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Sustainability of sprinkler- irrigated horticulture on sandy soils at Binningup - Swan Coastal Plain, W.A.

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CHAPTER 1. INTRODUCTION

1.1 Overview

Vegetable production by sprinkler irrigation on the Swan Coastal Plain of south western Australia extends from Gingin in the North, to Binningup and Myalup in the south (Figure 1-1). The soils on the Swan Coastal Plain are aeolian and contain less than 3% clay and 1% organic carbon (Prince et al. 2008). Commercial production areas do have an underlying superficial aquifer at shallow depth, with a surplus supply of water for sprinkler irrigation (Mackay 2014) but it is anecdotally accepted that summer crops occasionally fail or experience a reduction in yield, despite this water availability. To date there has been no definitive publication on the sustainability of the industry, particularly in regard to the widely anticipated reduction in rainfall due to climate change.

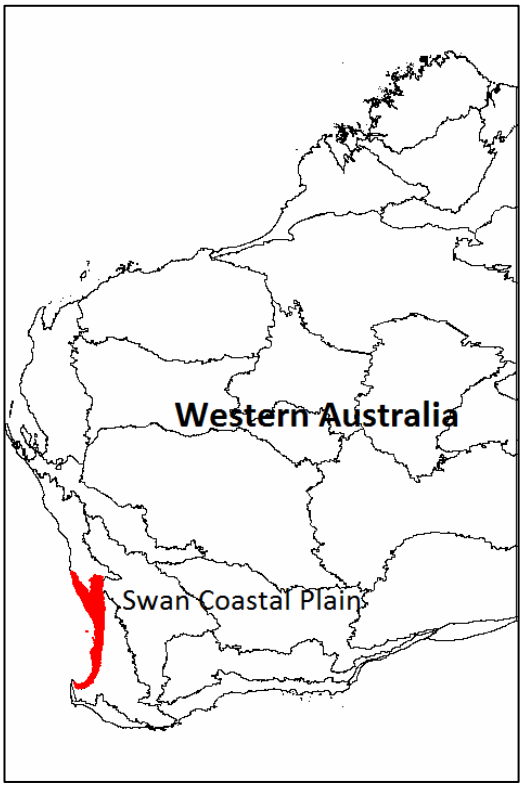

Figure 1-1: Swan Coastal Plain, Western Australia (Source: DoE 2015).

This investigation was prompted by the findings of research by Dr Tim Meagher (Unpub. Obs.) that was conducted in support of a licence for sprinkler irrigation at a vegetable farm at Binningup (Figure 1-2). The findings, which were essential to the aims of the current investigation, were summarised by Meagher (2010).

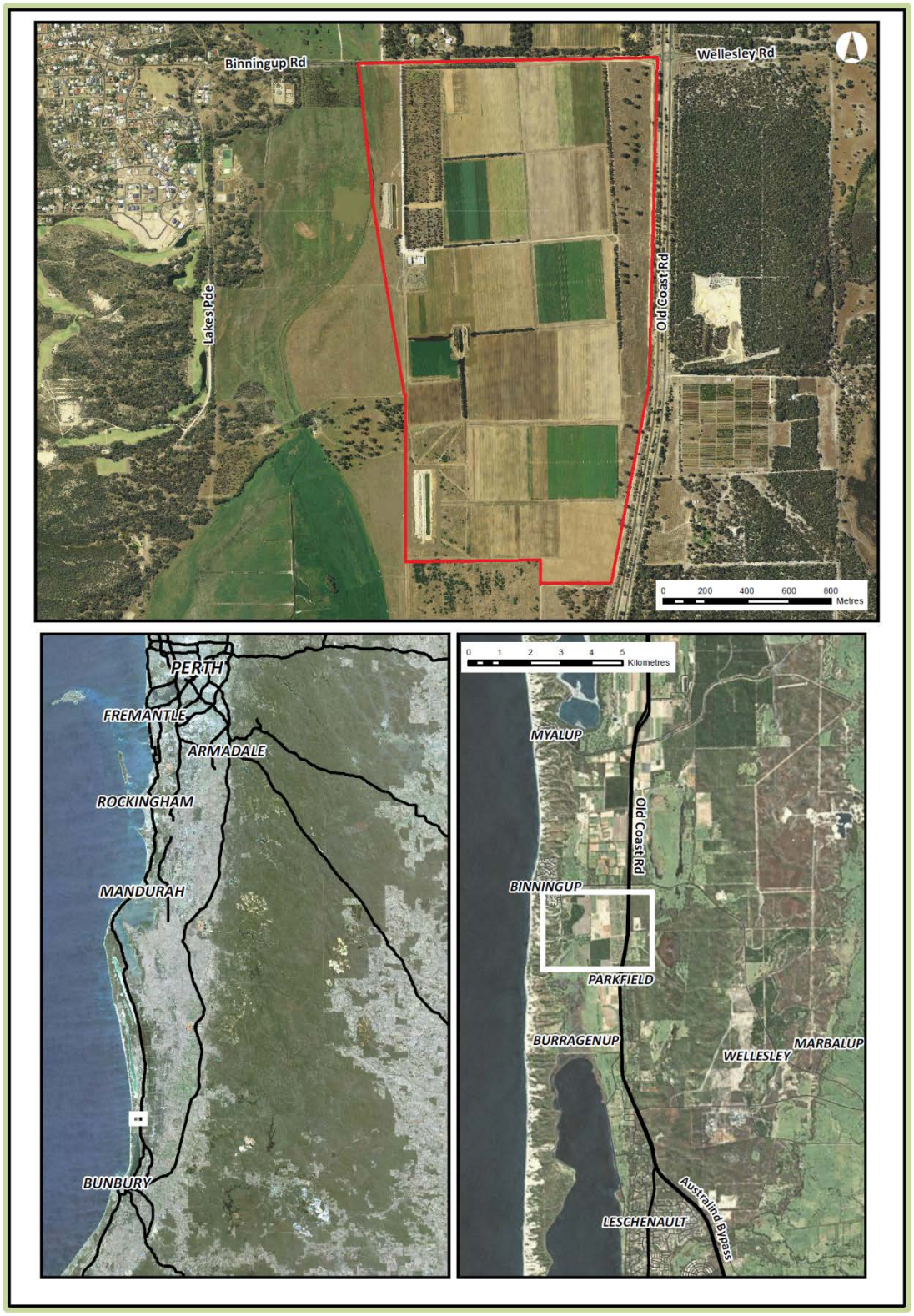

Figure 1-2: Research project location – Binningup, Western Australia.

At Binningup, while crops of mainly carrots, potatoes and onions are grown throughout the year, during summer they require a large amount of water. This is due to a combination of high soil porosity, low relative humidity, substantial wind and

high temperatures. As a result of the seasonal climatic conditions, very little sprinkler irrigation is required during winter.

Studies by Libutti and Monteleone (2012) and Monteleone and Libutti (2012) noted that, where irrigated agriculture is practiced in Mediterranean climates such as the study location, rainfall during the winter period played an important role in removing salts accumulated in the soil by summer irrigation. In addition when annual rainfall is too low to prevent salt accumulation, the practice of leaching through irrigation is recommended, given that the soil has sufficient permeability and the water table is at a depth that prevents any capillary rise to the root zone (Monteleone et al. 2004).

Licence holders in Western Australia are required to log the volume of water they draw from the aquifer and thus pumps at the research site were fitted with accurate meters. Meagher (2010) analysed the water production onsite and described a substantial seasonal variation in water requirement (Figure 1-3 and Figure 1-4).

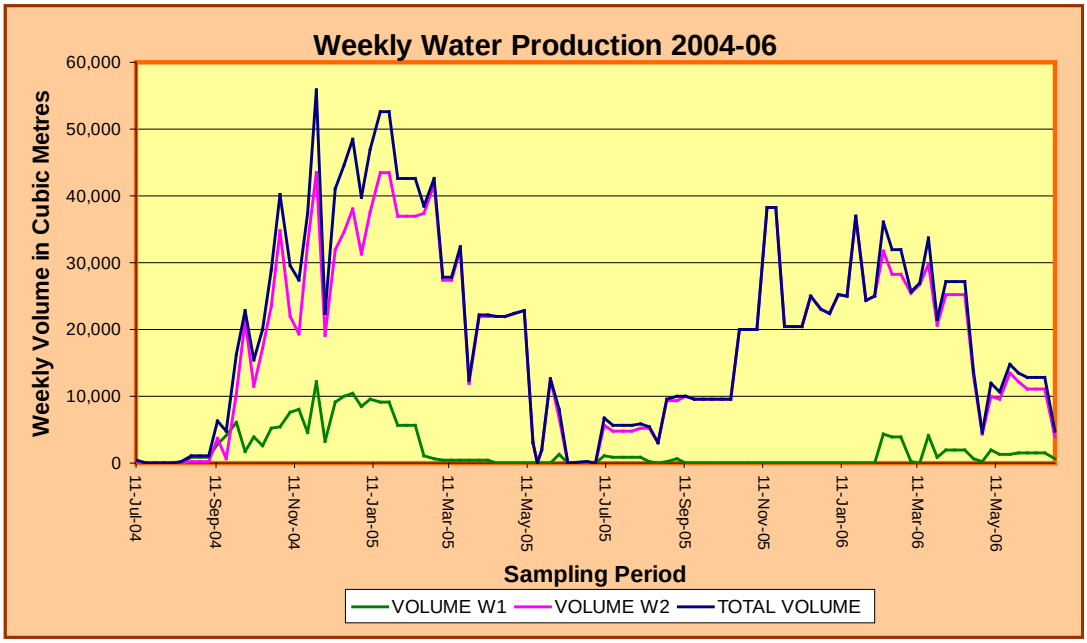

Figure 1-3: Water production from 2004–2006 (Meagher 2010).

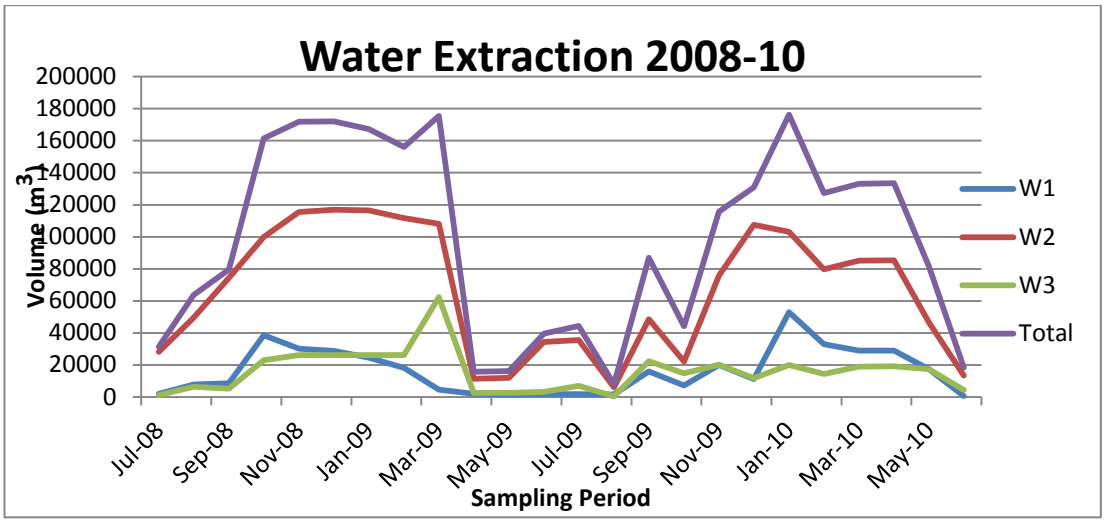

Figure 1-4: Water production 2008–2010 (Meagher 2010).

Meagher (2010) also noted that water quality began at 600–800 ppm of total dissolved salt (TDS) but after a few years of production, it increased and stabilised at 900–1,300 ppm TDS. Commander (1988) described the superficial aquifer beneath the Binningup study site as occurring in ~18 m thick karst and increasing in TDS with depth. An additional piece of information for this study's inception was a report by Rockwater (2000), which concluded, based on monitoring bore piezometric data, that groundwater would take approximately eight years to flow from the east side of the research project location to the excavations into the aquifer that supplied the irrigation water. This led to the question of whether evapotranspiration of sprinkler irrigation was responsible for the observed increase in TDS and that would eventually make crop production unsustainable.

The component of the unconfined aquifer underlying the study site occurs in a formation that is commonly referred to as the 'Tamala Limestone' which continues to both the north and south of the research area. However, there is a sharp demarcation immediately to the east where the superficial aquifer continues in a silica sand formation known as the 'Bassendean Sand'. The stratigraphy is described by Commander (1988) and in more detail by Semeniuk (1995).

A vegetable farm site at the research location shown on Figure 1-2 was closely monitored for water use in relation to the production of carrots, potatoes and onions between March 2011 and January 2012. The same crops are grown year-round. However there is a difference in both growing periods and associated sprinkler

requirements. The summer period is in the order of 17 weeks compared with 24 weeks for the winter period with a comparable yield.

Daily variation in soil moisture and soil water salinity during the crop cycle was investigated in relation to varying evaporative conditions and parameters included; temperature, wind speed, humidity and solar radiation. Accurate records of the area of crop, fertiliser application and volume of water used for each crop are maintained by vegetable producers. Salinity in the upper aquifer layers is known to increase through evapotranspiration via irrigation water and its return of salts. It is also understood that high-volume pumping via bores may draw more saline water from deeper in the aquifer and it is for this reason that local vegetable farmers install ponds and do not use bores. Therefore, appropriate irrigation practices are required to prevent continued increases in soil salt concentrations.

The soil water balance throughout a crop is known to limit crop quality and production (PIRSA 2006). If too much water is applied, fertiliser nutrients are rinsed past the root zone and into the underlying aquifer. If too little water is applied, there is the possibility of salt accumulation due to water losses through the sprinklers and evapotranspiration by the crop. Thus it is common horticultural practice to balance the volume of irrigated water applied to the crops so as to saturate the soil no deeper than the crop root zone for plant uptake (Fares and Alva 2000; Money 2000). An investigation by Schoups et al. (2005) on irrigated agriculture in the San Joaquin Valley, California also noted that for irrigated agriculture to remain sustainable, a soil/salt balance must be maintained that allows for a productive cropping system avoiding salt build-up in the soils and groundwater which threatens both productivity and sustainability.

It has also been recommended in Monteleone et al. (2004) that periodic leaching should be applied when soil salinity reaches the threshold concentration where crop yield is adversely affected. The physical characteristics of the sandy soils overlying the property enable 100% infiltration of rainfall and/or applied water which optimises leaching potential.

Before horticulture at the property, a Tasmanian blue gum (*Eucalyptus globulus*) plantation was trialled and in order for this to occur, the land was cleared of Tuart trees (*Eucalyptus gomphocephala*), a species currently in decline on the Swan

Coastal Plain. Evidence of the Tuart woodland exists in the Coastal or Tamala Limestone as solution channels.

1.2 Research objectives

The three main objectives of this research were:

- To record the behaviour of both rain and sprinkler water in the crop soil profile in response to the age of the crop and ambient meteorological conditions.
- To record salt accumulation from sprinkler water in the soil profile and determine the intensity and duration of rainfall required for effective leaching of the soil profile.
- To determine the replenishment of the aquifer below the crops and whether there was a significant accumulation of salt in the upper portions of the aquifer.

1.3 Research purpose

The purpose of this research was thus to find out if seasonal rainfall in Binningup was sufficient to effectively rinse the soil profile of salts and replenish the irrigation source water to sustain horticultural activities. In addition, it was hoped that this research would allow horticultural managers to develop an optimal regime of summer irrigation for salt reduction, fertiliser efficiency and crop yield.

At a local level, this research has been essential in determining the sustainability of irrigated vegetable production in the Myalup–Binningup area. Crops have failed in recent summers due to increased salinity of reticulation water and some water supplies are now too saline for reticulated irrigation (M. and P.G. Dell'Agostino, pers. comm.).

This research thus not only has potential significance in relation to the local (WA) domestic economy (supply, demand and water use) - there is the potential for domestic and commercial watering regimes across the Swan Coastal Plain to benefit in the long term as a result of the findings - but could also be used as a model with wide-reaching applications to irrigated horticultural practices that occur on sandy soils globally.

The overarching objective of the research was to provide an assessment of the sustainability of irrigated horticultural practices on a property with the given physical

characteristics and associated environmental conditions on a local scale – and if possible extrapolate to a global scale where properties face similar challenges. This required investigations on vegetable growth; soil moisture; soil and soil water salinity; and groundwater quality and movement beneath the property. As this was the focus of the investigation, soil physical and chemical properties were investigated during the research only inasmuch they influenced soil/salt water balances.

1.4 Thesis structure

The thesis begins with a detailed review of literature relating to the different aspects of the research project, with local national and international context. The physical characteristics of the research site are described in Chapter 3, including the geology and overlying soils in which the crops are grown; the underlying groundwater from which the irrigation water is sourced and the meteorological conditions affecting them.

Methods and materials used during the key investigations are described in Chapter 4 which leads into the investigation results for rainfall and irrigation application; soil water content; and crop salinity of both winter and summer crops.

The discussion draws on similar research and other literature previously described within the body of the thesis and is followed by the conclusions made from the investigation outcomes individually and holistically, against the research objectives.