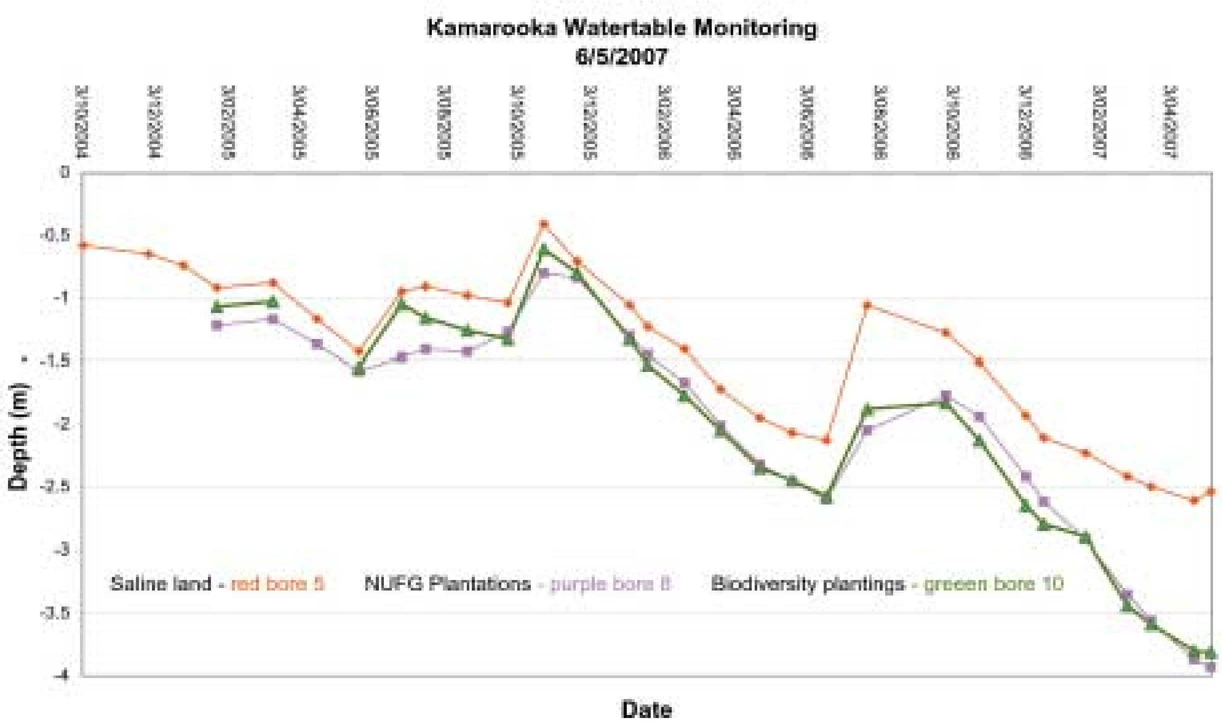

Figure 3: Bore data for the three treatments established as part of the Kamarooka Project

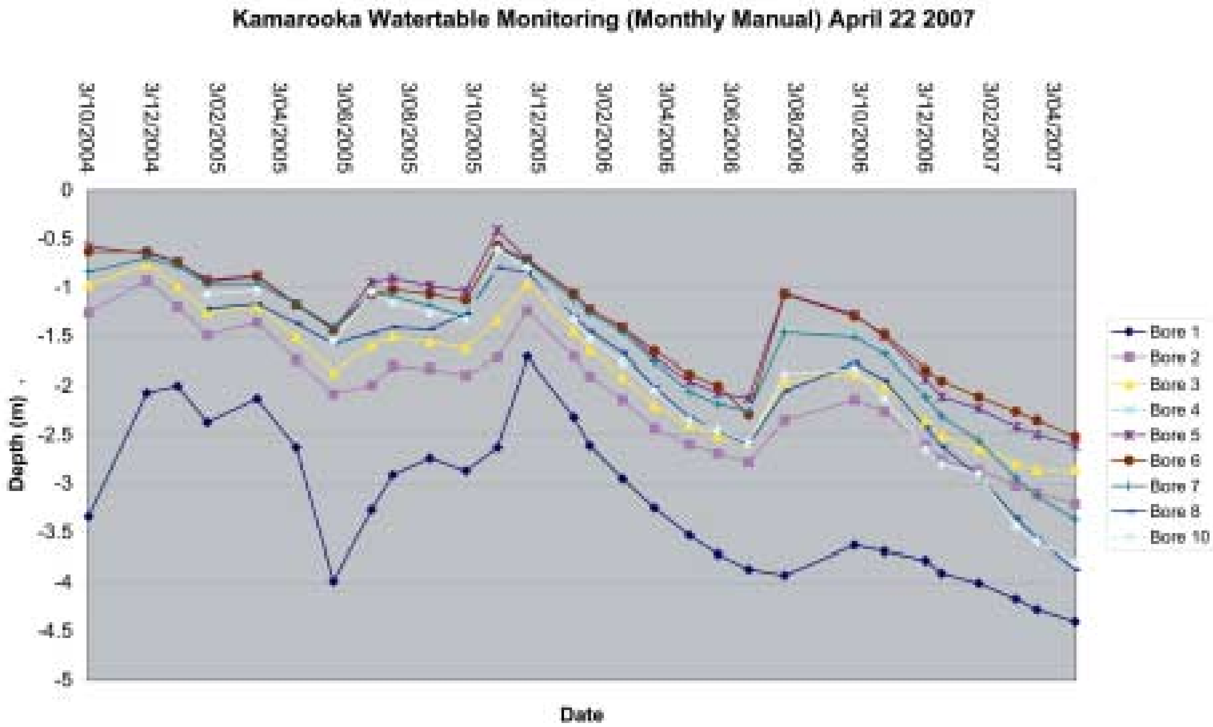

Figure 4: Bore data for all 10 bores across the Stage 1 planted area of the Kamarooka Project

Equally, the vegetative treatments remain relatively immature in terms of their water use, and there is a need to sustain our monitoring efforts whilst they continue to develop.

Figures 3 and 4 clearly show that both the farm forestry plantation and the biodiveristy plantation are drawing the watertable down.

Hydraulic conductivity at Kamarooka

The deeper bore under the northern remnant vegetation was bailed in April 2007 to check that it is accurately recording the groundwater head. Prior to emptying the bore the water level was about 3 metres from the surface. Bore C070 on the roadside to the north was also measured. It recorded a depth below ns (natural surface) of about 2 metres.

The differential between Bore 9 (currently dry and screened at 7.5 metres) and Bore 9b (12 metres deep and groundwater 3 metres below NS) is at least 3 metres. This suggests that there is a very strong upward hydraulic gradient between the groundwater in the deeper sediments/weathered bedrock and the uppermost regolith (difficult to avoid this word). This strong gradient occurs over a very short distance.

The upward gradient must be supported by very low hydraulic conductivity in the upper regolith in the immediate root zone of the old remnant trees. The upper regolith forms a partially confining layer that regulates/inhibits upward leakage of groundwater. This would seem to support the ability of the old trees to lower the watertable because the rate of upward leakage must be less than the transpiration.

As the trees lower the groundwater they must increase the upward hydraulic gradient. The upward flow of groundwater into the depression created by the trees is inevitable, as is the salt accumulation that must occur in consequence.

Figure 5: Phil Dyson and Ian Rankin (NUFG President) download watertable data from an electronic datalogger at Kamarooka.

Conclusion

The Kamarooka monitoring program breaks new ground. The climate-vegetation-landscape-groundwater systems are too complex for effective computer modelling. In this instance we will learn far more from simply continuing to measure and observe.

We now know that recharge is occurring on the discharge site. We can also clearly see from Figures 3 and 4 that both the farm forestry plantation and the biodiversity plantation are drawing the watertable down. But will the groundwater system bounce back with any return to wetter conditions? This question has great relevance well beyond Kamarooka.

References:

Reid, M. 2006, pers. comm.