Agricultural Water Management 164 (2016) 291–303

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

# ‘Keeping salt on the farm’—Evaluation of an on-farm salinity management system in the Shepparton irrigation region of South-East Australia

Bruce C. Gill*, Alister D. Terry

*Department of Economic Development, Jobs, Transport and Resources—Agriculture Research and Development Division, Tatura, Victoria, Australia*

ARTICLE INFO

*Article history:*
Received 6 May 2015
Received in revised form 12 October 2015
Accepted 14 October 2015
Available online 7 November 2015

*Keywords:*
Salinity management
Sub-surface drainage
Groundwater re-use
Conjunctive use
Irrigation
Land salinisation
High watertable

ABSTRACT

High watertables and land salinisation in irrigation areas worldwide can often be managed with various forms of sub-surface drainage, but constraints on the disposal of saline drainage water to downstream users and environments often requires on-site management methods. In the Shepparton Irrigation Region of northern Victoria, Australia, groundwater pumping with on-farm re-use is a well-established and effective salinity management method, provided the groundwater salinity is less than 5 dS/m. In this study, a trial system established on an operating dairy farm could utilise 60 Ml/yr of 10 dS/m groundwater without requiring any off-site disposal. Normally in this region, such a circumstance would require evaporation basin disposal, but in this trial system, a salt-tolerant tree plantation established on already salinized land within the area of influence of the groundwater pump replaced an evaporation basin.

Evaluation of the system was accomplished using monitoring data collected since the establishment of the trial in 1998. This data supported the development of a mass balance model to calculate where the salt loads mobilised by the groundwater pumping move to and evaluate the longer-term operation of the system. Re-distribution of the salt, both diluted with irrigation water onto the broader farm area and undiluted onto the tree plantation, appears to approach a dynamic equilibrium in about 20 years. Modelling results suggest the tree plantation might reach equilibrium at soil salinities of 45 dS/m.

Transferability of this system to other sites would require some similarities in respect to soils, hydraulic properties, salinities, groundwater gradients, and irrigation practices. Overall, the model of the system demonstrates a viable means of sustainably managing irrigation salinity through groundwater pumping with on-site re-use. Partitioning of the pumped high salinity groundwater to a combination of conjunctive use and undiluted irrigation to a salt tolerant tree plantation is able to meet the criteria of not requiring off-site disposal.



## 1. Introduction

The Shepparton Irrigation Region (SIR) in southeastern Australia (Fig. 1) is approximately 560 km$^2$ in area. Irrigation commenced in the 1880s and by the 1970s, over 280 km$^2$ was irrigated. Increased hydraulic loading of the landscape that arose from the introduction of irrigation, removal of deep-rooted perennial vegetation and a wetter climate phase from the 1950s to the mid-1990s, drove salinisation processes throughout the SIR (Lyle et al., 1986a). High watertables were first observed in the 1930s and by 1995, a high watertables of less than 2 m below surface had developed under 260 km$^2$ (GBCMA, 2001). Salts (primarily sodium chloride) are naturally present in the alluvial floodplain soils and groundwater as a consequence of the semi-arid climate, where cyclic salt (in rainfall) and wind borne salt accumulated in the landscape over tens of thousands of years. Typical salt loads in the region average 100 tonnes of salt per hectare in the top 10 m, so following sustained rises in groundwater levels since the 1900s (Tickell and Humphrys, 1987; Thayalakumaran et al., 2007), the resulting high watertables caused waterlogging and salinisation of the soils. This caused a decline in agricultural production and increasing downstream environmental impact on regional water bodies and the Murray River.

A comprehensive salinity management plan was developed for the region (SIRLWSMP, 1989; Su et al., 2005) through a

* Corresponding author at: Department of Economic Development, Jobs, Transport and Resources, 255 Ferguson Road, Tatura VIC 3616, Victoria, Australia. Fax: +61 358335377.

*E-mail addresses:* bruce.gill@ecodev.vic.gov.au (B.C. Gill), alister.terry@ecodev.vic.gov.au (A.D. Terry).

http://dx.doi.org/10.1016/j.agwat.2015.10.014

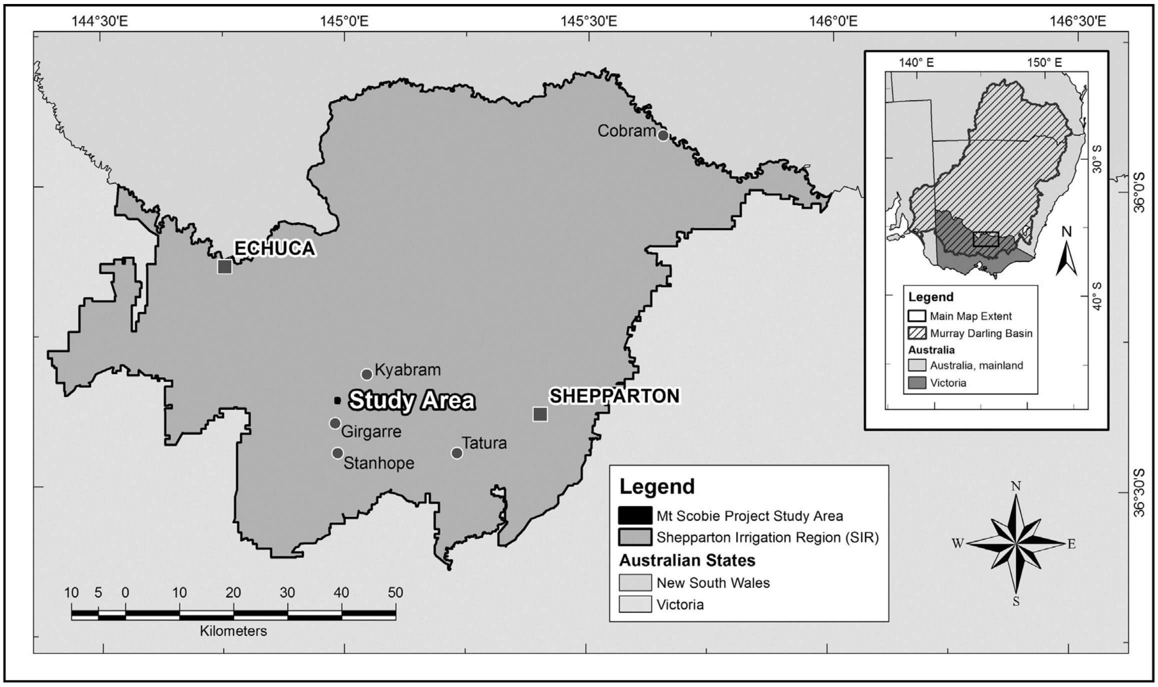


**Fig. 1.** Location of the study area (36 21′ 33″S, 144 59′ 00″E) in SE Australia, relative to the Murray Darling Basin, the SIR and some nearby towns.

partnership between the community and the State Government in 1989. The key aim of the plan was to reduce accessions to groundwater and limit salinity impacts both within and outside of the irrigation region. It contained a diverse program of works to minimise the causes and impacts of salinity, one of which was to develop sub-surface drainage by pumping from shallow aquifers (SIRLWSMP, 1989; Heuperman, 1999; Bethune et al., 2004).

Sub-surface drainage is a commonly applied method used to manage salinity and rehabilitate saline soils in irrigated regions, both in Australia (Christen et al., 2001) and in other parts of the world (Westcott, 1988). In the SIR, this widely implemented salinity control measure has been possible due to the presence of shallow (less than 20 m deep) aquifers found in many parts of the region. Where the pumped groundwater is of relatively low salinity (less than 5 dS/m) it can be readily diluted to a recommended salinity of less than 0.8 dS/m by mixing with surface irrigation water (DPI, 2004). This on-farm conjunctive use of the shallow groundwater of the SIR provides a valuable supplementary irrigation supply, especially during periods of low surface water availability and its impact on forage production can be managed and has been well documented (e.g. Mehanni & Chalmers, 1986; Rogers, 2002; Burrow et al., 2002). At higher groundwater salinities, on-farm groundwater use becomes increasingly impractical because sufficient dilution cannot be achieved with the available fresh water supply.

In instances where the sub-surface drainage water salinity is up to 11 dS/m, shared public pumping schemes are used, with off-site disposal into major regional irrigation supply channels or the regional surface drainage system, provided acceptable dilution ratios are feasible. However, the downstream impact of more saline drainage on receiving water bodies can place limits on this option (Westcott, 1988; Blackmore et al., 1999; Christen et al., 2001; Bethune et al., 2004; Wichelns and Oster, 2006). Evaporation basins can provide a disposal option in this circumstance, but are costly to build and operate, and finding suitable sites for them is often difficult. Only one evaporation basin has been built in the SIR, near the town of Girgarre in 1987 (G-MW, 1995).

Another system for the disposal of high salinity pumped groundwater in the SIR called Serial Biological Concentration (Su et al., 2005; Cervinka, 1990) was trialled in the mid 1990s on a farm about 20 km east of Kyabram. While that trial demonstrated that it was not possible to concentrate and capture salt mobilised by the groundwater pumping and re-use at that site (due to the overriding influence of the high watertable on the tile drainage effluent) it did show again the effectiveness of shallow aquifer pumping and tile drainage for salinity control.

An alternative system for mitigating waterlogging and salinisation problems for locations with groundwater salinities in the range 5–11 dS/m was established on a privately owned dairy farm near a location called Mt. Scobie in 1998. This trial aimed to test the practicality and sustainability of a farm scale sub-surface drainage based salt management system where the groundwater is too saline for conjunctive use on pastures alone, has no off-site disposal option, yet is not concentrated enough for efficient evaporation basin disposal. This trial site demonstrates a hybrid approach using partial conjunctive use of pumped saline groundwater diluted with fresh water for irrigation re-use, combined with the on-farm disposal of the remaining undiluted groundwater via irrigation of a salt tolerant tree plantation. The tree plantation was established on a salt affected part of the property within the area of drawdown of the groundwater pump.

It must be noted that the trial was not set up as a controlled scientific experiment of soil – crop – aquifer hydraulic and solute processes. It was set up as a field trial of an untried system of salt management designed for farms in the region with shallow aquifers suitable for pumping, but where groundwater salinities were too high for full conjunctive re-use and with the requirement for no off-site disposal. The success or otherwise of this system was not to be based on a detailed numerical modelling of the farm, but rather; did the system work in practice and were the aims of the trial (as detailed in Section 2.3) actually met. In summary, these are:

- Did soil salinities in the rootzone of the pastures within the area of influence of the groundwater pump decline due to the pumping and partial conjunctive re-use?
- Did the trees survive and grow in the groundwater re-use tree plantation?